A Perspective on Canada’s Ecosystems

By Ed B. Wiken, David Gauthier, Ian Marshall, Ken Lawton and Harry Hirvonen
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An Overview of the Terrestrial
and Marine Ecozones

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Significant Internet Sites
Canadian Council on Ecological Areas
   http://www.cprc.uregina.ca/ccce/
State of the Environment Reporting, Environment Canada
   http://www1.ec.gc.ca/~soer/
Land and Biological Resources Centre, Agriculture and Agri-Food Canada
   http://res.agr.ca/CANSIS/NSDB/ECOSTRAT/
In the mid 1980s, many agencies and professionals from across Canada contributed to the development of the Terrestrial Ecozones of Canada (Wiken, 1986). This product was and remains to be a highly significant undertaking by world standards. Unlike many other ecosystem classifications, this scheme considered ecosystems as holistic entities. The use of the term ‘ecosystem’ was not a veil to describe sectoral themes like the distribution of current or past plant species, climatic regimes or physiographic features. The focus was ecosystems—distinctive areas where organisms (including humans) and the physical environment (i.e. soils, water, climate,) cohere as a system.

The ecozone report was the outcome of many regional and national ecosystem classifications. As well, it was a response to a need to look for a more holistic way of viewing and managing Canada’s ecosystems. Programs like the Canada Land Inventory and conferences like Resources for Tomorrow had already pointed-out that a more integrated and longer-term view had to be taken on defining the relationship resource use and the well-beings of Canadians. The focus on these relationships is reflected in currently vogue concepts such as sustainable development and world conservation strategies.

Ecosystem classifications within Canada have continued to be refined at the national and regional levels (e.g. ESWG, 1996; ). New developments have also taken place at the continental and state level. The draft North American Ecosystem Framework produced by the Commission for Environmental Cooperation (1996) and the Ecoregions of Alaska (Gallant et al, 1996) published by the U.S. Geological Survey are examples. Provincial reports like the ‘Ecoregions of Saskatchewan’ (Padbury and Acton, 1994) are also examples of recently published and updated Canadian studies. Perhaps of more importance, ecosystem classifications have been used increasingly to evaluate a broad spectrum of issues, redesign monitoring systems, focus research programs, and better integrate the information sources and capabilities of organizations from across Canada.

All of these efforts are essential to be able to inform Canadians on the status of ecosystems and to relay what this information means to them in the sense of their health and well-being. National (Government of Canada, 1996) and provincial (B.C. Government, 1995; Yukon Government, 1996) state of the of the environment reports perhaps have been the most effective in capitalizing on the use of ecosystem frameworks. These reports have employed innovative ecosystem approaches and have provided some of the best discussions on linkages between environmental and socio-economic issues. The analysis of both status and connections has taken a broader interpretation of ‘our well-being’. Human needs—prosperity, clean air and water, productive soils, renewable resources, protected areas,—all depend on understanding the total life support system. Success—socially, economically and ethically—is dependent upon providing due care and attention to organisms (e.g. plants, animals, humans,) as well as to the physical environment (e.g. soils, water, atmosphere,) of which they are a part. The ecosystem perspective is essential.

Canada is often considered to be a warehouse of life support systems which are considered to be ‘natural’ or ‘native’. Unlike many other countries, the landscapes and seascapes of Canada seemingly remain untouched. While this is not entirely true, factors like the country’s vastness, the southern concentration of people and the poor northern access provide credence to this notion of untold wilderness areas. Having much of what we started with in respect to natural ecosystems, allows us the opportunity to
further adopt an 'anticipate and prevent' mode of planning rather than a 'react and cure' mode. Sustaining resources, maintaining healthy ecosystems, keeping clean water and air, and merging economic and environmental are forward looking goals. Achieving those ends will depend to a large degree on having a fundamental knowledge of ecosystems. How can you sustain a resource (i.e., timber, wild animals,) without knowing something about the ecosystems of which they are a part? How can you protect wilderness areas into the future without understanding the ecosystems which they represent? How can we protect and conserve ecosystem diversity without knowing the range and type of ecosystems that exist in Canada? What is essential in sustaining the components and processes of ecosystems? Developing an ecosystem perspective is essential.
Acknowledgements

The concept and application of ‘ecozones’ have a considerable history in Canada. Over three decades ago, the need for ecozones grew from a much more overall need to examine Canada’s full range of ecosystem resources. Some of these needs were intended to address site and regional planning/assessments, while others were intended for national and international purposes. The ‘ecozone’ concept provides a basis for the broader country-wide perspective. Inherently, this required the input of many professionals, organizations and disciplines from across Canada. At times, expertise was also sought from other countries particularly neighbouring USA.

The first attempt to consolidate an ecozone perspective was done through a joint project with the Canada Committee on Ecological Land Classification (CCELC) and the Lands Directorate of Environment Canada. The results were published as: Terrestrial Ecozones of Canada (Wiken, 1986). While these two core agencies helped to publish the report, over 60 professionals and 20 agencies contributed to its development.

The State of the Environment Service of Environment Canada and the Canadian Council on Ecological Areas (CCEA) jointly refined and enhanced the 1986 version of the ecozones of Canada. Beyond improving the descriptions and maps covering the terrestrial ecosystems, new sections were developed to cover the nation’s marine ecosystems. Much of this was captured in the Eco-vignettes initiative—a series of twenty posters which were published by Environment Canada as a companion product to the 1996 State of the Environment Report (SOER) for Canada. SOER staff members such as V. Neimanis, J. Reid, W. Bond, A. LeHenaff, G. Ironside, H. Vandermeulen, J. Anderson, C. Pupp, N. Ward, T. Turner, D. Duggan, A. Kerr, R. Frith and N. Spooner made valuable contributions to the Ecovignettes, as well as to the Ecozone Chapters of the SOER and Indicator bulletins. The current CCEA ecozone report builds on many of these elements as well as provincial/territorial initiatives and former reports.

The images for the ecozones are a new addition. Images for the ecozones were produce by Autumn Downey (Arctic Cordillera, Northern Arctic, Southern Arctic, Taiga Plains, Taiga Shield, Taiga Cordillera, Boreal Shield, Pacific Maritime, and Prairies), Serge Bédard (Boreal Plains, Pacific Marine, Arctic Basin, and Atlantic Marine) and William Johnson (Hudson Plains, Boreal Cordillera, Montane Cordillera, Atlantic Maritime, Mixedwood Plains, Arctic Archipelago, and Northwest Atlantic). The publication layout and graphic design as well as the map illustrations were produced by Serge Bédard.

Many organizations have assisted in producing this report. They include:

- Canadian Plains Research Centre, Regina
- National Atlas, Ottawa
- Canadian Soil Information System, Ottawa
- Canadian Forest Service, Ottawa
- Statistics Canada, Ottawa
- State of the Environment Directorate, Ottawa
- Canadian Wildlife Service, Ottawa

We owe special thanks to our international colleagues. In the USA, in particular, we have greatly appreciate the input that we received from Jim Omernik and Glen Griffith. Irene Pisanty and the North American Commission on Environmental Cooperation have also been very helpful in extending the ecozone concept across North America.
Section 1

Introduction

This report offers a broad perspective on Canada’s ecosystems, both terrestrial and marine. It describes as of 1996, Canada’s twenty major ecosystems—the ecozones. All of Canada’s ecozones are not in a pristine or natural state. Many of the southern ecozones are very much human modified/dominated ecosystems. However, each ecozone is distinct, containing its own particular sets abiotic and biotic characteristics. Some of the defining features of ecosystems may be associated with economic resources (i.e., timber species, productive grassland soils,), and others may be linked with specific geological, climatic, or physical features. Still other defining features are found in the peculiar types of wildlife and vegetation or the human activities that exist within an ecozone. Ecozones are described holistically according to a range of characteristics—some biological, some physical, some structural, some process and some relational.

Canada has been a world leader in ecosystem classifications and evaluations since the early 1960’s. It is one of the few countries which has applied a holistic definition in its development of ecosystem classifications and assessments. Most of Canada’s focus was initially on the terrestrial landscape but the concern over applying an ecosystem approach to marine waters directed recent initiatives to building a parallel seascape focus.
Defining Ecozones and Ecosystems

The Canadian system of ecosystem classification divides the country into twenty major units—fifteen are Terrestrial Ecozones and five are Marine Ecozones (see figure 1). Ecozones are commonly the top level used in Canada. The hierarchy of ecosystems then subdivides into ecoregions, ecodistricts, eosections, ecosites, and ecoelements. The lower levels are more useful for regional through to site level planning, conservation and management purposes.

Since the 1970s, governments, non-government groups (NGO), universities and industry have worked to establish a common, hierarchical ecosystem framework for terrestrial and marine ecosystems in Canada. The underlying principle of the initiative has been a basic commitment and need to think, plan, and act in terms of ecosystems (Wiken and Lawton, 1995). This principle has required people to move away from a reductionist emphasis of placing the sole attention on individual elements that comprise an ecosystem to a perspective that is more comprehensive—a holistic approach.

The ecosystem classification described in this report has been a model for developing similar frameworks in other countries. While work on further refining ecosystem frameworks within Canada has progressed since the 1960’s, the North American Free Trade Agreement (NAFTA) introduced new opportunities to extend the ecosystem framework to the whole continent. Canada, the United States, and Mexico agreed that a continental ecosystem framework would be needed to effectively communicate and report on shared issues. While these three countries recognized their respective jurisdictions, things like transboundary pollution, migratory species, ecosystems and ocean currents do not. To develop the continental ecological framework, the three countries sponsored a collaborative project (EWG, 1996) through the Commission on Environmental Cooperation (CEC).

Tables 1 and 2 which follow list the major characteristics of each ecozone. Terrestrial and marine ecozones are relatively large areas within Canada and the ecosphere. Each ecozone represents a very generalized type of ecosystem. For Canadians, the ecozones have provided a useful function in providing a basis for informing people on the overall diversity and wealth of ecosystems which exist in the country. It is common for the average Canadian to think of Canada in the context of oceans, forests, prairies and the arctic. The ecozones contrastingly go beyond these four settings and portray Canada in the context of twenty major ecosystems—fifteen terrestrial and five marine. This framework of major ecosystems has been successful in organizing information as well as thought.

Like many words, the term ecosystem has a long history. In Canada, the meaning has been significantly influenced by the nation’s early concerns for landscape management and planning. Programs like the Canada Land Inventory and the Northern Land Use Inventory as well as major landmark conferences like the Resources for Tomorrow Conference which started in the early 60s and 70s are examples of initiatives which caused many agencies and individuals to take a much more integrated view of the landscape. This led to the establishment of support organizations such as the Canada Committee on Ecological Land Classification (CCELC), the Canadian Council on Ecological Areas (CCEA) and the Canadian Society for Landscape Ecology and Management (CSLEM). These organizations were extremely innovative and brought many of the hallmark events to landscape ecology thinking in North America.
What influence did all of these programs, conferences and organizations have? Fundamentally, they shaped the Canadian concept of ecosystem. In its simplest form, *ecosystem* became defined as home. Home, unlike the word house conveys the idea that the occupants (people in the case of ourselves/other living creatures in the case of the wildness) are integral parts of the setting. Stan Rowe (1990) in his *Home Place* book and the State of the Environment Report (1991/Introductory chapter) have expounded upon the importance of this notion. We and all other organisms are part of ecosystems and not apart from them. The concept of home therefore includes those who dwell there and everything that they may need or rely on to live.

In a more scientific manner *ecosystem* is defined more rigorously. It is a *unit of nature comprised of organisms (including people), the physical environment (land, water, climate,) and the relationships which exist between them*. With the early development of a landscape ecology focus in Canada, it has become customary to think of *unit of nature* as a physical space(s)—the arctic, the
<table>
<thead>
<tr>
<th>Ecoregion</th>
<th>Landform</th>
<th>Surface materials/coastal features</th>
<th>Climate/oceanographic characteristics</th>
<th>Vegetation/soil productivity</th>
<th>Wildlife (mammals/birds)</th>
<th>Human activities</th>
<th>Main communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic</td>
<td>Continental</td>
<td>Mountains</td>
<td>Ice, snow, cryozone, rock/Cryosols</td>
<td>Extremely cold, dry, continuous permafrost</td>
<td>Mixed evergreen deciduous forest</td>
<td>Poler Bear (along coast), Arctic Tern</td>
<td>Hunting, tourism</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Peary Caribou, Muskox, Wolf, Arctic Hare; Red-seeded Lemn, Brunt, ptarmigan, Greater Snow Goose</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains, hills</td>
<td>Moraine, rock, marine/Cryosols</td>
<td>Very cold, dry, continuous permafrost</td>
<td>Herb-layer tundra</td>
<td>Peary Caribou, Muskox, Wolf, Arctic Hare; Red-seeded Lemn, Brunt, ptarmigan, Greater Snow Goose</td>
<td>Hunting, tourism/recreation, scene mining</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains, hills</td>
<td>Moraine, rock, marine/Cryosols</td>
<td>Cold, dry, continuous permafrost</td>
<td>Sub-boreal tundra</td>
<td>Barnes ground Caribou, Wolf, Grizzly Bear, Peary Fox, Arctic Ground Squirrel, Lemmings, Arctic Loam, ptarmigan, Sacred Owl</td>
<td>Hunting, trapping, tourism/recreation, mineral development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains, some foothills</td>
<td>Organic, moraine, lacustrine/Cryosols, Brunisols</td>
<td>Cold, semi-arid to moist, discontinuous permafrost</td>
<td>Open to closed mixed evergreen deciduous forest</td>
<td>Moose, Woodland Caribou, Wood Bison, Wolf, Black Bear, Red Squirrel, Northern Shrike, Spruce Grouse</td>
<td>Hunting, trapping, tourism/recreation, oil and gas development, marginal agriculture in south</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains, some hills</td>
<td>Glacial Shield rock, moraine/Cryosols, Brunisols</td>
<td>Cold, moist to arid, discontinuous permafrost</td>
<td>Open evergreen deciduous forest, some tundra, open woodland</td>
<td>Moose, Barren-ground Caribou, Wolf, Snowshoe Hare, Red Squirrel, Red-backed Snowshoe, Northern Shrike</td>
<td>Tourism/recreation, some mining, some hunting and trapping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains</td>
<td>Organic, moraine/Cryosols</td>
<td>Cold to mild, semi-arid, discontinuous permafrost</td>
<td>Shrub-bog tundra</td>
<td>Dall's Sheep, Grizzly Caribou, Black Bear, Grizzly Bear, Peregrine Falcon, ptarmigan</td>
<td>Trapping, hunting, mining, tourism/recreation, oil and gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains</td>
<td>Organic, lacustrine/sedimentary</td>
<td>Cold to mild, semi-arid, discontinuous permafrost</td>
<td>Shrub-bog tundra</td>
<td>Woodland Caribou, Moose, Black Bear, martens, Arctic Fox, Canada Goose</td>
<td>Hunting, trapping, recreation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains</td>
<td>Moraine, lacustrine</td>
<td>Cold, moist</td>
<td>Mixed evergreen deciduous forest</td>
<td>Woodland Caribou, Mule Deer, Moose, Black Bear, beaver, Mink, Blue Jay, Bald Eagle, Blue Jay</td>
<td>Forestry, agriculture, tourism/recreation, oil and gas development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains, some hills</td>
<td>Canadian Shield rock, moraine/Cryosols, Brunisols</td>
<td>Cold, moist</td>
<td>Various forest, mixed evergreen deciduous forest</td>
<td>White-tailed Deer, Mule Deer, Black Bear, Canada Lynx, martens, Red Squirrel, Porcupine, Blue Jay</td>
<td>Tourism, mining, tourism/recreation, hunting-trapping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains</td>
<td>Moraine, rock, moraine/Cryosols, Brunisols</td>
<td>Moderately cold, moist</td>
<td>Largely evergreen forest, some tundra, open woodland</td>
<td>Moose, Dall's Sheep, Grizzly Bear, Black Bear, ptarmigan, Spruce Grouse</td>
<td>Tourism, hunting, trapping, forestry, tourism/recreation, mining</td>
</tr>
<tr>
<td>Boreal</td>
<td>Continental</td>
<td>Mountains, some hills</td>
<td>Moraine, moraine, rock/Cryosols, Brunisols</td>
<td>Cold, semi-arid</td>
<td>Various forest, mixed evergreen deciduous forest</td>
<td>Mule Deer, White-tailed Deer, Porcupine, Grizzly Bear, Snowshoe Hare, Sag Grizzly, Burrowing Owl</td>
<td>Agriculture, urbanization, recreation, oil and gas development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains</td>
<td>Moraine, moraine, rock/Cryosols, Brunisols</td>
<td>Cold, semi-arid</td>
<td>Mixed deciduous evergreen forest</td>
<td>White-tailed Deer, Mule Deer, Black Bear, Coyote, Raccoon, Blue Jay, Eastern Bluebird</td>
<td>Forestry, agriculture, fish processing, tourism/recreation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plains</td>
<td>Moraine, moraine, rock/Cryosols, Brunisols</td>
<td>Cool, wet</td>
<td>Mixed deciduous evergreen forest</td>
<td>White-tailed Deer, Mule Deer, Black Bear, Coyote, Raccoon, Blue Jay, Eastern Bluebird</td>
<td>Agriculture, urbanization, tourism/recreation</td>
</tr>
</tbody>
</table>

### Table 1  Some descriptive biophysical characteristics of Canada’s marine and terrestrial ecozones (cont’d)

<table>
<thead>
<tr>
<th>Ecolozone</th>
<th>Landforms</th>
<th>Surface characteristics</th>
<th>Climate/physiography</th>
<th>Vegetation/</th>
<th>Wildlife (mammals/birds)</th>
<th>Humans activities</th>
<th>Main communities</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Marine ecozones</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pacific</td>
<td>Pacific Ocean basin and marine continental shelves; numerous islands</td>
<td>Generally ice-free except for local patch of walruses (catchal)</td>
<td>General surface warming; oceanic currents (hurricanes) with divergence point off the coast; pronounced upwelling in the north; El Niño influence</td>
<td>One of Canada's most productive oceanic areas</td>
<td>Important seasonal migrations of habitat between marine and terrestrial areas; important commercial species include salmon, herring, Pacific Hake; Submarine: Pacific Halibut, Chinook, Dungeness Crab, rockfish and flatfish species.</td>
<td>Fishing, hunting</td>
<td></td>
</tr>
<tr>
<td>Arctic Archipelago</td>
<td>Limited to “shelf-type” depots; high Arctic islands, Arctic and Hudson Bay coastline; much is rocky coastline, numerous channels and straits; high coastal relief in east, low in south and west</td>
<td>Seasonal ice; open water 2-3 months in summer</td>
<td>Relatively high freshwater input along northern continental boundary</td>
<td>Higher productivity and abundance of life than permanent ice area</td>
<td>Intense summer migration into region, generally following the ice edge retreat; locally high concentrations of marine birds and mammals, including Beluga, Walrus, seals; Polar Bear</td>
<td>Oil and gas, limited fishing and hunting</td>
<td></td>
</tr>
<tr>
<td>Arctic Bades</td>
<td>Limited to the most northern polar seas</td>
<td>Mostly permanent pack ice</td>
<td>Affected by capybara while driving a shelfwater and polar geyser in basic ice-lake components</td>
<td>Low biological productivity and diversity</td>
<td>Polar Bear and some subarctic mammals</td>
<td>Few, if any, activities</td>
<td></td>
</tr>
<tr>
<td>Northwest Atlantic</td>
<td>Primarily continental shelf; generally low coastal relief</td>
<td>Seasonal ice area</td>
<td>Labrador Current exerts strong influence both on shelf and offshore (lower-salinity cold water)</td>
<td>Strongly influenced by the Labrador Current and Arctic waters</td>
<td>Subarctic species in north to boreal species in south; important commercial species include oyster, shrimp, snow crab, haddock, tuna, Pollock, American Plaice, codfish, halibut, haddock, herring, mackerel, Capelin, and Atlantic Salmon</td>
<td>Fishing, tourism</td>
<td></td>
</tr>
<tr>
<td>Atlantic</td>
<td>Labrador shelf area; Labrador Banks, Scotian Shelf, as well as the Northwest Atlantic Offshore</td>
<td>Generally ice-free except for local patch of ice in shallow areas of special local importance</td>
<td>Includes mostly complex water masses; mining from the south, Gulf Stream, offshore, and Sargasso Water Currents at the Thiel brook; mixing route between cold, low-salinity water from the north and warmer water from the south</td>
<td>A very productive area for many species</td>
<td>Includes both service and commercial species; important commercial ground fisheries occur on these; important commercial species include cod, haddock, halibut, Pollock, redfish, oyster, herring, and Atlantic Salmon</td>
<td>Fishing, tourism</td>
<td></td>
</tr>
</tbody>
</table>
Table 2  Some quantitative environmental and socioeconomic characteristics of Canada’s terrestrial ecozones

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land</td>
<td>Fresh water</td>
<td>Canada</td>
<td>Urban areas</td>
</tr>
<tr>
<td></td>
<td>Total area (% of Canada)</td>
<td>Area (km²)</td>
<td>% of Canada’s total area</td>
<td>Area (km²)</td>
</tr>
<tr>
<td>Arctic Cordillera</td>
<td>2.5</td>
<td>220,873</td>
<td>2.5</td>
<td>19,717</td>
</tr>
<tr>
<td>Northern Arctic</td>
<td>15.2</td>
<td>1,361,433</td>
<td>13.7</td>
<td>149,447</td>
</tr>
<tr>
<td>Southern Arctic</td>
<td>8.3</td>
<td>773,041</td>
<td>7.8</td>
<td>59,349</td>
</tr>
<tr>
<td>Taiga Plains</td>
<td>6.5</td>
<td>580,139</td>
<td>5.8</td>
<td>66,850</td>
</tr>
<tr>
<td>Taiga Shield</td>
<td>13.7</td>
<td>1,253,877</td>
<td>12.6</td>
<td>212,513</td>
</tr>
<tr>
<td>Taiga Cordillera</td>
<td>2.7</td>
<td>264,980</td>
<td>2.7</td>
<td>392</td>
</tr>
<tr>
<td>Hudson Plains</td>
<td>3.6</td>
<td>353,364</td>
<td>3.5</td>
<td>8,996</td>
</tr>
<tr>
<td>Boreal Plains</td>
<td>7.4</td>
<td>679,969</td>
<td>6.8</td>
<td>57,831</td>
</tr>
<tr>
<td>Boreal Shield</td>
<td>19.5</td>
<td>1,782,252</td>
<td>17.9</td>
<td>164,118</td>
</tr>
<tr>
<td>Boreal Cordillera</td>
<td>4.7</td>
<td>459,880</td>
<td>4.6</td>
<td>4,932</td>
</tr>
<tr>
<td>Pacific Maritime</td>
<td>2.2</td>
<td>205,175</td>
<td>2.1</td>
<td>13,835</td>
</tr>
<tr>
<td>Montana Cordillera</td>
<td>4.9</td>
<td>479,057</td>
<td>4.8</td>
<td>13,053</td>
</tr>
<tr>
<td>Prairies</td>
<td>4.8</td>
<td>469,681</td>
<td>4.7</td>
<td>8,429</td>
</tr>
<tr>
<td>Arctic Maritime</td>
<td>2.0</td>
<td>183,978</td>
<td>1.8</td>
<td>39,775</td>
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<tr>
<td>Mixedwood Plains</td>
<td>2.0</td>
<td>138,421</td>
<td>1.4</td>
<td>56,009</td>
</tr>
<tr>
<td>Canada total</td>
<td>100.0</td>
<td>9,215,435</td>
<td>92.4</td>
<td>755,189</td>
</tr>
</tbody>
</table>

* Marine ecozones are not listed.

Note: Percentages may not add up owing to rounding.
Source: State of the Environment Directorate, Environment Canada.
wetland, the lake, the Carolinian forest, and even urban areas. They are all distinctive places with distinctive sets of characteristics. The structure, functions, and processes associated with the biological and physical characteristics in each place is relatively unique and enduring. Each ecosystem/place is further characterized by relationships (dependencies, interactions, transactions, intra-actions,) which exist between the inherent biological and physical parts or members—these relationships are the cement which makes it possible for the system to hold together on a more or less permanent basis. The presence of permanent and seasonal sea ice in the arctic are, for example, dependent upon the cold arctic climate regime and the patterns of oceans currents. These sea ice and weather conditions are, in turn, important elements in sustaining the habitats which are necessary for species like polar bears as well as for the species upon which the bears prey.

Large order ecosystems in a landscape sense are called ecozones in the Canadian system of classification. Ecozones may be more commonly known by terms such as the Arctic, the Boreal or the Prairies. These units depict areas of the earth's surface where a fairly definitive and enduring mix of abiotic and biotic elements exist. While there is a perception of overall constancy in these ecosystems, it does not mean that there is no change. In the boreal forest ecosystem, forest systems go through cycles that may allow them to mature, burn at any stage, be harvested at maturity or be renewed through natural processes or human intervention. They, however, change within relatively set limits over time and have fairly stable traits. The Prairie ecosystems are characterized, for instance, by many relatively stable factors—grassland type soils, prairie fauna, prairie climatic regimes, prairie cereal grain production, ranching, etc. Human activities here greatly affect how the systems are sustained in a particular condition. The arctic ecosystems, in contrast, are not as widely affected by human activities. The arctic ecosystems like the prairies show a markedly stable set of characteristics over time—factors like frozen soils, frost patterned ground, arctic flora and fauna, arctic climatic regimes, permafrost, etc.

This conceptual way of looking at an ecosystem is not restricted just to relatively large ecozones but applies to ecosystems of any particular size (i.e., ecoregions, ecodistricts, ecosections, ecosites, ecoelements,). The main thing that changes is the precision which is applied to detailing the biophysical characteristics both descriptively and spatially. The overall ecosystem classification system, thus, forms a bridge between macro systems and small systems. The various orders of ecosystems are related in a hierarchy in which a lower order ecosystem is nested within a higher order one. This hierarchy allows us to view Canada's ecosystems from a broad perspective—the ecozones—or at a more detailed sub-unit level or at any level in between. Since each ecosystem consists of a distinctive assemblage of physical and biological characteristics, the responses to or the sustainability of particular human activities, land/sea uses or practices can be broadly determined.

The marine ecosystem units are fairly new in comparison to the terrestrial units. As with the terrestrial ecosystem work, the units and concepts were derived through workshops and discussions held with numerous federal, provincial, NGO and university representatives from across Canada. The marine ecosystem units like the terrestrial ones will undergone further revision and refinement.

**Mapped Information**

Maps are useful as most people have an inherent sense of location. People are familiar with the places where they live and those places they have visited. This sense of comfort often draws individuals to the visual presentation of ecosystems—pictures, diagrams and MAPS. Having a good knowledge about what maps represent is of primary importance. Mapped information can frequently be misleading, unless the assumptions and techniques used to develop
them are understood. For Canada several important items related to Terrestrial and Marine Ecosystems include: the concept of generalization, the nature of map lines, the notion of map units, and the purity or relative homogeneity of mapped areas.

**Ecosystem Generalization in Canada**

Determining zones or regionalizing information is a method of reducing or eliminating details which do not, on the average, hold true over an area. Canada's resource base and features have been regionalized in map form for many purposes. Forest Regions of Canada” (Rowe, 1972) “Geological Provinces of Canada” (Douglas, 1970), “Physiographic Regions of Canada” (Bostock, 1970), “Wetland Regions of Canada” (Wetland Working Group, 1981), “Ecoclimatic Regions of Canada” (Zoltai et al., 1983) “Marine Ecological Classification System” (MEQAG, 1994) and “Ecoregions of Canada” (Wiken, 1993; Crowley, 1967) are just a few of the many examples.

Each map addresses a different purpose and use; each employs its own criteria in deriving and describing mapped areas. For example, “Ecoclimatic Regions of Canada” largely depicts the range of major climatic regimes. To determine the spatial extent of these climatic regimes, key reference sites or mesic soil sites are used. Soils would not be too nutrient rich nor too poor, drainage would not be overly excessive nor impeded, sites would not be too exposed nor too sheltered, and so on. The development of vegetation and soils on these sites would be assessed to see where similar climatic conditions prevail. Mesic sites may, however, not represent the average condition across the landscape and may even be a rare occurrence. In the Hudson Bay Lowland, a mesic site would be rare as much of the plain in subject to high water-tables and other sites like the strandlines (i.e., old beaches) are too dry.

The “Geological Provinces of Canada” addresses another mapping purpose. These provinces delineate distinctive geological units based on the bedrock’s age and general type. One assumption used in mapping is that the earth’s soil cover is ignored. The bedrock may lie several 10s of metres below the earth’s surface. Again, an area such as the Hudson Bay Lowland would, for example, be referenced by the underlying bedrock (e.g., Hudson Platform of flat lying strata) rather than by the organic and marine deposits that cover most of the surface.

Although there is no single and all-useful form of regionalization, most agencies require a system that gives them the greatest flexibility. Operating under the principles of sustainable development, multiple resources use and multiple stakeholders requires an approach that supports a broad spectrum of activities (e.g., forestry, agriculture, wildlife and urbanization). It also needs to be flexible in allowing for changes in scale (i.e., global to local) and time. These were the main factors that were taken into account when the Canada Committee on Ecological Classification developed their system. An ecosystem classification was viewed as a process of delineating and describing ecologically distinctive areas of the earth’s surface (Wiken, 1986/1996; Environmental Conservation Service Task Force, 1981). Each area can be viewed as a relatively discrete ecosystem which has resulted from the mesh and interplay of the geologic, landform, soil, vegetative, climatic, wildlife, water and human factors which may be present. The dominance of any one or a number of these factors varies with the given ecosystem. This holistic approach to classification can be applied incrementally on a scale-related basis from very site-specific ecosystems to very broad ecosystems.

**Map unit boundaries**

The boundary lines shown on maps are clear and of even width. This may imply an equivalent degree of precision exists in how the world’s/country’s ecosystems are separated from each other. Map lines are merely conveniences to approximate the location where changes take place. With ecozones, the changes are associated
with broad sets of biological and physical characteristics.

It is possible to represent map unit boundaries using variable widths of lines. This would be more technically correct but it becomes equally more distracting in communicating some of the core concepts. The real importance of map unit lines is to show that distinctive entities or populations of things exist. The arctic ecosystems are different than the neighbouring boreal ecosystems; the wetland ecosystems are different than the adjacent dry-upland ecosystems. Each ecosystem type requires its own special considerations in relationship to management, planning and sustainable resource use.

At times, the boundary area details can be significant. To accurately delimit the various types of transitions between all ecosystem units and the neighbouring units, the boundaries might be shown as bands of grey, and not necessarily of an even width. The boundaries at the ecozone level may be tens to hundreds of kilometers wide, depending on the particular unit and with which neighbour the transition is taking place. The Taiga Shield Ecozone has a comparatively sharp boundary with its neighbour, the Hudson Plains. In contrast, the boundary with its more northerly map unit, the Southern Arctic, commonly takes place over greater distances.

**Map unit types**

As cartographic tools, map units have certain limitations. The foremost problem is that they are attempting to show a three dimensional object—an ecosystem—on a two dimensional surface. While traditional maps allow you to reasonably represent biophysical characteristics that vary on the horizontal plane they are more cumbersome in illustrating the characteristics which change vertically. Because of this, map units have often been labeled as ‘simple map units’ or as ‘complex map units’. The Hudson’s Bay Ecozone is considered to be a simple map unit as the characteristics of this flat lying unit are fairly uniform in horizontal or vertical dimensions.

With mountainous ecosystems like the Boreal Cordillera Ecozone or the Taiga Cordillera Ecozone, this is not the case. Within these map units, significant variation in biophysical characteristics occur with elevation and indeed with aspect. The lower elevations can be forested ecosystems and the mountain summits can be alpine or snow bound. At times it is extremely difficult to separate these major ecosystem types using a map, so they are treated as a complex map unit. They should be considered as a multiple set of major ecosystems that are enclosed within a particular map unit. They can be, however, like a layered cake which has distinctive layers that occur in a regular pattern. In the Boreal Cordillera Ecozone, for instance, the forested ecosystem predominates the mid and lower elevations and the alpine ecosystems occupy the higher reaches.

The relative type of uniformity that one can expect within a given map unit is partly a function of the type of map unit—simple or complex. The simple map unit demonstrates greater overall uniformity than do complex ones. Complex map units are largely associated with the mountainous terrain of the arctic and the west.

A second limitation of map units is that they do not easily illustrate ecosystem connections and relationships. Ecosystems do not stand in isolation of each other. Climate systems cross ecosystems, water and nutrients flow between ecosystems, animals migrate between ecosystems, and pollution moves from one ecosystem to another. These ties and exchanges are not necessarily just between adjacent ecosystems but they may happen between distant ecosystems. Much of the pollution which affects the arctic comes from Japan or the heartland of Russia.

Because map units are ‘generalizations’, they are not 100% pure. They may contain ‘inclusions’ of other things. The rule of thumb is that 15 % of a unit may be taken-up by biophysical features which are not typical or average. The boreal upland of the Cypress Hills, for example, is...
often considered as an inclusion in the Prairie Ecozone map unit. While inclusions are not considered/shown on one scale, they are usually recaptured on more detailed levels of mapping. The boreal areas of the Cypress Hills typically emerge on the more detailed ecoregions and ecodistricts maps. Inclusions are a minor limitation at one scale of mapping but not necessarily at another.

**Map unit numbers**

Why did the ecozone classification result in 20 map units? For the most part, they are the natural partitions within nature. The prairies are different from arctic, the major oceans are different from the forested and arctic lands. Beyond these over-riding factors, the ease of understanding the character of ecosystems for purposes such as planning and reporting role may play a role. What can conveniently be shown on a map of a given scale before the details become overwhelming? What level of resolution is best for planning? What is the most readily acceptable way of displaying ecosystems to convey an understanding? What can be used to best improve knowledge? All of these items are weighed.

**Defining Criteria For Ecozones**

Conceptually, terrestrial ecozones are “macro-order” ecosystems which possess characteristics which tend to cohere and endure in an area over the long term. While the number and kinds of shared characteristics must obviously be general due to the large size of ecozones, they identify ecosystems with similar kinds of properties. The descriptions of these mapped areas attempt to stress the predominant, the stable and the actual occurrences in that ecozone. Sometimes these are largely ‘natural’ factors but at other times they are related to human activities. These notions, along with the holistic focus, largely govern the criteria for delineating ecozones.

To match the ecozone level of generalization, defining criteria from equivalently thematic classifications are often used as a framework for analysis (see appendix 1). Macro-climatic regimes, major plant formations, major soil orders and first-order subcontinental landforms are examples of elements that would be used from thematic classifications. But instead of just using these elements in isolation, part of the emphasis is on trying to draw connections and relationships between them. The elemental pieces interact as an assemblage to produce the basic character and pattern of the ecosystem unit. Table 1 summarizes some of the biophysical characteristics of the ecozones. Table 2 summarizes the environmental and socio-economic characteristics of the terrestrial ecozones. A more detailed outline of the basic methodology, concepts and techniques is given in various publications (EWG, 1996; Wiken, 1996; ESWG, 1996; Wiken, 1986).

**Ecozone Descriptions**

The following sections highlight the biological, physical and socio-economic characteristics of the ecozones. The first fifteen address the terrestrial ecozones (see figure 2) and the next five (see figure 3) refer to the marine ecozones. The material has been adapted largely from existing studies as noted in the cited literature.
The Terrestrial Ecozones of Canada

Figure 2  Map of Canadian terrestrial ecozones

Legend

<table>
<thead>
<tr>
<th>Terrestrial Ecozone</th>
<th>Legend Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic Cordillera</td>
<td>Map1</td>
</tr>
<tr>
<td>Northern Arctic</td>
<td>Map2</td>
</tr>
<tr>
<td>Southern Arctic</td>
<td>Map3</td>
</tr>
<tr>
<td>Taiga Plains</td>
<td>Map4</td>
</tr>
<tr>
<td>Taiga Shield</td>
<td>Map5</td>
</tr>
<tr>
<td>Taiga Cordillera</td>
<td>Map6</td>
</tr>
<tr>
<td>Hudson Plains</td>
<td>Map7</td>
</tr>
<tr>
<td>Boreal Plains</td>
<td>Map8</td>
</tr>
<tr>
<td>Boreal Shield</td>
<td>Map9</td>
</tr>
<tr>
<td>Boreal Cordillera</td>
<td>Map10</td>
</tr>
<tr>
<td>Pacific Maritime</td>
<td>Map11</td>
</tr>
<tr>
<td>Montane Cordillera</td>
<td>Map12</td>
</tr>
<tr>
<td>Prairies</td>
<td>Map13</td>
</tr>
<tr>
<td>Atlantic Maritime</td>
<td>Map14</td>
</tr>
<tr>
<td>Mixedwood Plains</td>
<td>Map15</td>
</tr>
</tbody>
</table>
The Arctic Cordillera Ecozone features some of the world's most spectacular mountain glacial scenery. Some of Canada's highest but least-known peaks are found here, towering over gaping U-shaped valleys and deep fjords that extend many kilometers inland. A vast mountain chain forms the spine of this ecozone. It runs along the northeastern fringe of the Northwest Territories and Labrador, dominating Labrador, eastern Baffin, and Devon islands and most of Ellesmere and Bylot islands. Because of the extreme cold, high winds, and lack of soil, the higher portions of this ecozone are largely devoid of plants and animals. Ice barrens and frost-shattered rock prevail over much of the landscape. At lower elevations, pockets of tundra meadow dotted with arctic flowers and ground-hugging shrubs occupy sheltered valleys, streambanks and coastlines. During the brief arctic summer, these sites are concentrations of life.

In contrast to the biological impoverishment of the land, the adjacent fjords and nearshore waters are richly endowed with marine life. Complex current systems, localized upwellings of nutrients, and "polynyas" (which remain ice-free year round) create the Arctic's most productive aquatic ecosystems.

Among the animals living here are globally significant populations of Polar Bear, Narwhal Whale, and the endangered Bowhead Whale.

Landforms and climate
The ecozone contains one of Canada's two major mountain chains. The mountains of the Arctic Cordillera span two geological "provinces," each with its own distinctive rock type. The mountains of volcanic rock range in age from 1.2 billion to 65 million years old. The mountains of southeastern Ellesmere and eastern Baffin Island belong to the older Churchill province, which is typified by Canadian Shield rock, a mix of granites, metamorphic gneisses, and ancient sediments. Glacial ice engulfed northern Canada near the beginning of the Pleistocene epoch 2 million years ago. Since then, huge glaciers, far exceeding the depth and extent of present ones, have swept over this landscape at least four times. The main paths of the Pleistocene glaciers are marked by deep U-shaped valleys, which in coastal areas merge with steep-sided fjords that may rise over 1000 meters above the sea. Past and present glaciers have created bowl-like cirque basins, pyramidal peaks called horns, knife-edged ridges or aretes, and other landforms. After being depressed into the Earth's crust by the colossal weight of Pleistocene ice, the landscape is now rising, in places by as much as 30 cm per century. Raised beaches now well back from existing shorelines attest to this continuing process.

The climate is typically harsh, with long, extremely cold winters and short, cool summers, although the brief summer growing season is enhanced by long periods of daylight. Only July and August have mean daily temperatures above the freezing point. Eureka, Canada's coldest and most northerly weather station, has an average annual temperature of -19.7°C and a February mean monthly temperature of -38°C. A typical year sees just 250 mm of precipitation, although it is much higher in Labrador.

Plants
Ice and bald rock dominate 75% of the Arctic Cordillera. For plants and animals, this is one of
the most inhospitable places on earth. To the north, ice caps prevail; to the south, glaciers are more common. Even lichens, which as a group are immensely adaptable, are largely absent from the area. Summer lasts just a few weeks and killing frosts are not unknown throughout the season. The average July temperature is only 5°C. Soils are virtually non-existent over much of the area due to ice cover and the slow rate of soil formation. Moreover, the area receives about the same amount of precipitation as the Sahara desert. What little moisture there is in the soil, or in plants themselves, is liable to be sucked away by fierce arctic winds.

In spite of the generally severe conditions, several hardy plant species flourish where moisture, heat, and nutrients create favourable microhabitats. Isolated pockets of biological productivity can be found in sheltered streambanks and coastlines, south-facing slopes watered by late-melting snow, and fertilized areas near animal dens and bird perching sites.

Arctic plants share several characteristics that help them cope with the extreme conditions. Most grow close to the ground to avoid the chilling and drying effects of summer winds and to ensure protection beneath the snow in winter. Some species grow in dense mats or cushions, where temperatures can be with thick heat-trapping and wind-stopping hairs.

Wildlife

Due mainly to sparse plant life, land mammals are rare in the Arctic Cordillera. Arctic Hare, Arctic Fox, Ermine, and the Collared Lemming are among the few species that live in the region. However, their densities and abundance are generally much lower than in Arctic habitats endowed with more plant cover. In most cases these animals thrive in pockets of higher plant productivity along moist sheltered streams and coastal areas. Also favouring these habitats are the few species of songbirds and shorebirds that come to the far north to breed. Most common are Hoary Redpoll, Little Ringed Plover, and Snow Bunting.

There are few large terrestrial mammals other than muskox, arctic wolf and polar bear associated with this ecozone. For the most part, Polar Bears stay close to the sea, where biological productivity is many times higher than on land. In spring and early summer, Polar Bears take to the water and drifting ice floes in search of Ringed and Bearded Seals, their preferred prey. When the ice breaks up in August, Polar Bears come ashore to feed on mussels, starfish, birds’ eggs, and carrion. Though Polar Bears are usually solitary, a beached Bowhead Whale carcass may attract a group of 40 or more bears.

Besides Polar Bears, seals, and whales, the region’s unusually productive marine waters support large concentrations of seabirds, which congregate by the thousands. The waters surrounding Bylot Island and within Lancaster Sound support huge breeding colonies of Northern Fulmars, Thick-billed Murres, and Black-legged Kittiwakes.
Human activities

Canada’s Arctic Cordillera Ecozone is one of the world’s most sparsely populated areas. The communities of Broughton Island and Clyde River are home to only about 1 000 people (1991). The Inuit, who have occupied the region for 1 000 years or more, form over 80% of the population. They consist of regional groups that share a unique heritage and one language with several dialects.

Arctic communities feature a mixture of traditional and cash economies. Much of the local population depends on subsistence hunting, trapping, and fishing. Residents are also involved in mining, oil and gas development, construction, services, and government activities. Those Inuit employed full-time as wage earners turn to weekend and part-time hunting to supplement their diet with preferred country foods. Some tourism is linked with Bylot Island and Auyuittuq national parks.

Table 3 Statistical Profile: Arctic Cordillera Ecozone

<table>
<thead>
<tr>
<th>Area = 250 590 Km² (2.5% of Canada)</th>
<th>Dominant Landcover Class</th>
<th>% total area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991 Population = 1 047 (0.004% of Canada’s total)</td>
<td>Arctic/Alpine Tundra</td>
<td>4.3</td>
</tr>
<tr>
<td>Parks and reserves (strictly protected areas) = 23.5% of ecozone</td>
<td>Barren Lands</td>
<td>43.6</td>
</tr>
<tr>
<td>Endangered Wildlife Species = 3</td>
<td>Perennial Snow or Ice</td>
<td>52.0</td>
</tr>
<tr>
<td>Threatened Species = 0</td>
<td>Total</td>
<td>99.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond Inlet, N.W.T.</td>
<td>974</td>
<td>Service</td>
<td>31.3</td>
</tr>
<tr>
<td>Clyde River, N.W.T.</td>
<td>565</td>
<td>Public Administration</td>
<td>28.6</td>
</tr>
<tr>
<td>Broughton Island, N.W.T.</td>
<td>461</td>
<td>Wholesale and retail trade</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fishing and hunting</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Finance</td>
<td>3.4</td>
</tr>
</tbody>
</table>
Covering 1.5 million square kilometers, or about one seventh of Canada, the Northern Arctic Ecozone extends over most of the non-mountainous areas of the arctic islands and parts of northeastern Keewatin, western Baffin Island, and northern Quebec. It is among the largest arctic ecosystems in the world. Winters pass in near darkness with the polar night measured in weeks and months rather than hours. Snow may fall any month of the year and usually remains on the ground from September to June. Extremely low temperatures and an average precipitation of about 200 mm per year characterize the climate. When not covered in snow, much of the landscape is typified by barren plains covered in frost-patterned soils and the occasional rock outcrop.

**Landforms and climate**

Much of the Northern Arctic Ecozone consists of low rolling plains covered with soil and rock debris left by glaciers. In these areas, the landscape may be covered by nothing more than frost-patterned soils, broken limestone, and sandstone for hundreds of square kilometers. The area has numerous landscape features more commonly associated with the badlands of the American southwest.

Many coastlines are characterized by wide flat plains that extend up to 10 km inland. Most of these coastal plains were once submerged. Following the retreat of the glaciation, they have rebounded over the past few thousand years, leaving ancient beaches or strandlines far from shore. Some shorelines are closely paralleled by lines of “boulder barricades” pushed there by sea ice carried ashore by strong tides and storm waves.

Broad plateaus (i.e., an elevated plain) are common in the interior area. The plateaus on Brodeur Peninsula and Devon Island are among the most spectacular. They often show deep V-shaped cuts along the edges of their escarpments where past or present streamflows have cut through their sedimentary layers. On some islands, the plateau edges are sheer cliffs of 100s of meters that create inaccessible coastlines. Some cliffs located beside productive marine waters provide protected nesting habitat for colonies of seabirds such as Thick-billed Murres and Northern Fulmars.

Permafrost lies beneath the entire ecozone. Under a thin active soil layer, which freezes in winter and thaws each summer, permafrost may extend downwards for several hundred meters. The constant freezing and thawing creates unstable soils that form cell-like shapes known as “patterned ground.” Summers are short and cold, with mean daily temperatures above freezing only in July and August. Daily winter temperatures average less than -30°C in the coldest area of this ecozone, the northern islands. Snow cover usually lasts from September to June, but it can snow during any month. Annual ecozone precipitation is less than 250 mm except in southeast Baffin and Labrador where it can exceed 500 mm. While the northern islands have the least precipitation of the arctic ecozones, moisture is plentiful — in lakes and rivers, in muskegs and permafrost, in the snow cover, in the permanent ice, and in the Arctic Ocean.

**Plants**

Plant life in the Northern Arctic Ecozone is generally sparse and stunted. Plant colonization is impossible for all but the hardiest of species, due to the exceedingly dry climate, permafrost,
frost-churned and calcareous soils, and gale force winter winds. Not surprisingly, the number of plant species is very low — only about 140 species compared with 3 000 in southern Canada. Moss and lichen, however, seem to thrive in this ecosystem. Over 600 species are found in the Northern Arctic compared with about 500 in the more temperate latitudes.

Although much of this zone is virtually devoid of plants, relatively lush “oases” are found scattered across the landscape. These oases are confined mainly to coastal lowlands, sheltered valleys, and moist, nutrient-rich corridors along streams and rivers. They often support thick hummocky carpets of sedges, mosses, and lichens and are vital to many species of wildlife.

Arctic plants have developed numerous adaptations to this harsh ecosystem. Nearly all species are perennial because too little energy is received for plants to germinate, bloom, and produce seeds during one brief summer. To avoid the chilling arctic winds, most plants are very short. Woody species such as the Arctic Willow assume a ground-hugging form. Others, such as Moss Campion and Yellow Oxytrope, grow in dense cushions or mats that reduce heat loss caused by the wind.

Wildlife

The extreme cold, harsh soils, and limited plant communities of the Northern Arctic Ecozone are reflected in the relatively low diversity and abundance of mammals. Of the approximately 200 species of mammals found in Canada, fewer than 20 occur in the ecozone. There are few insect species and a total absence of reptiles and amphibians.

Muskoxen are found across much of the Northwest Territories portion of the area. They roam the plains and plateaus in small herds or individually during the summer, and in larger family groups in the fall and winter. Peary Caribou, found only on the high arctic islands, are smaller and more pale than the Barren-ground Caribou which inhabit the mainland of the Northwest Territories, Baffin Island, Quebec, and Labrador. Although they lack the spectacular mass migrations of many Barren-ground Caribou herds, most Peary Caribou make seasonal movements of up to several hundred kilometers between arctic islands. Polar Bears also range widely as they journey along coastal areas or follow the sea ice in search of seals.

The only small mammal hardy enough to survive the harsh climate of this region is the Collared Lemming. It seeks protection from frigid temperatures under snow. To the Arctic Fox, Ermine, and birds such as the Gyrfalcon and Snowy Owl, the lemmings are a vital source of food. A reduction in lemming numbers, caused by severe weather or as yet unexplained population cycles, can have a ripple effect in many arctic food chains.

In spring, thousands of migrant birds arrive to breed. Snow Geese, Brant, and Canada Geese nest in moist wetlands that line coastal areas and river valleys. Eider and Oldsquaw Ducks nest beside small ponds.
on grassy tundra. These areas also support large numbers of shorebirds, including the Black-bellied Plover, Ruddy Turnstone, and Red Phalarope. Hoary Redpolls, Horned Larks, and Snow Buntings need very little vegetation cover for nesting and thus can survive in even the most sparse arctic landscape.

**Human activities**

Canada’s Northern Arctic Ecozone is among the least populated areas of the world. The total population, scattered in 20 communities, is only about 15 000 people (1991). Iqaluit is the largest centre, with a population numbering 3 552 in 1991.

The Inuit, who have occupied the area for a thousand years or more, form over 80% of the population. They consist of regional groups that share a unique heritage and one language with several dialects.

Arctic communities feature a mixture of traditional and cash economies. Much of the local population depends on subsistence hunting, trapping, and fishing. However, residents are also involved in mining, oil and gas development, construction, services, and government activities. Those Inuit employed full-time as wage earners turn to weekend and part-time hunting to supplement their diet with preferred meats.

The arctic ecozones, representing Canada’s last natural resource frontier, are rich in mineral and hydrocarbon reserves. Beginning in 1989, the value of metallic mineral production dropped because of weak global markets. Mines are currently operating in the Northern Arctic Ecozone: the base metal Polaris mine on Little Cornwallis Island, and the Nanisivik mine on Baffin Island. Despite their locations, they are among the lowest-cost zinc producers in the world.

The arctic ecozones also have 59% of Canada’s estimated oil resources and 48% of potential gas resources. Yet there has been no substantial development since the 1980s. This is largely due to external factors, such as low crude oil prices and the global recession. Tourism is also significant to the economy, generating $11.8 million for arctic businesses in 1993.
Southern Arctic Ecozone

When the first European visitors confronted Canada’s Arctic, they called it the Barren-lands. This was largely a reflection of the treeless nature of the landscape. For almost a million square kilometers, the Southern Arctic shows a pattern of sprawling shrublands, hills and plains, wet sedge meadows, and cold, clear lakes.

The Northwest Territories portion of the Southern Arctic Ecozone is home to the world’s biggest concentration of free-roaming large mammals. These are Barren-ground Caribou, the so-called “Buffalo of the Tundra.” They began their annual migration cycle through this area soon after the last ice age ended. Evidence of that age is still plainly visible in the glacial etchings and deposits found throughout the region. For thousands of years, abundant large mammals lured hunters from both sides of the treeline. The Dene and Inuit used its rivers — the Thelon, Back, and Coppermine — to reach Caribou, Muskox, and Moose. They came most often in the fall to secure the large supplies of meat necessary to carry them through the winter. Though float-planes are now the main mode of access, the rivers are still used by people from all walks of life to enjoy the beauty and bounty of the frontier.

Landforms and climate

The last glaciers finally retreated from this area about 8 500 years ago. As the 3 km thick ice sheet melted, it released a huge volume of soil and rock debris, which is now strung across the landscape in the form of cigar shaped piles of bouldery moraine (i.e., drumlins), and etched by long eskers extending up to 100 km. Occurring less frequently are outwash aprons of crudely sorted sand and gravel, raised beach ridges along the shores of phantom preglacial lakes, and marine sediments from former sea bottoms. The resulting undulating terrain is studded with innumerable lakes and ponds. Some of these water bodies formed in round shaped “kettle” depressions created when ice blocks, abandoned by the main ice sheet, became engulfed by glacial drift and then melted away. Other lakes occupy the depression between drumlins.

Occasionally emerging through this thick mantle of glacial moraine is the Canadian Shield, which consists mostly of granitic rock. Lakes in the Shield country tend to conform to large fractures and fault line patterns in the rock. They are typically deeper and clearer than lowland lakes. The most recent passage of the glaciers can still be read in these rocks, which often show scour lines in the bedrock carved by rock fragments embedded in the bottom of the advancing ice sheet.

On its journey south, the glacier carved large chunks of rock from weak spots in the Canadian Shield. Dropped a few meters or a few thousand kilometers from their source, these rocks sometimes have little in common with the surrounding bedrock, hence the name “glacial erratic.”

Permafrost occurs continuously throughout the Southern Arctic Ecozone. Lying sometimes just a few centimeters below the surface, it acts as a dam that stops the downward flow of water. Consequently, even though there is little precipitation here, the soils are often waterlogged or frozen. Repeated freezing and thawing of these soils creates interesting features on the surface, including cell-like polygons, bulging hummocks, and bare mud boils where the soil is so active that no plants can take root. Intense
frost heaving often splits apart the underlying bedrock and forces large angular “boulders” to the surface.

Summers are short (about four months), cool, and moist, whereas winters are long and extremely cold. Total annual precipitation is usually less than 250 mm in the west and rarely more than 500 mm in the east.

**Plants**

This ecozone is bounded to the south by the treeline, a broad ecological division between the taiga forest and the treeless arctic tundra. The treeline is not really a clear line but rather an irregular transition zone. Within the zone, small scattered clumps of stunted spruce trees grow on warmer, sheltered sites. They often appear in dense cushions, or krummholz, less than a meter high that help protect them from the worst of winter winds.

Low precipitation and extremely low winter temperatures are among the factors that discourage tree growth in this ecozone. The near continuous blowing of cold, dry winds and the presence of permafrost also restrict plant growth. Low shrubs such as Willow, Shrub Birch, and Labrador Tea are well adapted to these conditions. Where soil is sufficiently developed, these plants form vast shrublands interspersed in lower areas with wet sedge meadows and ponds. On the most exposed sites, low shrubs give way to mats of lichens, mosses, and ground-hugging shrubs such as Mountain Cranberry and Least Willow.

Where hummocks, mud boils, patterned ground, and other permafrost-related features are present, ribbons and circles of vegetation result in response to different amounts of moisture or levels of soil disturbance.

Subtle variations in the distribution, abundance and size of plants in the Southern Arctic Ecozone reflect their sensitivity to small changes in micro-climate. The resulting variety of plants is best appreciated in the autumn when the tundra produces its rich display of reds, oranges, purples, and yellows. Berry picking is also at its best this time of year, when blueberries, cranberries, and bearberries are often found in great abundance.

**Wildlife**

Low biological productivity, a short growing season, and extremely cold, long winters impose severe demands on wildlife in the Southern Arctic. As a result, the number of resident bird and mammal species drops sharply as one moves beyond the trees onto the tundra. Food chains are relatively short and changes in the abundance of one species may profoundly affect another species. For instance, a cold, late spring drastically reduces the nesting success of Canada Geese. This causes trouble for Arctic Fox, which depends heavily on egg predation at this time of year.

Close to a million caribou migrate south each year, including the Bluenose, Bathurst, Beverly, and Qaminirjuak herds in the Northwest Territories, the Porcupine herd of the northern Yukon, and the Leaf River and George River
herds of northern Quebec and Labrador. They move from their summer calving grounds along the northern fringe of the ecozone to their winter range in the taiga forest. During migration, they travel in large groups, often using the many snake-like eskers as natural highways through the tundra.

Flocks of ducks, loons, geese, and swans migrate through the ecozone. Like Caribou, Willow Ptarmigan migrate only as far as the taiga forest to find food and shelter during the winter months. The brief summer sees the hatching of countless billions of insects. The broad silhouette of the Rough-legged Hawk is a familiar sight as it scans the mossy hummocks and shrublands for voles and lemmings.

A limited number of Grizzly Bears can be found in the Northwest Territories portion of the Southern Arctic Ecozone, as can Muskox and other prominent wildlife species. The Barren-ground Black Bear is common throughout Northern Quebec. Moose are also present, particularly along the treeline to the south. Polar Bears roam the coastal areas during the summer and venture onto the growing pack ice as winter sets in.

Human activities

Canada's Southern Arctic Ecozone is one of the most sparsely populated areas of the world. The total population, scattered in 17 communities, numbers only about 10 000 people (1991). Rankin Inlet is the largest centre, with a population in 1991 of 1 706. The Inuit, who have occupied the region for a thousand years or more, form over 80% of the population. They include regional groups sharing a common heritage and one language with several dialects.

Arctic communities feature a mixture of traditional and cash economies. Much of the local population depends on subsistence hunting, trapping, and fishing — activities valued for their contributions to independence, self-esteem, tradition, and a healthy lifestyle. Residents are also involved in mining, oil and gas development, construction, services, and government activities. Those Inuit employed full-time as wage earners turn to weekend and part-time hunting to supplement their diet with preferred meats.

The arctic ecozones, representing Canada's last natural resource frontier, are rich in mineral and hydrocarbon resources. Since 1989, however, the value of total metallic mineral production has fallen due to a weak global markets. The Lupin gold mine is now the only mine operating in the Southern Arctic Ecozone.

The arctic ecozones have 59% of Canada's estimated oil resources and 48% of potential gas resources, but there has been no substantial development since the 1980s. This is largely due to external factors, such as low crude oil prices and the global recession. Tourism is also significant to the economy, generating $11.8 million for arctic businesses in 1993.
### Table 5  Statistical Profile: Southern Arctic Ecozone

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<th>Area = 832,390 km$^2$ (8.3% of Canada)</th>
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The Taiga Plains Ecozone is an area of low-lying plains centred on Canada’s largest river, the Mackenzie, and its many tributaries. Taiga is a Russian word which refers to the northern edge of the boreal coniferous forest. With an area of about 550,000 square kilometers, it is Canada’s sixth largest ecozone. Approximately 90% of the Taiga Plains is located in the western Northwest Territories, with small extensions into northeastern British Columbia and northern Alberta. It is bounded to the east by Great Bear and Great Slave lakes, to the west by the rolling foothills of the Mackenzie Mountains, to the north by the Mackenzie Delta, and to the south by the spruce forest of the Boreal Plains.

The northern reaches of the ecozone feature a rich diversity of plants, birds, and mammals from both the Subarctic and the Arctic. The southern portion is home to the world’s largest Wood Bison herd, contains the only known nesting site of the endangered Whooping Crane, and encompasses the sprawling Peace-Athabasca Delta, a wetland habitat of global significance.

Settlement of the Taiga Plains began around 11,000 years ago, near the end of the last ice age. At this time the Paleo-Indian people began moving through an ice-free corridor that stretched down the Mackenzie Valley to the Peace-Athabaska area of western Alberta. Over the past 300 years, the area has played a major role in the northern fur trade, development of frontier oil and gas resources, and provision of a major water transportation route through northwestern Canada.

**Landforms and climate**

A northern extension of the flat interior plains that dominate the Prairie provinces, the Taiga Plains feature typically subdued relief consisting of broad lowlands and plateaus. The nearly level to gently rolling plains are occasionally interrupted by some of the large river valleys, which can be hundreds of meters deep.

Underlying these landforms are horizontal beds of sedimentary rock consisting of various combinations and ages of limestone, shale, sandstone, and conglomerates. Many of the limestone deposits contain clearly visible fossils of marine creatures that lived here hundreds of millions of years ago. Trapped in isolated pockets and cracks within the sedimentary layers are rich natural reservoirs of oil and gas, created from the carbon residues of early life forms.

Several waves of glaciers over the region have left behind deposits of sand, gravel, and boulders. These glacial moraine areas predominate and occur in various forms and thicknesses, such as the elongated ridges called drumlins and undulating and low-relief hills. Alluvial deposits are common along major rivers and the braided networks of abandoned stream beds. Large wetlands and muskeg dominate the lowest areas. The organic soils found in the eskers of this ecozone are generally shallow, highly acidic, and nutrient-poor. The mineral soils are also poorly developed and often frozen.

The Taiga Plains Ecozone contains most of the Northwest Territories’ two “Great Lakes”, Great Slave and Great Bear, which were carved by glaciers along the western margin of the Canadian Shield. Numerous smaller lakes dot the broad floodplains of the ecozone, which is crisscrossed with patterns of former meandering channels and crescent-shaped oxbow lakes. Other signs of the dynamic power of large rivers
include steep, fast-eroding riverbanks and ice-scoured shores.

The ecozone experiences considerable variation in daylight over the course of a year. Areas north of the Arctic Circle endure at least one day in which the sun never rises and at least one in which it never sets.

The subarctic climate is characterized by short, cool summers and long, cold winters. The mean annual temperature ranges from -10°C in the Mackenzie Delta region to -1°C in Alberta and British Columbia. From north to south the mean summer temperature ranges from 6.5°C to 14°C. The mean winter temperature ranges from -26°C in the north to -15°C in the south of the ecozone. Precipitation is low to moderate, averaging 250 to 500 mm a year across much of the ecozone. Snow and freshwater ice-cover persist for six to eight months annually.

**Plants**

Permafrost, where present, detracts from the soil's productivity by chilling it and creating waterlogged conditions in the thawed “active layer” near the surface. Taiga Plains plant communities are relatively simple, dominated by a few species well-adapted to poor soil conditions and the harsh subarctic climate.

Tree species of the northern taiga forest include Black Spruce, White Spruce, Jack Pine, Tamarack, Paper Birch, Trembling Aspen, and Balsam Poplar. Though less frequent, White Spruce and Balsam Poplar may grow to an impressive height and girth on the nutrient-enriched alluvial flats bordering rivers, rivaling the largest of trees found elsewhere in Canada. Willow and alder shrubs also flourish in this habitat.

Low shrubs are abundant throughout this ecozone and include many species of heather, such as Labrador Tea and Leatherleaf, plus a wide array of berry-producing species, including Cranberries, Currants, and Blueberries. Lichens and mosses dominate the ground cover, often forming a thick continuous carpet. Wetlands feature various sedges and mosses.

Forest fires that destroy several thousand hectares of trees are not uncommon in this ecozone. On average, 1% of the Northwest Territories' forests burn every year. Many taiga plant species benefit from the regular cycle of fires, which can purge old, stagnant forests of insects and disease. The distinctive mosaic of forest types created by fires usually results in a boost to the overall productivity and diversity of habitats available to wildlife.

**Wildlife**

The islands and flood-enriched shores of the Mackenzie, Liard, and Slave rivers are favourite habitats for many wildlife species, including Moose. In summer, Moose feed mostly on aquatic vegetation in shallow waters. In winter, they browse heavily on shoreline willows, leaving behind abundant signs in the snow in the form of tracks, trails, droppings, and shed antlers.

Barren-ground Caribou from the Porcupine Herd overwinter in the northwest corner of this ecozone, while scattered groups of Woodland Caribou are found throughout the area during all
seasons. Other common mammal species include Wolf, Red Fox, Snowshoe Hare, Lynx, Black Bear, Marten, Mink, Ermine, Wolverine, River Otter, Porcupine, Muskrat, Red Squirrel, Beaver, and Northern Red-backed Vole. Two thirds of the 3 000 Wood Bison in Canada range freely in the Mackenzie Bison Sanctuary along the eastern shore of Great Slave Lake.

Common bird species that breed here during the brief spring and summer include the Red-throated Loon (in the northernmost part), Ring-necked Duck, Greater Scaup, Canvasback, Sharp-tailed Grouse, Hawk Owl, Northern Shrike, and Fox Sparrow. During this time of year, fish-eating raptors such as the Bald Eagle, Peregrine Falcon, and Osprey are familiar sights as they soar above the shorelines. Hundreds of thousands of Ducks, Geese, and Swans use the region’s many lakes, rivers, and wetlands as staging or nesting areas. The Mackenzie Valley forms one of North America’s better-traveled migratory corridors for waterfowl breeding along the arctic coast.

Year-round bird species adapted to long, cold winters include the Common Raven, Sharp-tailed Grouse, Gray Jay, Common Redpoll, and Willow Ptarmigan. High insect populations make the ecozone a welcome breeding habitat for insect-eating forest birds and other insect eaters.

Lake Trout, Lake and Mountain Whitefish, Arctic Cisco, Longnose Sucker, Arctic Grayling, Dolly Varden, Burbot, Walleye, and Northern Pike are among the many fish species able to thrive in the Taiga Plain’s cold, nutrient-poor lakes and rivers.

Human activities

The sparse human population of 22 000 is 60% aboriginal. Water access dictated the location of most communities in the Taiga Plains Ecozone. As a result, many are found in ecologically rich valleys and estuaries. Even the largest towns, such as Fort Nelson in British Columbia (3 804 residents) and Inuvik in the Northwest Territories (3 178), are immediately adjacent to vast tracts of pristine land. The few all-weather roads reach every community with a population over 1 000 persons, such as Hay River, Fort Smith, and Fort Simpson, all in the Northwest Territories.

Relatively few areas in the Taiga Plains are dominated by human activity. Much of the local economy is based on subsistence hunting, trapping, and fishing. However, the economy does include a small number of industrial activities such as mining, petroleum extraction, and, in recent years, forestry.

Fossil fuel reserves in the Mackenzie Valley are currently being exploited at the Pointed Mountain and Kotaneelee gas fields, located on the Liard Plateau, and at the Norman Wells oil field, which is Canada’s fourth-largest producer.

Table 6 Statistical Profile: Taiga Plains Ecozone

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<td>Wholesale and retail trade</td>
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Taiga Shield Ecozone

The Taiga Shield Ecozone stretches across part of Canada’s subarctic north. This is the Athapaskan “land of little sticks” that stretches from Labrador to Alaska and from Siberia to Scandinavia. In northern Canada, much of this forest rests on the Canadian Shield, the bedrock heart of the continent. With an area of over 1.3 million square kilometers, the Taiga Shield is one of Canada’s largest ecozones. One-third of it lies in the Northwest Territories.

The unique natural history of this area includes bald Precambrian bedrock that dates back to the planet’s earliest days. Dotting the ancient landscape are millions of lakes and wetlands that were carved by successive waves of glacial erosion or which conform to natural depression in the bedrock. The Taiga Shield is an ecological crossroads where climates, soils, plants, birds, and mammals from two worlds — the Boreal and the Arctic — meet.

In the Northwest Territories, settlement of the ecozone began over 7 000 years ago as the Paleo-Indians followed Barren-ground Caribou northwards in the wake of receding glaciers. More recently, this area has played a major part in the story of Canada’s development due to its pivotal role in the northern fur trade, its concentration of rich mineral resources, and its position as a cultural and political focal point for today’s Aboriginal peoples, the Dene and the Inuit.

Landforms and climate

The Canadian Shield’s massive rolling hills of ancient bedrock cover almost two-thirds of Canada. As monolithic as the Shield may seem, it is actually made up of seven distinct geological “provinces.” The world’s oldest rocks are found on the Taiga Shield in the Slave Geological Province north of Great Slave Lake. They were formed near the dawn of the Earth’s geological history 4 billion years ago.

During the Precambrian Era, Shield rocks were warped, folded, and faulted by violent spasms in the Earth’s crust. Since their birth, relentless weathering and erosion from countless rainstorms, rivers, floods, and the annual freezing and thawing cycle have worn down the rocks. In places, the Shield was repeatedly plucked and scoured by the advance of glaciers, leaving areas now frequently infilled as lakes. Elsewhere it was blanketed by boulders, gravel, and sand released by glaciers in retreat.

This story of geological creation and change is plainly recorded in exposed bedrock and surface deposits of the Taiga Shield. Volcanic rocks testify to the earliest eruptions of lava that created the Earth’s crust as we know it. Some of these eruptions occurred under extreme water pressure at the bottom of ancient seas, creating globular “pillows” of lava. Vast areas of granite, once buried deep beneath the rock surface, reveal the power of billions of years of erosion. And the passage of glaciers can be read by recognizing the striations and grooves etched in the rocks. Soils are usually shallow and coarse and sometimes laced with patterns caused by the presence of permafrost.

The Taiga Shield Ecozone experiences considerable variation in daylight over the course of a year. Areas north of the Arctic Circle endure at least one day in which the sun never rises and at least one in which it never sets.

The subarctic climate is characterized by short, cool summers and long, cold winters.
Precipitation is low to moderate, averaging 250 to 500 mm a year across much of the ecozone. On the Labrador coast, it ranges up to 1,000 mm annually. Snow and freshwater ice-cover persist for six to eight months. Dams and diversions have changed seasonal patterns of flow on several rivers in the eastern Taiga Shield.

**Plants**

Cool temperatures, a short growing season, frequent forest fires, and thin, acidic soils covering permafrost are among the many challenges faced by plants in this ecozone. The open, stunted forests of the Taiga Shield are dominated by a few highly adaptable tree species such as Black Spruce and Jack Pine. These forests are mixed with innumerable bogs and other wetlands, scattered stands of Paper Birch and Trembling Aspen, and bare rock outcrops dominated by lichens and ground-hugging shrubs.

Forest fires add to the distinctiveness of the Taiga Shield by creating conditions favorable for plant communities that vary widely in species composition and age. Although fire often destroys large areas of forest and occasionally threatens human activities or property, it also has a renewing effect on the landscape by triggering new growth, purging forests of insect pests and disease, and increasing the variety of habitats available to wildlife.

Permafrost is another major influence, especially in low areas where the soggy ground or active layer above the permafrost regularly freezes and thaws. As trees grow in these ever-shifting soils, they often tip in random directions.

**Wildlife**

One of the most spectacular wildlife displays in the Taiga Shield is the return of ducks, loons, geese, and swans during the spring migration. The area's abundant water attracts hundreds of thousands of birds, which come to nest or simply feed and rest before journeying farther north to arctic breeding grounds.

As an ecological crossroads between two very different ecosystems — the boreal and the arctic — the ecozone offers a relatively wide variety of habitats for birds. Lakes, wetlands, and forests are interwoven with open shrublands and sedge meadows more typical of the tundra. At the southern limit of their summer range are such species as the Arctic Tern, while a host of other water birds, including the Common Tern and White-throated Sparrow, reach their northern limit on the Taiga Shield.

Among the mammals of the ecozone are Barren-ground Caribou, which migrate south from the tundra to their winter range in the taiga forest. Close to a million Caribou from the Bathurst, Beverly, and Qaminirjuaq herds in the Northwest Territories, and the Leaf River and George River herds of northern Quebec and Labrador, make this journey each fall and return to calve on the tundra each spring.

Mice, Voles, Shrews, Weasels, Canids, and other carnivores, plus all the tundra dwellers such as the Grizzly Bear and Arctic Fox, make regular visits to the trees of the Taiga Shield. In all, there are about 50 species of mammals inhabiting the ecozone. The
ecozone’s waters, meanwhile, are home to Lake Trout, Lake Whitefish, Arctic Grayling, Burbot, and Northern Pike.

**Human activities**

The human population of about 340,000 persons is 60% aboriginal, divided into Algonquian-speakers in most of the ecozone and Athapaskan-speakers in the western portion. The population is concentrated in a few permanent settlements, the location of which largely reflects the history of recent colonization.

Coastal settlements were established in the eastern Taiga Shield during the fur trade and whaling eras. The location of more recent communities, including Yellowknife in the Northwest Territories, Uranium City in Saskatchewan, and Churchill Falls and Labrador City in Labrador, reflects the location of ore bodies or hydro-electric potential. Even the largest towns, such as Yellowknife (15,179 persons) and Labrador City (11,390 persons), are surrounded by wilderness. There are few all-weather roads, but they reach every community with at least 1,000 persons. In the Quebec portion of the ecozone, several thousand kilometers of roads for logging, mining, and other uses have been built in recent decades.

The economy combines a small number of industrial activities. Two of Canada’s three largest hydro developments are found in the ecozone. The economic importance of mining to the economy of the Taiga Shield is significant. In 1991 diamonds were discovered in the Slave Geological Province in the Northwest Territories. Uranium mining is conducted in northern Saskatchewan, gold is extracted near Yellowknife, and iron is mined in Quebec and Labrador. In 1995, vast deposits of nickel, copper and other metals were discovered at Voisey’s Bay, near Nain in Labrador. Despite urbanization, subsistence hunting, trapping, and fishing are still practised widely.

**Table 7  Statistical Profile: Taiga Shield Ecozone**

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The Taiga Cordillera Ecozone is well known for its mountain peaks, rivers slicing between sheer rock walls, broad uplands dominated by alpine and arctic shrubs and flowers, plus vast wetlands and spruce-lined valleys that support many kinds of wildlife. This land hosts some of Canada’s largest waterfalls, deepest canyons, and wildest rivers.

Straddling the Yukon-Northwest Territories border, this ecozone contains the northernmost arc of the Rocky Mountain chain. To the northwest are expansive wetlands and rolling hills that stretch to the Beaufort coast. Treeless arctic tundra dominates its northern reaches and gives way to a mix of alpine tundra and lowland forests farther south. “Cordillera” refers to the series of mountain ranges and valleys that form this ecozone’s rugged interior. Here the mark of forces that create and destroy mountains can be clearly seen in the record of the rocks.

The diverse habitats, from valley bottoms to mountain tops, support a wide range of mammals, including two kinds of caribou and bears. The birds that nest here include a mixture of species typical of the Arctic and Subarctic, as well as eastern and western Canada.

The earliest human inhabitants of this area migrated across the Bering land bridge during the decline of the last ice age about 12,000 years ago. An ice-free corridor paralleling the Mackenzie Mountains allowed early colonization by the Athapaskan ancestors of today’s Slavey, Mountain Dene, and Gwich’in peoples. Industrial developments related to this area’s rich oil, gas, and mineral reserves are few, and the northwestern rim of the country remains a vast wilderness area.
the high plateaus and mountains; and the simple action of gravity, which caused mountains to gradually collapse. Some of the most unusual landscapes are, however, now near the Beaufort Sea. These areas escaped glacial scour.

The cyclic freezing and thawing action of permafrost-rich soils enhances these processes of disintegration. The resulting polygon and stripe-like patterns often seen in alpine areas attest to the dynamic state of this ecosystem.

The climate is extremely cold and humid, with long, dark winters and short, cool summers. Precipitation is low to moderate, averaging from 250 to 300 mm a year across much of the ecozone. Snow and freshwater ice-cover persist for six to eight months annually.

**Plants**

The types of plants in this ecozone and the lushness of their growth are strongly influenced by their position on mountain slopes, which determines the amount of available soil moisture and sunlight. Western slopes often have more luxuriant plant cover than eastern ones, since clouds deposit most of their moisture on western slopes before continuing east. Similarly, northern and southern mountain slopes show pronounced differences in plant growth because of differences in the amount of sunlight they receive. South-facing slopes tend to be warmer and drier, conditions that favour soil nutrient release and plant growth common in more temperate climates. Plants on north-facing slopes typically include species better adapted to cold climates.

Four main vegetation zones are found in this ecozone. Extensive areas of alpine tundra occur on the upland plateaus and highest mountain slopes. Here, scattered among lichens, sedges, and mosses are species that typically possess very large flowers relative to the rest of the plant. Their function is to attract insect pollinators during the short growing season.

Further downslope is the subalpine transition zone, which is dominated by scattered Alpine Fir trees and a dense understory of Willow and Shrub Birch. White and Black Spruce replace firs in the lower parts of this zone. Below the subalpine zone on the lower flanks of the mountains is the montane zone, characterized by spruce-lichen woodlands and flat benches of Lodgepole Pine. Isolated stands of deciduous trees such as Trembling Aspen and Paper Birch are found here, growing in the aftermath of forest fires.

In the lowland zone, sheltered conditions, abundant moisture and relatively well-developed soils promote the growth of dense spruce-feathermoss forests and riverside communities of Balsam Poplar, Willow, and Alder. Marshes and other productive wetlands are also common in this zone, particularly along flat river valleys. Wetlands reach their greatest extent in the Old Crow Flats, a vast plain of wetlands and lakes. Many of the lakes take on a natural square like form.

**Wildlife**

Because of its diversity of habitats, from dense spruce forests to arctic tundra, from alpine
mountain peaks to marshy flats, the Taiga Cordillera Ecozone includes a wide array of wildlife species representative of both arctic and temperate climates.

Mammals most common in alpine terrain include the American Pika, Hoary Marmot, Grizzly Bear, and Dall's Sheep. Mountain Goats, which are not really goats at all but members of the antelope family, are found on mountains in southern regions. During the spring and summer, alpine habitats are populated with several tundra-adapted birds, such as the White-tailed Ptarmigan, Horned Lark, and Water Pipit.

Woodland Caribou, Lynx, Marten, and Black Bear are common mammals of the lower forested habitats. Common birds in this zone include the White-winged Crossbill, Varied Thrush, and Gray Jay. River and wetland habitats support several waterfowl species, including Canvasback, Common Golden-eye, Mallard, and the rare Trumpeter Swan.

The Yukon's Old Crow Flats represent only a small part of this ecozone, yet it is a large and notable wetland that has received international recognition. Swans, Canada Geese, and other species nest or stage here each year in the tens of thousands. Another wildlife spectacle is the annual migration of the Porcupine Barren-ground Caribou, a herd of more than 150,000 animals that winters in the northwestern woodlands.

Evidence of this ecozone's wild and unspoiled character is Canada's largest concentration of Wolverines, a species that has been called a true wilderness creature. Like other members of the weasel family, this solitary nomad is curious, bold, and strong. It will fiercely defend its food against the attack of animals many times its size. Renowned for evading traps and robbing the most carefully protected caches of food, the Wolverine plays a leading role in the camp-fire tales of this region.

**Human activities**

The Taiga Cordillera is a sparsely populated ecozone and home to the Vuntut Gwich'in people. The total population consists of 300 people, 256 of whom reside in the settlement of Old Crow, the Yukon's most northerly community. Much of the area remains essentially untouched wilderness. Subsistence hunting, trapping, and fishing dominate much of the local economy. The Northern Yukon Park and the area's spectacular scenery makes this ecozone attractive to tourists from around the world.

**Table 8 Statistical Profile: Taiga Cordillera Ecozone**

<table>
<thead>
<tr>
<th>Area = 264 840Km² (2.7% of Canada)</th>
<th>Dominant Landcover Class</th>
<th>% total area</th>
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<tr>
<td>1991 Population = 309 (0.001% of Canada’s total)</td>
<td>Arctic/Alpine Tundra</td>
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<tr>
<td>Parks and reserves (strictly protected areas) = 5.3% of ecozone</td>
<td>Barren Lands</td>
<td>27.3</td>
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<td>Endangered Wildlife Species = 1</td>
<td>Forest (Coniferous)</td>
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<td>Forest (Transitional)</td>
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<td></td>
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<td>Wholesale and retail trade</td>
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</table>
Hudson Plains Ecozone

Canada has approximately 25% of the world's wetlands. The Hudson Plain alone embraces the bulk of this figure. Some say it is the largest coextensive wetland on the planet.

For the early explorers and fur traders, the Hudson Plain Ecozone acted as a gateway to the interior of central Canada. The area has been associated with the early wars between England and France and with the harshness of pioneering days. Its sense of prominence is largely tied to historical events. Today, it gains much of its recognition from the profile of Polar Bear Provincial Park.

Most of the ecozone lies in northern Ontario but it reaches into Manitoba and, to a lesser extent, Quebec. It occupies about a quarter of Ontario and 4% of Canada, covering 369,000 square kilometers of land and 11,800 square kilometers of water. About 10,000 people live there, representing just 0.04% of Canada's population. The density is 2.7 people per 100 square kilometers, whereas the Boreal Shield to the south has 155 per 100 square kilometers. Only the Taiga Cordillera and the Arctic Cordillera ecozones have fewer people. Fewer than 10% reside in urban areas.

Overall, the Hudson Plain is poorly drained, flat and dominated by extensive wetlands. The greenery of the plains is marked by a series of arcing and evenly-spaced white lines. These belts of raised beaches show the steady progress of rebounding from the weight of the ice sheet that covered the area thousands of years ago. They present striking patterns of successive ridges alternating with bogs and swamps. A cold and long subarctic winter prevails for much of the year. Rising temperatures and melting ice in the summer make fog common on the coast. The short cool summers provide a brief window for the thousands of migratory birds that make their home on the plains.

The wetlands and fog brought early notoriety to this area. For the people in the coastal fortifications established by the Hudson's Bay Company, the long bitter winters were considered generally insufferable. Summers brought little relief. They summarized the warm season by calling the place an insect-infested landscape of bog and fog.

Landforms and climate

Few areas in Canada are comprised of extensive plains. Only parts of the central prairies and Northwest Territories are comparable. Churchill in northern Manitoba represents the approximate western edge of the Hudson Plain and it extends about 1,300 kilometers east to just beyond Fort Rupert in Quebec. To the north, the plains shoulder the waters of Hudson Bay and James Bay. From this coastline, the plain arcs south for 200 to 300 kilometers to Gillam, Mba., and close to Kapuskasing, Ont. Rising slowly from sea level, this flat lowland reaches an average elevation of just 120 meters.

The mineral soils that cover much of the area are finely-textured silt and clay deposited by both marine and glacial processes. Outcrops of the underlying sandstone and shale are rare. During the last ice age, the weight of the glaciers depressed the Hudson Bay region and the ocean waters later flooded areas up to 300 kilometers inland from the current coastline. During the retreat of the massive continental ice sheets, drainage into Hudson Bay was blocked and
expansive lakes — Agassiz and Ojibway — were formed along the margins of the retreating ice. Seven thousand years later, the area is still rising. This has led to the development of the striking stripe-like features marking a succession of beach ridges. The lines, often composed of sandy material, radiate like ripples from the present-day coast, marking different stages of the rebound.

Since glaciation, the flat terrain, impervious soil and poor drainage have promoted the development of wetlands throughout the plains. Web-like or polygon patterns in organic soils are typical of northern wetlands. The widespread permafrost and ground ice also contribute to poor surface drainage and the slow rate of decay. Frozen organic soils predominate, while partly decayed organic soils are more common in southern parts and moderately weathered mineral soils are restricted to the warmer and drier locations, such as the beach ridges. Rivers and streams generally flow north-easterly to the coast and most have headwaters in the Boreal Shield ecozone to the south.

Major rivers include the Nelson and Hayes in Manitoba, the Severn, Winisk, Albany and Abitibi in Ontario, and the Eastmain and La Grande in Quebec. These rivers follow fairly long and straight routes. Flow varies dramatically over the course of the year and is virtually non-existent between September and January. In late summer, the channels may contain pools and stretches of trapped water, and spring floods can push water levels 10 to 15 meters higher than usual.

The narrow river valleys often provide the only areas of marked relief from the plains. These major rivers are fed by streams with gentle gradients and sluggish flows. Small, shallow ponds and lakes are numerous and dot the landscape in a leopard-like pattern. Ocean tides are weak and the currents flow counterclockwise around the bay.

Hudson Bay moderates the temperature of the lowlands during summer but the effect diminishes in winter when the bay is ice-covered. Cold, dry arctic air typically lingers over the area throughout winter. With little marked relief, the temperature and precipitation correlate closely with latitude.

Temperatures throughout the year tend to be colder near the coast and warmer inland.

Summers are cool and brief. The average mean daily temperature in July ranges from 12°C to 16°C and in January it hovers around -25°C to -23°C. Frost free periods are shortest (about 70 days) on the coast and longest (80 days) along the southern margin. The average growing season ranges from 500 to 1 000 growing degree days above 5°C. Average annual precipitation is approximately 500 mm to 700 mm per year, and is lowest in the north. Rainfall peaks in the month of July at about 100 mm. Of this precipitation, snow accounts for very little; snowfall may be in the 2 000 mm range, half that of the Great Lakes area. The mean maximum depth of snow averages less than 1 000 mm. The spring break-up on major rivers tends to occur in late April or early May and ice jams can raise river levels by 7 to 10 meters.
Plants

Plant species in the Hudson Plain follow latitudinal and soil drainage patterns. Where the boreal forests and the tundra merge in the lowlands, vegetation resembles that of the arctic tundra and to a larger degree the taiga transitional forests. Trees here are few and far between.

The treeless areas extend about 30 kilometers south from the coast but stands of trees can penetrate further north where sites are sheltered or better drainage and deeper soil are available. Arctic tundra can be divided into low and high types. This area is largely representative of the low arctic. Wet areas are dominated by tussocks of sedge, Cottongrass and Sphagnum Moss. Dwarf Birch and Willow shrubs are also common. On drier sites, shrubby and the low-lying Lapland Rosebay, Crowberry, Blueberry and Cloudberry take hold. Herbs such as Arctic Aven, Purple and Prickly Saxifrage, and Lousewort are also found.

South of the tundra is a transition zone known as the taiga. In the lowlands, it can be fairly narrow or up to tens of kilometers wide. Open stands of White Spruce dominate drier areas, while low stands of Willow, Black Spruce and Tamarack are common on wetter and more exposed sites.

The low taiga areas are similar to the high boreal forests. The basic components are boreal in nature but growth and productivity are low and forest stands tend to be more open. White Spruce, Black Spruce, Larch, Balsam and Poplar are the most common trees and Willow and Dwarf Birch are typical shrubs. White spruce in association with Reindeer Moss, Caribou Lichen and Crowberry cover the better-drained and elevated areas.

Wildlife

Summer on the Hudson Plain sees the greatest numbers and variety of wildlife. It is associated with the nesting and rearing stages of millions of Snow Geese, which migrate to Canadian wetlands from areas as far south as the Gulf of Mexico. Other migratory bird species returning to these lowlands include Canada Goose, Black Duck, Oldsquaw, King Eider, Pintail and Whistling Swan. While fewer in number, upland bird species such as Willow Ptarmigan, Spruce Grouse, Snow Owl, and Raven can also be found and are among the few year-round residents. Osprey, Gyrfalcon, Duck Hawk and Peregrine Falcon are birds of prey reported in the area. Small mammals include Muskrat, Ermine, Weasel, Marten and Wolverine. Large mammals have traditionally been more abundant in the interior Shield country to the south, but Woodland Caribou, Moose, Black Bear and Timber Wolves are not unknown. Other species include the Canada Lynx, Snowshoe Hare, and Striped Skunk. Closer to the coast are such species as Polar Bear, which ventures onto the sea ice in winter, and Arctic Fox. Marine mammals include Walrus, Bearded, Ringed and Harbour seals, along with Beluga Whale and the rare Bowhead whales.

Famous in many arctic areas are the clouds of insects. In summer the abundant and poorly drained wetlands provide the ideal breeding ground for massive numbers of mosquitoes and other biting insects. An area of one hectare can produce more than 10 million mosquitoes. Black Fly and No-see-um are other pests to humans and wildlife.

The common fish found in inland streams and lakes are Brook Trout, Northern Pike and Walleye. Some, including the Brook Trout, are migratory, wintering in the interior lakes and summering in the river mouths and estuaries of Hudson Bay.

Human activities

Human activities have strong historical roots in the Hudson Plain. The ill-fated expedition of Henry Hudson, who was set adrift by his mutinous crew in 1611, left the legacy for most of the names on today’s maps. Later, interest in fur drew other English and French explorers to this area. In the late 1600s, the Hudson’s Bay Company erected a series of forts along the bay.
at the Albany, Rupert, Moose and Hayes rivers and, later in the early 1700s, on the Churchill River. These posts were the early gateways to the riches of central Ontario, Manitoba, Saskatchewan and the Northwest Territories.

To people that lived in the forts, the surrounding lowlands were dubbed the “land of bog and fog” or the “insect-infested swamp.” Further to the south, the lowlands were bordered by an area of “little else than rocks with innumerable lakes.” They regarded the area as a “food desert” because many of the initial settlers found food supplies difficult to find. By European standards, it was a harsh and testing environment. In many respects, the fur trade brought European and aboriginal cultures together and for years it was a prosperous venture. Unfortunately, fierce competition for furs between the North West Company from lower Canada and the Hudson’s Bay Company eventually strained the native economy, affecting subsistence and commercial activities.

Today, the settlements of Churchill and Moosonee are perhaps the most recognized in the ecozone; each lies at the end of a railway line. Fort George, Eastmain, Fort Albany, Attawapiskat, Lake River, Winisk, Fort Severn and Shamattawa are less well known. Except for these largely coastal villages, the area is almost unpopulated, home to only 10 000 residents. While the ecozone is ecologically diverse, it is not well-endowed with timber and minerals. Instead, tourism, fishing, hunting, and trapping provide the main economic base. Polar Bear Provincial Park draws many tourists. The varied wildlife, contrasting landscapes, ocean coasts and scenic rivers of the area have become popular attractions.

Table 9  Statistical Profile: Hudson Plains Ecozone

<table>
<thead>
<tr>
<th>Area = 362,360 Km² (3.6% of Canada)</th>
<th>Dominant Landcover Class</th>
<th>% total area</th>
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<td>1991 Population = 9,938 (0.04% of Canada’s total)</td>
<td>Arctic/Alpine Tundra</td>
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<tr>
<td>Parks and reserves (strictly protected areas) = 7.8% of ecozone</td>
<td>Barron Lands</td>
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<tr>
<td>Endangered Wildlife Species = 2</td>
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<tr>
<td>Threatened Species = 1</td>
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<td>Forest (Deciduous)</td>
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<td>Total</td>
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<tr>
<td></td>
<td></td>
<td>Transportation</td>
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</table>
Boreal Plains Ecozone

The Boreal Plains Ecozone is part of the flat Interior Plains of Canada, a northern extension of the Great Plains of North America. The subdued relief consists of low-lying valleys and plains stretching across the mid portions of Manitoba and Saskatchewan, and continuing through almost two-thirds of Alberta. It covers 650 000 square kilometers, an area larger than the Yukon. The majority of the surface waters are part of three watersheds: those of the Saskatchewan River, the Beaver River, and Peace, Athabasca, and Slave rivers’ watershed.

Timber covers 84% of the Boreal Plains and forestry is the primary industry. Less than 20% of the land area is devoted to agriculture. However, precipitation and surface and groundwater sources are more than adequate to meet agricultural demand.

The ecozone has traditionally been viewed by some as the next untapped resource frontier. The ecozone’s relative remoteness and absence of large population centres has resulted in little comprehensive scientific study. To explore, produce and deliver the potential oil and gas products believed to be buried under the ecozone, vast road, railway and pipeline networks have been developed and thousands of kilometers of seismic exploration lines cut through the forests, providing access to previously remote areas.

**Landforms and climate**

Multiple ice ages had a pronounced effect on the Boreal Plains. Continental glaciation flattened the landscape and left behind a variety of glacial deposits consisting almost entirely of undulating and level to gently rolling plains dotted with small lakes. Following glacial retreat 8 000 to 11 000 years ago, larger lakes developed from glacial meltwater, creating extensive deltas and dunes. Lake Winnipegosis, for example, is a remnant of the bygone Lake Agassiz. Underlying these landforms are horizontal layers of sedimentary bedrock laid down millions of years ago during the Cretaceous and Tertiary periods.

Most of the major rivers have their origin in the Rockies. These rivers flow east across the ecozone and are the products of rainfall, snowmelt and glacial runoff at their headwaters.

The climate of the Boreal Plains Ecozone is determined by its location in the heart of North America. The Rocky Mountains to the west block moisture-bearing winds from the Pacific. The result is short, warm summers and long, cold winters. The annual precipitation, approximately 450 mm, is greater than the evaporation rate, resulting in surplus moisture of up to 100 mm near the southern edge of the ecozone and up to 300 mm in the northern and foothills regions.

**Plants**

Nearly half of the Boreal Plains is occupied by productive forest land. The pace of logging increased after 1956 when the first pulp mill was established in Alberta. Others followed in Saskatchewan in 1968 and Manitoba in 1971. Technology improvements during the 1980s led to a 20-fold increase in the harvesting of previously little-valued Aspen. Between 1951 to 1991, the amount of forest logged increased by 82%. Pressure is mounting to find methods to log without causing irreversible damage to the environment.

Today, most of the ecozone is associated with the boreal forest. It is composed of White and Black
Spruce, Balsam Fir, Jack Pine and Tamarack in some peatlands. Of the broadleaf trees, Aspen and Poplar are the most common, and Birch exists in some areas. Fire, the most powerful influence on the forest, determines distribution and growth rates. In a typical year, more than one million hectares burn, despite increasingly effective fire suppression and prevention efforts. In particularly bad fire years, such as 1989 and 1995, huge areas were devastated by fire. The forests are also affected by native insect pests and disease. Unchecked outbreaks of Spruce Budworm have killed extensive tracts of spruce and fir forests. Other insects, such as the Tent Caterpillar, have defoliated and damaged Trembling Aspen stands, most notably in 1988. Secondary organisms, including other insects and fungi, often attack and kill trees weakened by defoliation or drought.

The characteristic soils are grey Luvisols, developed in loamy conditions under a forest canopy. Lakes and wetland areas, such as sloughs and marshes, are areas of rich vegetation. In poorly-drained areas, extensive bogs have developed.

### Wildlife

Human activities have divided the original ecosystems of the Boreal Plains into fragments. As a result, most wildlife populations and their habitats have greatly diminished. Although logging is believed to be partly responsible for an increase in Moose populations since 1955, forest habitat has been lost steadily to timber harvesting. Fish in major rivers and lakes must now face subsistence and commercial fisheries and an array of recreational activities. Within these aquatic ecosystems, there is concern for high-value fish stocks, particularly Walleye and Sauger, which are sought after by both commercial and recreational fishers. Habitats also suffer from increasing water consumption and toxic farm run-off.

Wetlands form an essential part of wildlife habitat, often surviving forest fires to provide refuge and initial browsing lands for wildlife. River levees also provide productive and sheltered areas, especially during harsh winters. Floodplains and associated marshes form unique waterfowl and Muskrat habitat. Bogs, with their ground and tree lichens, are the main habitat for Woodland Caribou.

The most prominent local species include Timber Wolf, Black Bear, Moose, Woodland Caribou, Mule Deer, Elk, and Beaver. Typical bird species are Gray Jay, Common Loon, White-tailed Sparrow, American Redstart, Canada Warbler and Ovenbird. Game birds found in the region include species of grouse, geese, ducks and ptarmigan. The ecozone’s lakes and streams teem with Walleye, Lake Whitefish, Northern Pike, Burbot, Perch, and scattered populations of Lake Trout. Little is known of the insects and arthropod communities.

At least four vertebrate species have disappeared from the area: the Plains Grizzly, Swift Fox, Black-footed Ferret, and Greater Prairie Chicken. Peregrine Falcon (anatum), Mountain Plover, Eskimo Curlew, Piping Plover, and Whooping Crane are
endangered, according to the Committee on the Status of Endangered Wildlife in Canada. Threatened species include the Borrowing Owl and Ferruginous Hawk.

**Human activities**

The Boreal Plains entered the history books as a gateway to the great northwest interior of North America. Trading companies established posts along the major rivers at such sites as The Pas and Cumberland House. But the most significant impact on the ecozone was the fur trade. Bison was hunted, first for its meat, which was consumed by fur traders in the 1780s, and then for its hides, which were sold to the North American fashion industry. Thousands of bison were killed each year, leading to the virtual elimination of free-roaming bison by the 1880s.

Development accelerated greatly after 1870, when the Hudson’s Bay Company surrendered its charter and sold Rupert’s Land, which included the entire Boreal Plains Ecozone, to Canada. As a means of securing the area from potential expansion of the United States, Canada encouraged land development. Much of the arable land was occupied in the years following the completion of the transcontinental railway in 1885, which also introduced coal mining. With the settlement of the prairies came demand for lumber. Nearly half the ecozone is occupied by productive forests. Logging was concentrated in the southern fringes and, by 1900, large sawmills were in operation.

Demand for petroleum products early in the 20th century led to the discovery of the substantial oil and gas reserves in Alberta, where they have been a focal point of the economy for the last 50 years. In Manitoba and Saskatchewan, meanwhile, several hydro-electric power plants were built.

Today, only about 700,000 people, many of them relatively young, live in the ecozone. Despite rapid urban development over the past two decades, just 40% live in major cities. Most municipalities are relatively small compared with those of the Prairie Ecozone.

The most recent major development is the increased use of forests. Between 1951 and 1991, forest harvests increased by 82%. Agriculture has also become a more visible influence. Farmland has increased by 8% over the last 20 years, but still occupies less than 10% of the Boreal Plains. Agricultural activities are dominated by wheat, pasture and rangeland.

The economic structure of the ecozone reflects a relatively high dependence on the service sector, which employs 65% of the labour force, and the primary industries. Over the past century, much of the ecozone has been put to use harvesting natural resources. Forestry predominates, along with agriculture, oil and gas development, hydro-electric power generation, fisheries and mining. The First Nations of the ecozone are tied tightly to traditional places of spiritual significance and ancient burial grounds. They use the ecozone’s forests as both their home and workplace.

Wildlife is particularly valuable to those who rely on hunting, trapping, and fishing as a primary source of food.
Table 10 Statistical Profile: Boreal Plains Ecozone

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<th>Area = 737 800Km² (7.4% of Canada)</th>
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<td>Parks and reserves (strictly protected areas) = 9.0% of ecozone</td>
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<td>14 156</td>
<td>Wholesale and retail trade</td>
<td>13.2</td>
</tr>
<tr>
<td>Dawson Creek, B.C.</td>
<td>10 981</td>
<td>Mining</td>
<td>8.8</td>
</tr>
<tr>
<td>Hinton, Alta.</td>
<td>9 046</td>
<td>Transportation</td>
<td>8.0</td>
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</table>
Almost two thirds of Canada lies on the rock of the Boreal Shield Ecozone. Canada’s largest ecosystem, the boreal forest, forms a continuous belt from the east coast to the Rockies. Scientists call the area where the Canadian Shield and the boreal forest overlap the Boreal Shield, the largest of Canada’s 15 terrestrial ecozones.

Stretching 3,800 kilometers from Newfoundland to Alberta, the Boreal Shield includes parts of six provinces, covers more than 1.8 million square kilometers, and encompasses almost 20% of Canada’s land mass and 10% of its fresh water. Some of Canada’s largest rivers have their headwaters in the Boreal Shield, including the Nelson, Churchill, Rupert and St. Lawrence. Huge bodies of freshwater, including lakes Winnipeg, Superior and Huron, lie along its borders. Within it are countless other lakes, some big, such as Lake Nipigon and Lac St. Jean, others so small they remain nameless to this day.

The Boreal Shield is home to animals renowned as emblems of Canada’s north woods: the Beaver, Moose, Woodland Caribou, Wolf and Black Bear. This well-watered land also provides habitat for migratory ducks and geese drawn here each spring by the thousand.

The original inhabitants of this land — the Beothuk, Algonquians, and Iroquois — abided by its complex cycles and the movements of its animals. By the late 1700s, the area’s rich fur, timber and mineral resources had attracted the interest of Europeans. Two hundred years later, frontier resources still form the backbone of the Boreal Shield’s economy. While industrial development remains relatively small, far-sighted management practices will be needed to sustain the Shield’s resources for the use of future generations.

Landforms and climate

Canadian Shield rock forms the nucleus of the North American continent. Other geological structures assumed positions around or on top of the Shield millions of years after it was formed. The Rockies are relative newcomers on the geological stage, having risen a mere 60 million years ago. Most Shield rocks were formed well over a billion years earlier, during the very first chapter of the planet’s history known as the Precambrian era.

What once may have been a towering mountain chain is today a massive rolling plain of ancient bedrock. During the late Precambrian era, geological activity in the Earth’s crust warped, folded and faulted the Shield. The foundation of much of the ecozone is now metamorphic gneiss, a highly banded rock formed by intense pressure and heat. Many of the minerals that contribute to the Boreal Shield’s economy may have formed during these geologically turbulent times.

During the last ice age that ended 10,000 years ago, the advance of glaciers repeatedly plucked and scoured the Shield, carving striations in the bedrock and carrying large boulders many kilometers. In retreat, glaciers blanketed much of the landscape with gravel, sand and other glacial deposits. The many poorly drained depressions left behind, as well as natural faults in the bedrock, now form the millions of lakes, ponds and wetlands that give this ecozone its distinctive character and charm.

The climate of the Boreal Shield is generally continental with long cold winters and short warm summers. Cold air masses over Hudson Bay bring relatively high levels of precipitation.
to much of the area, from 400 mm in the west to 1000 mm in the east. The average midwinter temperature is -15°C, while in midsummer it hovers around 17°C. The typical year sees between 60 and 100 frost-free days. Regions bordering the Great Lakes and the Atlantic tend to be warmer in winter and cooler in summer thanks to the moderating influence of large water bodies.

**Plants**

Cool temperatures, a short growing season, frequent forest fires, and acidic soils challenge plant life in the ecozone. In spite of this, almost 88% of the area is forested by a few highly adaptable trees, such as Black Spruce, White Spruce, Jack Pine and Balsam Fir. Black Spruce, the most common species, yields high-quality wood pulp and is a prime species for Canada’s large paper industry. Further south are broadleaf trees such as Paper Birch, Trembling Aspen and Poplar, and conifers such as Balsam and White, Red and Jack Pine. In southeastern parts of the ecozone, species characteristic of more temperate climates, including Yellow Birch, Sugar Maple, Black Ash and eastern White Cedar, are common.

Throughout the Boreal Shield, these forests are mixed with innumerable bogs, marshes and other wetlands. Covering nearly 20% of the ecozone, these wetlands are among its most diverse and biologically productive ecosystems. Some larger wetlands in southern regions have been converted into commercial berry farms, which produce large volumes of cranberries and blueberries for markets around the world.

Where the scouring effects of glaciation were intense, bare rock outcrops predominate. The outcrops are masked by arrays of lichen and ground-hugging shrubs.

Forest fires add to the distinctiveness of the Boreal Shield by leaving a wide variety of plant life varying in species composition and age. Although fire often destroys large tracts of forest and occasionally threatens human activities or property, it also renews the landscape by triggering new growth, purging old forests of insect pests and disease, and increasing the variety of habitats available to wildlife.

**Wildlife**

Each spring the abundance of water in the Boreal Shield Ecozone attracts hundreds of thousands of ducks, loons, geese and swans. They come either to breed or simply rest and feed before flying on to more northerly nesting grounds. Among the more common waterfowl species that summer here are the Bufflehead, American Black Duck, Wood Duck, Ring-necked Duck and Canada Goose. Also found are the Boreal Owl, Great Horned Owl, Evening Grosbeak and Blue Jay. The songbird perhaps most often associated with this part of the Canadian Shield is the White-throated Sparrow.

Among the characteristic mammals of this ecozone are Woodland Caribou, White-tailed Deer, Moose, Black Bear, Wolf, Lynx, Snowshoe Hare, Fisher, Marten and Striped Skunk. The ecozone’s many wetlands, ponds, rivers and lakes provide important habitats for Beaver, Muskrat and Mink.

In the Atlantic marine environment, typical mammals include Grey, Harp and Hooded seals and Sperm, Killer, Atlantic Pilot, Fin and Blue whales. The endangered Northern Right and Bowhead whales and threatened Humpback Whale are also found in this region.

The biologically-rich marine areas off Quebec’s north shore as well as the continental shelf of Newfoundland and Labrador are vital to Canada’s commercial fisheries. The rocky shores of the Gulf of St. Lawrence and the Newfoundland coast provide exceptional nesting habitat for many seabirds. Lake Trout, Lake Whitefish, Burbot and Northern Pike are among the most common fish species thriving in the ecozone’s many freshwater lakes and rivers.
Human activities

The total population of this ecozone is now approximately 2.8 million, or about 11.5% of Canada’s population. Almost 60% live in urban centres, including St. John’s, Chicoutimi, Rouyn-Noranda, Timmins, Sudbury, Thunder Bay, Sault Ste. Marie and Flin Flon. Since the days the first humans migrated into the ecozone near the end of the last ice age, the Boreal Shield’s network of rivers and lakes has served as a crucial transportation route, a foundation for rich domestic fisheries, and a natural wellspring of fur-bearing mammals. More recently these waters have come to be known for mining, outdoor recreation and the development of hydro-electric power.

Much of the freshwater resources of the Boreal Shield are relatively untouched by human activity. Others have been widely exploited. Flow alteration and mercury contamination from hydro dams and associated river diversions, acidification from mine tailings and smelter emissions, and sedimentation and stream disruptions from extensive logging activities are the consequences of industrial development.

As for the boreal forest, fire suppression, insect control, clear-cutting and single-species tree farming are widespread. These practices may, over the long term, reduce the diversity of both plant and animal species and increase the forest’s vulnerability to disease.

Many Shield lakes and soils are extremely sensitive to changes in pH. Acid rain from local sources and from the long-range transport of airborne pollutants has already taken a toll. It may be weakening the general vigour and growth rate of trees, as well as of aquatic species, in sensitive areas.

Mining, forestry, hydro generation and fisheries are all important contributors to the economy. Close to 60% of the employment in the ecozone is in service industries, public administration, wholesale and retail sectors.
Table 11  Statistical Profile: Boreal Shield Ecozone

<table>
<thead>
<tr>
<th>Area = 1 946 370 Km² (19.5% of Canada)</th>
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<th>% total area</th>
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<td>Forest (Transitional)</td>
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<td>Cropland</td>
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**Boreal Cordillera Ecozone**

Consisting of extensive mountains and valleys separated by wide lowlands, this ecozone spans 444,000 square kilometers, occupying the southern Yukon and northern half of British Columbia. It is bordered by the Coast Mountains to the west and extends north from the Montane Cordillera to the Mackenzie and Selwyn Mountains beyond Dawson City and Keno in the Yukon. To the east, it reaches as far as the Peace River country.

The Boreal Cordillera Ecozone contains most of the Yukon's population. Whitehorse is the largest centre with a population of 23,000, while the entire ecozone is home to just 31,000 people (1991). The portion of the ecozone in B.C. is sparsely populated. The relatively small population does not preclude land-use conflicts. Much of the valuable land for residential, agricultural and wildlife habitat is located in confined valleys.

First Nations have a significant voice in managing the environment of the Yukon portion of this ecozone through the Yukon Umbrella Final Agreement signed into law in February 1995. As the individual land claims are settled, the agreements will provide the framework in which future uses of these lands will be adjudicated and reconciled.

**Landforms and climate**

The Boreal Cordillera Ecozone encompasses the St. Elias, Skeena, Cassiar, Ominica, and northern Rocky mountains as well as the Stikine, Yukon and Klondike plateaus.

The plateaus generally display the flat to rolling features of mature erosional surfaces and are dissected by streams. Ice age glaciers covered virtually all plateau areas and left widespread deposits of glacial debris. The mountain systems are lower and more subdued than the Coast and southeastern mountains. Deep glacial deposits are widespread in broad valleys, while the mountains — except on the higher ridges and peaks — commonly have a thin cover of colluvial debris.

The climate is an interior subalpine type, and the mean annual temperature is -0.7 to -0.3°C. Average temperatures top 10°C for only one month a year, although up to three months is possible at medium elevations. Mean annual precipitation is 460 to 700 mm with 35 to 60% falling as snow. Winters are long and cold, summers brief and cool. Moist Pacific air frequently causes sudden, often violent storms during summer. A more stable air mass usually prevails in winter, but cold spells can be broken by warm chinook winds.

Above the treeline, at elevations higher than 1,000 to 1,400 meters, alpine weather is the norm. This area is cold, windy and snowy and characterized by low temperatures during the growing season and a short frost-free period. Mean annual temperature ranges from -4 to 0°C. Frost can occur at any time and the average temperature remains below freezing for seven to 11 months each year. Mean annual precipitation is 700 to 3,000 mm, 70 to 80% of which falls as snow. Many high-elevation areas such as the St. Elias Mountains have perpetual ice and snow cover.

**Plants**

Lower elevations are generally forested by White Spruce and Subalpine Fir. A pattern apparent in many valleys is intermittent-to-closed forest cover of White Spruce with variable amounts of...
Pine and Aspen in the valley bottoms and on lower slopes. The best forest growth is associated with White Spruce on fine-textured moist soil near wetlands and water. Subalpine Fir dominates higher up, especially on northern and eastern slopes, where it often forms nearly pure stands. Black Spruce, Lodgepole Pine, and Trembling Aspen are relatively minor species, although locally abundant. Wildfires are not as common as in adjacent ecozones to the east although the occasional stand of Lodgepole Pine, which grows in the aftermath of fires, is not unknown.

Upper elevations near treelines are dominated by deciduous shrubs, mainly scrub birch and willows. Tree species are in stunted or "krummholz" form. The most common krummholz species are Subalpine Fir, Engelmann Spruce, White Spruce, Mountain Hemlock, and Whitebark Pine. Groves of stunted aspen and Balsam Fir occur at timberlines, usually on southern slopes. Alpine vegetation consists of shrubs, herbs, moss and lichen, with much of this area totally lacking in vegetation and dominated by rock, ice and snow.

Wildlife

The profound effect of the ecozone's climate on wildlife is especially apparent during late summer, when many species migrate south to avoid the abrupt transition to cooler autumn weather and the long cold winters that follow. Moose and Caribou are the most abundant and widespread ungulates. Valley bottoms provide the best winter range for both species, but much of this ecozone is abandoned by mid-winter because of deep snow. Mountain Goats are year-round inhabitants and tend to avoid the deep snow because of the steep terrain they inhabit. Stone Sheep are found on steep south-facing grasslands associated with rugged terrain. Dall Sheep, Grizzly Bear and Black Bear are also present. Other typical forest species are the Spruce Grouse, Common Raven, Gray Jay, Boreal Chickadee, Red-breasted Nuthatch, Three-toed Woodpecker, Ruby-crowned Kinglet, Red Squirrel, Wolverine and Marten. No reptiles are present and the Western Toad, Wood Frog and Spotted frog are the only amphibians.

The many open and shrubby valley bottoms are important as summer range for Moose and Caribou, but are too exposed and snowy to be used as winter range. The Willow Ptarmigan, Arctic Ground Squirrel and Wilson's Warbler are common in these areas.

Human activities

Close to half of the ecozone's labour force is engaged in public administration or services, with another 12% in commerce. This reflects, in large part, the nature of Whitehorse, the capital and commercial centre of the Yukon.

Most historic and present-day placer mining is confined to the Klondike plateau in the unglaciated areas of the Klondike, Sixtymile, lower Stewart and Indian River drainages. Of the 21 creeks that produced the most gold between 1978 and 1987, only three were not in these drainages.
Because placer deposits are associated with streambeds, much activity is within the floodplains of streams, which may be dammed, diverted and stripped of vegetation. As a result, impacts on fish habitat and water quality persist long after mining has ceased. Current regulations restrict sediment levels in placer effluent and measures must be taken to restore or compensate for lost habitat.

Important mineral deposits are found within the ecozone. Among these are the Casino deposit (copper-gold-molybdenum), Carmacks deposit (copper-gold) and the Mount Nansen deposit (gold-silver). Major hard rock mining properties in the past have included the lead-zinc mine at Faro, the Keno-Elsa Silver Mine, Ketza River Gold Mine, Mount Nansen Gold Mine and the Brewery Creek Gold Mine. All have been closed in recent years, but Faro reopened recently and a couple of others are planning to resume operations in the near future.

Forestry operations are small and centred around Watson Lake in the Yukon and areas of northeastern British Columbia. The forestry sector is growing and expected to become the major employer and economic contributor for the southeast Yukon.

Table 12  Statistical Profile: Boreal Cordillera Ecozone

<table>
<thead>
<tr>
<th>Area = 464 600 Km² (4.7% of Canada)</th>
<th>Dominant Landcover Class</th>
<th>% total area</th>
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<td>1991 Population = 30 839 (0.11% of Canada’s total)</td>
<td>Arctic/Alpine Tundra</td>
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<tr>
<td>Parks and reserves (strictly protected areas) = 6.1% of ecozone</td>
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<tr>
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<td></td>
<td>Forest (Mixedwood)</td>
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<tr>
<td></td>
<td>Perennial Snow or Ice</td>
<td>5.5</td>
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<tr>
<td></td>
<td>Total</td>
<td>99.6</td>
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<tbody>
<tr>
<td>Whitehorse, Yukon</td>
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<td>Service</td>
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<td>Dawson, Yukon</td>
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<td>Public Administration</td>
<td>18.8</td>
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<td>Faro, Yukon</td>
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<td>Wholesale and retail trade</td>
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<td>Haines Junction, Yukon</td>
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<td>Mayo Landing, Yukon</td>
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<td>Transportation</td>
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Pacific Maritime Ecozone

The Pacific Maritime Ecozone contains Canada’s tallest trees, the most rainfall, and the longest and deepest fjords. A combination mountain-maritime climate gives this ecozone its distinctive character.

In few other areas on earth can one experience such a variety in so short a distance — from undersea kelp forests to alpine tundra, from the lush, flat plains of the Fraser Delta to the massive glaciers punctuating the northern British Columbia coast.

As the name implies, the ecozone includes the land bordering Canada’s Pacific Coast. Covering more than 195,000 square kilometers, it includes the Coast Mountains, B.C.’s marine islands, plus a small corner of southwestern Yukon.

Landforms and climate

The Coast Mountains dominate most of the ecozone, rising steeply from the fjords and deep channels that line the Pacific coast. Glaciers and snowfields cap the tallest ranges. The ecozone includes Mount Waddington, at 4,000 meters B.C.’s highest mountain. The mountains of Vancouver Island and the Queen Charlotte Islands, although not nearly as high, make up in ruggedness what they lack in elevation. Igneous and sedimentary rocks lie beneath most of the area while fallen rocks and glacial deposits predominate on the surface.

In contrast with the mountains, the Estevan Coastal Plain is a long narrow strip of rocky coastline dotted by the occasional beach. Found only along the west coast of Vancouver Island, this unique landscape is constantly changing as it bears the full brunt of the Pacific’s ceaseless waves and scouring winds.

Striking mazes of fjords and channels dissect the coastline from Vancouver to Alaska. These are classic fjords, some of the world’s longest and deepest. They slash inland up to 190 kilometers, with sheer sides plunging over 2,000 meters. The deepest fjord in the world is Findlayson Channel, with soundings of over 795 meters.

The ecozone lies within the Pacific Ring of Fire, a narrow, semi-circular area known for volcanic eruptions and earthquakes caused by friction between the Earth’s crustal plates. Hot springs that beckon back-country adventurers bear testimony to crustal “hot spots” found throughout this area.

This ecozone has some of the warmest and wettest weather in Canada. Its maritime climate receives as little as 600 mm of precipitation per year in the lower Georgia Strait, while the area to the north is typically much wetter, receiving up to 3,000 mm. Compared to the rest of Canada, there is little variation in monthly temperatures. Averages in July range between 12 and 18°C and, in January, between 4 and 6°C. The frost-free period is up to 220 days long in the moist southerly valleys, decreasing to about 100 days in the mountains.

Plants

The combination of heavy rainfall and year-round mild temperatures support some of the most spectacular temperate rain forests in the world. Here are Canada’s most productive forests and its biggest and oldest trees. A record-breaking Douglas Fir near Red Creek measures over 14 meters around and 80 meters high; a western Red Cedar on Meares Island is 20 meters around; Carmanah Creek is home to the world’s tallest Sitka Spruce at 95 meters; Cathedral Grove is dominated by Douglas Fir as tall in feet.
as they are old in years — up to 250 feet (85 meters). Yet these trees are still young compared to other western Red Cedars, which reach over 2 000 years of age.

The forest ecosystems found here vary with elevation and precipitation. In low-lying coastal areas, Western Hemlock forests dominate; in higher elevations subalpine Mountain Hemlock forests are more common; and small areas of dry Douglas Fir forests are found on the leeward side of the mountains. It is the coastal Western Hemlock forests that make up the famous rainforests of this ecozone.

Coastal temperate rainforests are globally scarce, originally covering barely 0.2% of the earth's land area. Today, the largest undeveloped tracts of these forests are found in South America and North America, much of which — approximately 106 000 square kilometers — is in the Pacific Maritime Ecozone. These forests contain ecosystems with the highest biomass per hectare on Earth. The western coastal forest is composed mostly of Western Red Cedar, Western Hemlock, Douglas Fir, Mountain Hemlock, Amabilis Fir, Sitka Spruce, Yellow Cedar and Alder. Douglas Fir is confined largely to southern regions while, in the north, Amabilis Fir is more common. As the elevation increases, the Mountain Hemlock and Yellow Cedars give way to stunted clumps of trees known as "krummbolz." Above 900 meters, treeless alpine tundra takes over.

A unique forest ecosystem in the dry rainshadow climate of the Gulf Islands and Saanich Peninsula is the Arbutus and Garry Oak woodland. Among B.C.'s rarest forests, it is considered one of the most endangered ecosystems in North America. Urbanization, wildfire suppression and the introduction of exotic species such as Scotch Broom have destroyed about 95% of its original range.

Wildlife

Characteristic land mammals of this area include the Black-tailed Deer, Black and Grizzly bears, Mountain Lion (or Cougar), Fisher, and American Pika. Bird species unique to this area include the American Black Oyster Catcher, Tufted Puffin, Chestnut-backed Chickadee and, in southern regions only, the California and Mountain Quail. Other representative birds are the Northern Saw-whet Owl, Northern Pygmy Owl, Steller's Jay, Bald Eagle and Blue Grouse.

Several species and subspecies of wildlife evolved on the islands of the region: the Vancouver Island Marmot, found only in alpine meadows on Vancouver Island; the “Blond” or "Kermodei" bear, a subspecies of Black Bear found on a few north coastal islands; and the Roosevelt Elk, among others. Some are rare or endangered; others, such as the Dawson Caribou, once confined to Graham Island, are extinct.

The marine ecosystems of the ecozone support a tremendous abundance and diversity of organisms. Many seabirds, including the little-known Marbled Murrelet, nest along the coast. The area's many islands, estuaries and fjords provide critical habitat for countless migrating shorebirds and waterfowl, including the Trumpeter Swan and Sandhill Crane. Contributing to the biological richness of the ecosystem are a shallow continental shelf, ice-
free coastal waters, deep-water upwellings of nutrients, and numerous freshwater discharges from coastal rivers.

Typical marine mammals include the Northern Sea Lion, Northern Fur Seal, Harbour Seal, and a host of whales: the giant Beaked Whale, Sperm Whale, Grey Whale, Killer Whale, Pacific Pilot Whale and Blue Whale. The endangered Sea Otter has been reintroduced to the northwest coast of Vancouver Island. Several species of salmon and their spawning streams are located throughout the ecozone. Pacific Herring and Pacific Halibut are also found here. Common freshwater species include the Cutthroat Trout, Dolly Varden, and Steelhead.

Human activities

Although the Pacific Maritime ecozone is rich in wild fauna, flora, and ecosystems, much of the south is heavily stressed by population growth, urban development, and the forestry and pulp and paper industries.

Three-quarters of British Columbians, or about 2.5 million people, live here. Most are concentrated in the Georgia Basin, the area embracing the large urban centres of the Lower Mainland and Victoria. The population has grown by leaps and bounds over the past few decades, largely as a result of immigration. For instance, the population of the Gulf Islands rose by an astonishing 58% between 1971 and 1985. Rapid urbanization makes protecting wildlife habitats and prime agricultural land particularly challenging.

For well over a century, logging and related forest industries have been the economic mainstay of many communities in this ecozone. They have also changed the landscape dramatically. In the past 120 years, over 2 million hectares of the temperate coastal rainforest were clear-cut. Between 1920 and 1992, while the area logged each year doubled in the rest of Canada, it tripled in the Pacific Maritime.

The commercial fishing industry is another major player in the ecozone. Both native and aquaculture stocks of salmon are especially prized. Most Sockeye, Pink, and Chum Salmon stocks have increased since the 1960s. However, Chinook and Coho Salmon stocks are low due to overfishing, habitat damage, and natural factors. Contamination by organochlorine compounds released from pulp mills sometimes interferes with the harvesting of shellfish, as the toxins tend to accumulate in their tissues.

Since the days when the native Haida people routinely plied their dugout canoes along the west coast, the area has been an important marine transportation route. Boat traffic now includes huge cargo ships, fishing vessels, ferries, and all kinds of recreational craft. A fast-growing industry here is water-based tourism, offering everything from sea kayaks to multi-level tour boats.
Table 13  Statistical Profile: Pacific Maritime Ecozone

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<td>Chilliwack, B.C.</td>
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<tr>
<td>Port Alberni, B.C.</td>
<td>20,590</td>
<td>Manufacturing</td>
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</table>
Montane Cordillera Ecozone

The Montane Cordillera Ecozone is the most diverse of Canada's 15 terrestrial ecozones, exhibiting some of the driest, wettest, coldest, and hottest conditions anywhere in the country. The ecosystems are variable, ranging from alpine tundra and dense conifer forests to dry sagebrush and grasslands. Much of the region is rugged and mountainous.

The ecozone covers 473,000 square kilometers of Canada, stretching from north-central British Columbia south to the United States border. It encompasses the Alberta Foothills as well as the interior mountain ranges and valleys of B.C., including the Okanagan and the East and East Kootenay valleys.

The Montane Cordillera encompasses two of the four significant agricultural areas of the province; the Creston Valley and the Okanagan Valley. In the latter, orchards, vineyards and cash crops take advantage of favourable soil conditions. Cattle ranching is dominant throughout much of the other interior plateau and valley lands.

Forestry is the major industry of the lower and middle slopes, while the interior wet belt is the most productive fibre production area in the inland of B.C. Mining is an important activity within the ecozone — five of B.C's eight coal mines and three of Alberta’s 11 are located within its boundaries.

Landforms and climate

The 473,000 square kilometers of the Montane Cordillera Ecozone stretch from north-central British Columbia southeast to the southwestern corner of Alberta. The ecosystems range from alpine tundra and dense conifer forests to dry sagebrush and grasslands. Wetlands and small lakes dot the landscape, but there are also large, deep lakes and major river systems, including the Fraser and the Columbia River headwaters.

Much of this ecozone is rugged and mountainous. The major plains are more extensive in the north and extend out as intermontane valleys towards the southern half of the ecozone. Most of these plains and valleys are covered by glacial moraine and to some degree ancient riverbed and lakebed deposits, whereas the mountains consist largely of fallen rock debris and rocky outcrops.

The Columbia and Rocky mountains within this ecozone have a complex geology consisting largely of folded and faulted sedimentary bedrock. The mountain cliff faces disintegrate rapidly to form course, rocky slopes and aprons.

Moist Pacific air carried by westerly winds drops large amounts of rain and snow as it ascends the windward side of the Coast Mountains. The air drops over the eastern slopes into the Montane Cordillera, where it compresses and warms, causing clouds to thin out. The pronounced rainshadow cast by the massive Coast Mountains makes the valley bottoms of the south-central interior the driest climates of B.C. The air releases moisture again, creating an interior rain belt as it ascends the Columbia, Skeena, Ominica, Cassiar, and finally the Rocky mountains, which define the eastern extent of this ecozone.

Annual precipitation in the higher elevations ranges between 1,200 and 2,200 mm. The northern and interior portions of the ecozone receive between 500 and 800 mm annually. The driest rainshadow areas around Merritt and...
Cache Creek and the southern Okanagan receive well below 500 mm of precipitation.

Much of the ecozone has an interior continental climate dominated by easterly moving air masses that produce cool wet winters and warm dry summers. Periodic inundation by dry, high-pressure, continental air masses results in a few cold winter days and a few hot summer days. Temperatures vary with altitude. In the alpine, no month has an average daily temperature above 10°C. The upper forested slopes have seven to nine months per year of monthly mean temperatures of no more than 0°C. The Ponderosa Pine forests are the driest and, in summer, the warmest forests in B.C., with mean July temperatures averaging 17°C to 22°C. The hot, dry summers result in large moisture deficits during the growing season. The rainshadow grasslands and valley bottoms are characterized by hot, dry summers and moderately cold winters with little snowfall. It is not unusual to have daily high summer temperatures topping 30°C.

**Plants**

Vegetative cover varies widely; alpine environments contain various herbs, lichen and shrubs, whereas the subalpine regions are dominated by tree species such as Alpine Fir and Englemann Spruce. With decreasing elevation, the mountainous slopes and rolling plains split into three forest groups: a marginal band at upper elevations characterized by Englemann Spruce, Alpine Fir and Lodgepole Pine; a second zone characterized by Ponderosa Pine, interior Douglas Fir, Lodgepole Pine and Trembling Aspen in much of the southwest and central portions; and another featuring western Hemlock, western Red Cedar, interior Douglas-fir, and western White Pine in the southeast.

The Englemann Spruce-Subalpine Fir belt occurs at elevations of between 1 200 and 2 300 meters. It forms a continuous cover at its lower and mid elevations and becomes subalpine parkland at its upper limits. Lodgepole Pine is widespread after fire and is predominant in the drier regions. Other common species include Whitebark Pine and Alpine Larch. Subalpine heather and grassy meadows are also common. Snow avalanche tracks are evident throughout much of the high-snowfall areas.

High-elevation forest gives way to one dominated by White Spruce, interior Douglas Fir and Lodgepole Pine at mid elevations of 400 to 1 500 meters. Where the precipitation is relatively high (up to 1 500 mm annually) an interior wet belt forms, dominated by tree cover of western Red Cedar and western Hemlock. This area is concentrated on the lower slopes of the Columbia Mountains and the windward side of the Rockies and much of the Shuswap and Quesnel highlands. At lower elevations, particularly along dry valleys, Ponderosa Pine is dominant. Wildfires play an important role maintaining these forests. Stands are often open and park-like with an understorey of bluebunch wheatgrass. More moist sites are characterized by Douglas Fir, and water and paper birches, while the dry southern interior is devoid of trees and dominated instead by big sagebrush, rabbitbrush and antelope-brush. Grasslands featuring bunchgrasses and other grasses and shrubs appear in the valley bottoms and on plateaus in south-central B.C. from Riske Creek in the north to the Canada-U.S. border. Similar grasslands occupy smaller areas in the Kootenays of southeastern B.C.

The natural grasslands in this ecozone have not fared well. Most existing prior to European settlement have vanished, thanks to fire suppression, introduced species, and cattle grazing. Much of the grassland in the Okanagan Valley, for example, has been completely replaced by settlements, orchards, and crops. Today, introduced species have colonized many grasslands and the pockets of natural dry grasslands that survive are unique to Canada, dominated by species such as Bluebunch Wheatgrass that rarely occur east of the Rocky Mountains.

Extensive wetlands are infrequent in the mountainous portions of this ecozone. On slopes,
wetlands are generally restricted to small transitional and non-forested bogs, marshes and skunk cabbage swamps. Much of the valley wetlands have been destroyed by urbanization and agriculture. Less than 15% of the original wetlands of the Okanagan Valley remains and is under constant threat from development.

**Wildlife**

Wildlife is as diverse as the vegetative cover. In the alpine tundra, the snowpack does not melt until well into summer and plantlife is sparse. Several species have adapted to the harsh climate, including Mountain Goat, Gyrfalcon, White-tailed and Willow Ptarmigan, Water Pipit and Rosy Finch. Mule Deer, Rocky Mountain Elk, Stone Sheep, Grizzly Bear and Black Bear are common in lush meadow habitats and the stunted spruce groves known as krummholz.

Throughout the middle and upper elevations ungulates such as Mountain Goat, Moose, Caribou and Mule Deer are common. Rocky Mountain Elk, Bighorn Sheep, White-tailed Deer and Stone Sheep are found less frequently. Grizzly Bear and Black Bear are the most common large mammals. The conifer forests are also important habitat for fur-bearers such as Marten, Fisher, Red Squirrel and Wolverine and a diverse collection of birds that feed on conifer seeds, bark insects and small mammals.

Common birds include Pileated Woodpecker, Northern Flicker, Clark's Nutcracker and Red Cross-bill.

Ponderosa Pine parklands provide habitat for species that forage on large conifer seeds (Clark's Nutcracker, Pygmy Nuthatch and Yellow-pine Chipmunk), bark insects (Northern Flicker and White-headed Woodpecker) or flying insects (Common Poorwill). The open forest canopy passes sufficient light for the production of shrubs palatable to wintering ungulates (Mule Deer and White-tailed Deer). Dense stands of Douglas Fir and Ponderosa Pine, meanwhile, provide a warm cover for wintering ungulates and an abundant seed and insect source for a variety of birds, small mammals, and coyotes.

The treeless bunchgrass areas are small relative to the adjacent forests, but they have an abundance and diversity of wildlife. This is partly due to the wide range of habitats created by the juxtaposition of grasslands, shrublands, wetlands and forest. The grasslands also represent a northern extension of the intermountane steppe of the western Great Basin in the south. Southern species such as Pallid Bat, Burrowing Owl and Short-horned Lizard reach their northern breeding limit here. On the other hand, northern species that rarely move further south, such as Snowy Owl and Gyrfalcon, can be found on open rangelands in winter.

Encroachment and pressures of development on the grasslands and lower slopes of many of the valleys within this ecozone have led to the destruction of habitat for many indigenous species. In 1995, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed seven mammals that inhabit this ecozone as vulnerable. COSEWIC also lists 10 bird species as either vulnerable or threatened and four —
Mountain Plover, Sage Thrasher, Burrowing Owl and Peregrine Falcon (anatum) — as endangered.
Four fish species and seven plants are also listed by COSEWIC.

**Human activities**

As the dry Ponderosa Pine is of limited commercial value for forestry, the dominant land use is cattle grazing. Grasslands, although chronically overgrazed in the past, are now better managed. Flat areas, especially on ancient riverbeds and lakebeds, are irrigated for hay production. Overall, the arable land in B.C. accounts for less than 5% of its total land base.

The Montane Cordillera encompasses two of the few significant agricultural areas of the province: the Creston Valley and the Okanagan Valley. In the latter, favourable soils, when irrigated, are used for orchards and vineyards as well as cash crops.

The forested lower slopes often provide summer range for cattle. Forestry is the main industry of the lower and middle slopes with the interior wet belt being the most productive area for fibre production of all of the inland areas of B.C. Nine pulp and paper mills are located throughout the ecozone. The Fraser-Thompson River systems have seven such operations: three near Prince George, two at Quesnel, one at Williams Lake and one at Kamloops. The others are at Castlegar and Skookumchuk on the Columbia River. In addition, many small and large sawmills are found throughout the ecozone. Canada is the largest exporter of forest products in the world and B.C. produces 45% of the Canadian total. Although no specific figures are available by ecozone, the Montane Cordillera is a substantial contributor to the B.C. forest sector.

Mining is another important activity within the ecozone. Five of B.C.’s eight coal mines and three of Alberta’s 11 occur within its boundaries. A major lead-zinc refinery is located at Trail. Copper, gold, silver, molybdenum and other precious metals are also mined within the ecozone and two areas are seeing active diamond exploration.

This ecozone contains six national parks, including the oldest in Canada, Banff National Park. As well, there is an extensive network of provincial parks. The largest provincially protected area is Ts’yl’oos, a 2 332 square-kilometre park that is home to California Bighorn Sheep and B.C.’s third largest salmon run. A major concern is that many parks, most notably those of the Rocky Mountains, are becoming islands in a sea of development, their ecological integrity threatened by habitat destruction and fragmentation.

Within these parks, roads and railways remove habitat, form barriers to the movement of wildlife, and are a direct cause of wildlife mortality. Townsites and other developments further fragment the landscape. Outside the parks, adjacent lands that once formed extended blocks of wilderness are now subject to a variety of pressures, including new roads and industrial activities.

The dry valleys and lower slopes have intense recreational use, including hiking, cycling, horseback riding and some hunting and fishing. Most of the major lakes are lucrative tourist attractions, thanks to the many beaches and hot summers of this ecozone. Land-use conflicts are common in the valleys as a result of the pressure from the agricultural, recreational, transportation and industrial sectors, as well as urban development and the needs of wildlife.

Many of the interior cities have grown substantially over the past 20 years. For example, from 1971 to 1991 Kamloops grew 55% to 68 000 and Prince George by 42% to 70 000. With urbanization has come extensive transportation and communication networks, and major population centres in Alberta and the Lower Mainland of British Columbia have increased recreational pressure on the ecozone. With a growing population base of over four million to draw from, these pressures are not insignificant.

The labour force within the ecozone is becoming increasingly service-oriented. Of the total labour
force, 32% are employed in the service sector, 15% in commerce, 11% in forestry, 7% in construction, 5% in agriculture, 5% in transportation, and 4% in mining.

Urbanization and industrialization have placed increased pressures on both the quantity and quality of water supplies. Shortages are now common in parts of the Okanagan and Thompson basins, particularly in summer when demand is high but runoff low. The impact of pulp mill effluent on the Fraser and Thompson rivers is also cause for concern. However, great strides have been made recently toward the elimination of organochlorine compounds and suspended solids as companies work to meet regulations that require reductions of dioxins and furans to below detectable levels.

Table 14 Statistical Profile: Montane Cordillera Ecozone

<table>
<thead>
<tr>
<th>Area = 492 110 Km² (4.9% of Canada)</th>
<th>Dominant Landcover Class</th>
<th>% total area</th>
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<td>Vernon, B.C.</td>
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<td>Transportation</td>
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The Prairie Ecozone is often characterized as flat, rural, wheat- and oil-producing, or cold. The terms describe significant aspects of the environment and the economy but understate its diversity, character and recent evolution.

This ecozone is part of the Interior Plains of Canada, which are a northern extension of the Great Plains of North America. The relief is typically subdued, consisting of low-lying valleys and plains sloping eastward. With its base along the Canada-United States border, the ecozone stretches from the Rocky Mountains in Alberta to the Red River valley in Manitoba, reaching across the southern third of the Prairie provinces.

The Prairie ecozone, spanning an area of 520 000 square kilometers, is larger than the Yukon Territory and is one of the Canadian regions most altered by human activity. Farmland dominates the ecozone, covering nearly 94% of the land base.

Termed the Breadbasket of Canada, the Prairie Ecozone contains the majority of the country’s productive agricultural cropland, rangeland, and pasture. The area is the source of much of our food and, as a result of the export of grains, oilseeds, and animal products, is an important source of foreign exchange.

Agriculture is the major agent of change in this ecozone, influencing most native communities of plants and animals. Loss of habitat is the most critical threat to the flora and fauna. Little of the natural vegetation is left, a situation that made life difficult for some animals unique to the grasslands. Wetlands, which provide critical habitat for 50% of North America’s waterfowl, have been altered by agricultural practices and only half the presettlement wetland area remains.

Today, the Prairie ecozone is home to high numbers of threatened and endangered wildlife species and its native ecosystems are among the most endangered natural habitats in Canada.

**Landforms and climate**

Multiple glaciations have shaped the Prairie Ecozone. Continental glaciation flattened the landscape and left behind a variety of glacial deposits. For example, the flat fertile plain that dominates southern Manitoba resulted from the heavy clay soils that lay beneath the former glacial Lake Agassiz. Cedar Lake and lakes Manitoba, Winnipeg, and Winnipegosis are remnants of this bygone inland sea. Ponds and small lakes occupy many of the depressions in moraines. Following the glacial retreat 8 000 to 11 000 years ago, the ecozone evolved into treeless grasslands covering the southern third of what is now Alberta, Saskatchewan, and Manitoba.

Underlying these surface landforms are horizontal layers of sedimentary bedrock consisting of various Cretaceous and Tertiary sediments. Trapped in isolated pockets and cracks are rich reservoirs of oil and gas.

The Prairie Ecozone is now typified by large tracts of flat to rolling plains. A great variety of surface landforms, from hummocky lands to deeply entrenched river valleys, also exist.

Most of the major rivers have their origin in the Rockies. These rivers flow east across the ecozone and are fed by rainfall, snowmelt, and glacial runoff at their headwaters. Many smaller rivers and streams of the Prairie Ecozone have
highly variable flows and are often dry for long periods.

The ecozone's climate is determined by its location in the heart of North America and by the neighbouring Rocky Mountains, which block moisture-bearing winds from the Pacific. The result is a pronounced, subhumid to semi-arid climate. Winters are very cold. The mean temperature in the coldest month is \(-9.4^\circ C\) at Lethbridge and \(-18.3^\circ C\) at Winnipeg. Summers are short and warm. Mean temperatures for the warmest month are 16.1°C at Edmonton and 19.7°C at Winnipeg. Although dry, arctic air predominates in winter, periodic chinooks (strong, warm and dry westerlies that blow in from the Rockies) bring spring-like conditions to southern Alberta and, to a lesser extent, southern Saskatchewan, reducing snow cover and removing moisture from an already dry region.

A water deficit is typical as the ecozone receives considerably less precipitation than other parts of Canada and the world. Annual precipitation is extremely variable, ranging from 250 mm in the arid grassland regions of southwest Saskatchewan and southeast Alberta to slightly less than 700 mm in the Lake Manitoba plain, the warmest and most humid region in the Prairie Ecozone. About a quarter of the precipitation falls as snow. Summer thunderstorms are often severe, and south-central Alberta is reputed to be one of the worst hailstorm belts in North America. In summer, warm, moist air masses from the southern United States invade southern Manitoba, causing numerous thunderstorms and occasional tornadoes.

High winds predominate in the ecozone. Mean annual wind speed in many places is 18 to 21 km/h. In contrast, Vancouver's mean annual wind speed is 12 km/h while Toronto's is about 16 km/h. Wind accelerates evaporation, causing much of the dryness. In combination with precipitation and evaporation patterns, wind determines the amount of soil erosion and the resulting land degradation.

**Plants**

The shift from grassland to cropland in the Prairies has increased losses of organic matter and plant nutrients from the soil. It is estimated that the original organic matter levels have fallen by 40 to 50%. Over the past century the ecozone has been radically transformed and only a small fraction remains in its native state. Perhaps less than 1% of the Tall-grass Prairie, 18% of the Short-grass Prairie, and 24% of the Mixed-grass Prairie remain.

Today, the Tall-grass Prairie region of Manitoba is almost completely cultivated. Over 90% has been converted to crops or drastically changed by grazing and haying. And 75% of the Mixed-grass Prairie and Aspen Parkland has been converted to cropland or seeded to non-native forage species. The Aspen Parkland, the northern transition zone to the Boreal Forest, has expanded south into former grasslands since settlement put an end to prairie fires. The natural vegetation is generally dominated by Spear Grass, Wheat Grass, and Blue Grama Grass. Sagebrush is abundant. Local saline areas feature Alkali Grass, Wild Barley, Greasewood, Red Samphire, and Sea Blite. Drier sites in the southwest are home to yellow Prickly Pear Cactus.

The Short-grass Prairie occupies the driest southerly arc of the region, where brown and dark brown soils are dominant. The northern edge of the ecozone is dotted with groves of Trembling Aspen and Balsam Poplar and characterized by black Chernozemic soils. The most productive soils in the region are the black, dark grey, and dark brown soils of the Aspen Parkland and the Tall-grass and Mixed-grass Prairie.

Lakes and wetland areas are rich in vegetation. Depending upon rainfall, there are between 1.6 and 7.1 million wetlands in this ecozone, and lakes cover 7 800 square kilometers. The greatest number of wetlands occur along the subhumid Northern Grasslands and adjacent Aspen Parkland, where they make up half the land area.
However, lake and wetland areas are under threat. Virtually every major natural water system has been extensively modified and developed for hydro and thermal power generation, irrigation, flood protection, and water management. Agriculture and urbanization have cut the number of wetlands in half.

Few deciduous trees and shrubs grow in the ecozone except in the eastern regions, sheltered locations along waterways or at upper elevations. The east is characterized by Trembling Aspen and shrubs, whereas the southwest displays a mixed montane-type open forest of Lodgepole Pine. Southwest Manitoba contains a forest reserve that occupies most of the higher elevations of Turtle Mountain.

Wildlife

The Prairie Ecozone provides habitat for many animal species. Intermittent sloughs and ponds on the plains offer major breeding, staging, and nesting grounds for migratory waterfowl using the Central North American flyway. More than half of all North American ducks are born in Prairie Ecozone wetlands. River valleys also offer sheltered habitats important to wildlife, especially during the harsh winters. The Prairies offer unique habitat for the Black-tailed Prairie Dog, while its southern region is home to the Short-horned Lizard and Western Rattlesnake. Manitoba provides habitat for Black Bear, Moose, Sharp-tailed Grouse, Beaver, and Red Fox. Also present are various species of frog and toad. Local fish include Walleye, Lake Whitefish, and Northern Pike.

Considering its area and population, the Prairie Ecozone has a disproportionate number of threatened and endangered wildlife species. At least four vertebrate species — the Plains Grizzly, Swift Fox, Black-footed Ferret, and Greater Prairie Chicken — have disappeared from the area. The Peregrine Falcon, Mountain Plover, Eskimo Curlew, Piping Plover, Burrowing Owl, and Whooping Crane are all endangered.

Agriculture has probably had the greatest impact on the ecozone. By replacing natural grasslands with crops, draining wetlands, and destabilizing natural chemical balances in the soil with pesticides, the number and range of wildlife species has changed dramatically. As well, competing, non-native species have been introduced.

Within aquatic ecosystems, high-value fish stocks are under pressure, particularly Walleye and Sauger, which are prized by commercial and recreational fishers. Stocks have been reduced through overfishing and are sensitive to water quality in the controlled-drainage systems as well as to natural fluctuations. For example, contaminants from the widespread use of pesticides have damaged fish habitat.

Human activities

Between 1670 and 1870, the Hudson’s Bay Company was granted exclusive fur trading rights to the area drained by the rivers flowing into Hudson Bay, then called Rupert’s Land.

The earliest significant human modification of the native prairie ecosystems was spurred by
European demand for products of the fur trade, particularly those from bison. The killing of thousands of bison each year by European settlers led to the virtual elimination of free-roaming bison by the 1880s.

Settlement and landscape modification greatly increased after 1870, when the Hudson’s Bay Company surrendered its charter and sold Rupert’s Land to Canada. To secure the area against potential encroachment by the United States, Canada encouraged land development. In the early part of this century, following the completion of the transcontinental railway in 1885, a massive migration saw more than 200,000 homesteaders stake their claims.

Railways played a leading role in defining the pattern of development. Towns emerged along the rail line as collection points for grain and livestock exports and as distribution points for incoming supplies. By 1916, Canada was leading the world in wheat exports. Twenty-five years later, 60% of the Prairie Ecozone was under cultivation and the landscape resembled a checkerboard.

In 1936, farmers represented 50% of the population. Today that number has fallen to less than 10%. Population decline in the rural areas and growth in the urban areas has been the general rule since the 1950s. Although urban use of land is tiny in terms of area (0.3%), it remains an important influence on the ecozone. Today, the proportion of the urban population is 81% compared with 76% for all of Canada, a remarkable figure given that agricultural activities dominate the landscape of this ecozone. In 1991, the total population of the Prairie Ecozone was approximately 3.8 million, an increase of 25% since 1971. The major population centres are Calgary, Edmonton, Saskatoon, Regina and Winnipeg.

The economic structure of the ecozone reflects a dependence on the primary industries of agriculture, mining, and gas and oil extraction. The Prairies provide 19% of Canada’s total resource-based employment, with agricultural activities and food processing accounting for nearly 62% of the total. Its minerals industry (fossil fuels and related products) accounts for nearly a third of Canada’s total employment in this sector. In 1991, the Prairie Ecozone had an estimated Gross Domestic Product of roughly $91 billion, representing about 15% of Canada’s total GDP.

The Prairie ecozone has been farmed with a limited variety of crops. Only 15 field crops (grain, oilseeds, and pulses) and even fewer forage crops occupy more than 95% of the cropped area. With the exception of canola, which has recently surpassed wheat in the amount of area seeded, these crops have been the mainstay of production since European settlement. Beef and dairy cattle, swine, horses, chickens, and turkeys are the primary domesticated animals.

Mining, particularly the production of fuels, is the second most important industry. Although the value of mineral production increased in both Saskatchewan and Alberta between 1976 and 1991, land use for oil production has declined over the past decade, reflecting changes in world prices and incentives for exploration and development. By 1991, the value of mineral production in the Alberta portion of the ecozone made up 46% of Canada’s total mineral activity.

The Prairie economy is now shifting from primary and secondary industries toward service-based sectors. The primary and secondary industries are geared mainly at processing food, wood, metals, chemicals, and petrochemicals. In the 1980s, agriculture generated about $5 billion, or 25% of all exports from the region. This accounted for 2% of global grain, rice and vegetable oil output. Mineral and fossil fuel exploitation and other goods and services generate $15 billion annually.
Table 15  Statistical Profile: Prairies Ecozone

<table>
<thead>
<tr>
<th>Area = 478 110Km² 4.8% of Canada)</th>
<th>Dominant Landcover Class</th>
<th>% total area</th>
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</table>
Mixedwood Acadian forests, sand dunes stretched along seaboards, and coastal islands are some of the unique ecosystems of the Atlantic Maritime Ecozone. It extends from the Gaspé Peninsula at the mouth of the St. Lawrence River southwest through Quebec to the U.S. border south of Sherbrooke. It also includes the three maritime provinces of Prince Edward Island (P.E.I.), Nova Scotia, and New Brunswick.

The harvesting of forests was made possible after the end of the last ice age 10,000 years ago. As the climate continued to moderate, southern temperate vegetation migrated north, merged with existing boreal forests, and spread as the unique mixedwood forest now characteristic of much of the area. The ecozone’s forests have contributed to the development of a distinctive Atlantic Canadian way of life since the area was first settled.

Where tidal mixing and upwelling of deep nutrient-rich waters occur, excellent finfish and lobster fisheries have prospered. Fishing has traditionally played a pivotal role in the ecozone’s history. Today, it is threatened by a diminishing resource base, and aquaculture, mining, and tourism are the preferred alternatives.

The history of human settlement within the Atlantic Maritime Ecozone is intimately linked to its coastline. Both the Mi’kmaq and Maliseet aboriginal populations, who once inhabiting most of the ecozone, relied upon coasts and major waterways for transportation, food, and recreation. The first Europeans to arrive in Atlantic Canada in the 17th century settled in coastal lowlands with promising harbours.

The ecozone saw frequent battles over natural resources. Control was passed from the Mi’kmaq-Maliseet to the French, then to dual sovereignty of France and Britain in 1713, and eventually to the British in 1763.

Landforms and climate

The Atlantic Maritime Ecozone constitutes a cluster of peninsulas and islands which form the northeastern end of the Appalachian mountain chain that runs from Newfoundland to Alabama. The highest point, Mount Carleton in New Brunswick, reaches 807 meters. In the uplands, repeated glaciation has produced shallow, stony soils, and outcrops composed of granite, gneiss, and other hard, crystalline rocks. Rough upland terrain and poor soils are often unsuitable for farming and have discouraged extensive settlement. The inhospitable highlands feature cold, wet climates and acidic soils, but yield vast forests.

Coastal lowlands of the Northumberland Plain accommodate the greater share of the population and agricultural activities. Here, deeper soils are traced to marine deposition and glacial erosion of underlying sandstone, shale, and limestone bedrock. With the exception of P.E.I., abrupt transitions between uplands and lowland basins mark much of the ecozone’s landscape. The majority of the ecozone is overlaid by nutrient-poor Podzol soil and better-quality grey-brown Luvisol soils.

Numerous lakes speckle rugged regions of igneous rock, such as volcanics and granite, which are covered by a thin layer of soil. Rivers and streams predominate in areas of sedimentary bedrock and thicker soils. Over 11,000 kilometers of coastline are deeply indented by tidal inlets and sand dunes. Almost
4 000 offshore islands dotted with lagoons and extensive marshes ring Nova Scotia. Red sandstone cliffs and hard volcanic rocks in the Bay of Fundy tower over intertidal beaches up to 5 kilometers wide.

The proximity of the Atlantic ocean creates a moderate, cool, and moist maritime climate. Most of the ecozone experiences long, mild winters (averaging about -4°C in January) and cool summers (the mean daily July temperature is 18°C). Coastal communities are generally several degrees warmer in winter and slightly cooler in summer.

During late spring and early summer, the mixing of the cold Labrador Current and the warm Gulf Stream produces frequent banks of sea fog over coastal areas. Average precipitation varies from 1 000 mm inland to 1 425 mm along the coast. The average annual growing season ranges from 1 500 to over 1 750 growing degree days above 5°C. Frost-free days, on average, fluctuate from 80 in the New Brunswick highlands to 180 along the coast. With a storm frequency higher than anywhere else in Canada, sunshine can be rare.

**Plants**

Centuries of forestry, agriculture, and natural disturbances have left few pockets of old-growth forest. Today, forests are predominantly secondary and tertiary growth on old clear-cuts and abandoned farms. Decades of logging are also responsible for habitat destruction, soil erosion, and increased nutrient loss.

The Atlantic Maritime Ecozone ranks as the third most forested ecozone with 76% of its surface area covered with forests, which are divided into three distinct regions: Boreal, Great Lakes-St. Lawrence, and Acadian. The Boreal region, associated with fir and spruce, stretches from the northwestern tip of New Brunswick into the Gaspé Peninsula. Eastern White Pine, Red Pine, Yellow Birch, and Eastern Hemlock typify the relatively small Great Lakes-St. Lawrence region of northern New Brunswick. Acadian forests, covering 44% of the entire ecozone, are characterized by a mixture of coniferous and deciduous species. Hardwoods, such as Sugar Maple, Beech, and Yellow Birch, dominate shallow but well-drained slopes and hillsides. Conifers, especially Red Spruce, are concentrated in moist soils, coastal fringes, and areas recovering from disturbances. All three regions are interlaced with numerous lakes and wetlands.

Moss, lichen, ferns, and heathers are typical of swampy areas and rocky barrens. Seaweed and kelp grow along exposed coastlines. Acadian forests are decorated with wildflowers such as Trailing Arbutus, Lady Slipper, Pitcher Plant, and several varieties of violets. The Ostrich Fern, harvested for its fiddlehead in the spring, thrives on deciduous-covered streambanks in New Brunswick and Nova Scotia. Blueberry, Pin Cherry, and Speckled Alder are also common. The Purple Loosestrife, an introduced species, has proliferated and displaced many native wetland species.

At least 10 plants are recognized as either endangered or threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The endangered Water-pennywort, a small creeping species of tropical origin, is limited to two localities in southeastern Nova Scotia. Cottage development and recreational activities have placed the Water-pennywort at risk. The Furbish’s Lousewort grows exclusively along a 200-kilometre stretch of the Upper Saint John River in New Brunswick. Habitat destruction due to farming, forestry, and flooding from hydro-electric development has put the Furbish’s Lousewort on the endangered list.

The Spruce Budworm has significantly influenced the ecozone’s forests. The most recent outbreak, beginning in the late 1960s, either destroyed or severely damaged large expanses of spruce forests. Since 1991, the budworm population has collapsed in all but northern New Brunswick. Other species, such as Jack Pine, have taken advantage of the blight, forest fires, and other disturbances.
Wildlife

Although the ecozone represents only 2% of Canada, it embraces a wide variety of critical terrestrial, freshwater, and marine environments. Kelp and seaweed along rocky coasts provide shelter and food for various marine communities of mussels and crab. The Scotian Shelf off Nova Scotia is one of the most productive offshore areas in the ecozone. Low-lying beaches and tidal flats of the Upper Bay of Fundy and the southern Gulf of St. Lawrence are dominated by burrowing crustaceans. The Gulf is well-known for its scallop, mackerel, groundfish, and herring fisheries. Seals, dolphins, porpoises and Black Guillemots are among the higher predators within the ecozone. Both seal- and whale-watching are popular tourist attractions.

Rivers draining the area are vital for the commercially important Atlantic Salmon and other ocean fish that return to inland streams to spawn. Brook Trout, Gaspereau, Halibut, and Bass are highly valued by recreational and commercial fishers.

Lakes and waterways within forests supply habitat for herons, loons, and freshwater ducks, while osprey and eagles nest in tall trees. Canada Goose, Blue-winged Teal, Ring-necked Duck, and 31 other bird species breed exclusively in the unique freshwater habitats of the Atlantic region. Tens of thousands of shore and migratory birds feed on crustaceans in the tidal mudflats of the Bay of Fundy. With productive seas and substantial coastal estuaries, the Atlantic Maritime Ecozone is often referred to as “an international crossroads for seabirds.”

Much of the ecozone’s wildlife is dependent on forest ecosystems. Terrestrial mammals include Black Bear, Bobcat, Snowshoe Hare, Northern Flying Squirrel, and White-tailed Deer. Large moose herds concentrate in various regions, especially in the heart of the Chics-Chocs mountains of the Gaspé Peninsula. Wolves, Mink, and the occasional Lynx also reside in the ecozone.

Alteration and loss of habitat from human activities are the greatest threat to wildlife. Fragmented landscapes and species decline can be attributed to logging, agriculture, overfishing, and urbanization. The Grey Whale has disappeared from the Atlantic after centuries of hunting. The endangered status of the Acadian Whitefish is the result of overfishing and water quality degradation from acid rain and other contaminants. The threatened Roseate Tern’s feathers were exploited by the fashion trade of the 19th and early 20th centuries. Today, the species is challenged by expanding Herring Gull populations preying on its eggs and chicks.

Many initiatives have been taken to preserve the ecozone’s unique fauna. Provincial regulations and protected areas help maintain species and habitat. Machias Seal Island, a migratory bird sanctuary in the Bay of Fundy, is home to the only colonies of the Atlantic Puffin and Razorbill in New Brunswick. Several species also seek refuge in the ecozone’s six national parks. The threatened Blanding’s Turtle population, for
example, is almost exclusively confined to acidic waters and peaty soils within Kejimkujik National Park.

**Human activities**

No single resource has influenced socio-economic development in the Atlantic Maritime Ecozone more than fish. For 500 years the seas off Atlantic Canada were one of the world’s richest commercial fisheries. Traditional fisheries focused on groundfish: Cod, Pollock, Haddock, Plaice, and, closer to shore, Mackerel. Modern fishing technology led to new heights in the number of ships and catch levels. The Northern Cod catch rose from about 200,000 tonnes to 300,000 tonnes a year between 1850 and 1950. With the introduction of foreign fleets, the annual catch in the northwest Atlantic climbed to a peak of 800,000 tonnes by the late 1960s. A drastic decline to 200,000 tonnes a year in the 1970s was followed by a catastrophic collapse in the 1980s. The collapse of the groundfish industry is the result of severe economic pressure causing the resource base to diminish.

Traditional fishing-dependent communities now face many challenges. Aquaculture, or fish farming, may compensate for some of the economic setbacks. This new and expanding industry can employ some former fishers and helps satisfy a world-wide demand for high-quality fish products. Today, aquaculture concentrates primarily on finfish, such as Atlantic Salmon, and various shellfish, such as Blue Mussel, Oyster, and Lobster. In 1993, P.E.I. alone exported nearly 4,500 tonnes of cultured mussels, worth almost $10 million.

A relatively short, cool growing season and mediocre soils have hampered farming in many regions. Specialized potato farms on fertile lowland soils throughout most of P.E.I. and northwestern New Brunswick, along with prosperous fruit orchards in the Annapolis-Cornwallis Valley of Nova Scotia, are two exceptions. In 1991, agriculture accounted for 31% of total resource-based employment. Although less land area is farmed today, that which remains is used more intensively. In fact, only 8.7% of the ecozone’s surface cover area is now classified as agricultural cropland.

Both forestry and tourism contribute significantly to the ecozone’s economy. The 1991 forestry and forest products labour force consisted of some 48,000 workers. The ecozone’s economically strong pulp and paper industry uses roughly 65% of the total volume of wood harvested. Naturally scenic landscapes are principal attractions for tourists. Places of interest include Cape Breton Island and its celebrated Cabot Trail, and the Bay of Fundy, which features 16 meter tides, the world’s highest. Hiking, birdwatching, and photography are popular ecotourism activities.

The Atlantic Maritime Ecozone had an estimated 1991 Gross Domestic Product of approximately $40 billion, contributing 7% of Canada’s total. The ecozone provides 12% of Canada’s total resource-based employment, with the fishery and fish products sector accounting for 25% of this total.

Home to over 2.5 million people in 1991, the ecozone represents 9% of Canada’s population and 6% of its urban population. Contrary to most ecozones, more people live in rural areas than cities. Today, the urban population sits at 49%, significantly less than the national average of 76%. Halifax represents the largest metropolitan area, with 320,000 residents in 1991. Small fishing villages and resource-dependent communities hugging coastlines are more commonplace than large urban centres.
### Table 16  Statistical Profile: Atlantic Maritime Ecozone

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<th>Area = 203 750 Km² (2.0% of Canada)</th>
<th>Dominant Landcover Class</th>
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<td>Manufacturing</td>
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<td>Charlottetown, P.E.I.</td>
<td>33 153</td>
<td>Construction</td>
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Mixedwood Plains Ecozone

An extensive system of waterways, including the St. Lawrence River and the Great Lakes, combines with surrounding rich fertile soils to create one of the most productive ecozones in Canada. The Mixedwood Plains Ecozone, encompassing a relatively small area of 175,963 square kilometers, is bounded by three Great Lakes in southern Ontario and extends along the St. Lawrence shoreline to Quebec City. With its relatively mild climate, it represents the most populous and prosperous terrestrial ecozone.

Native communities, including the Mohawk, Algonquian, Iroquoian, and Cree, inhabited the favoured plains long before European settlement. The earliest French arrivals, also recognizing the St. Lawrence River’s many advantages, established themselves along the shoreline at Quebec City in Hamilton, and Toronto in Upper Canada during the mid-18th century.

Interlaced with national and international transportation routes, the ecozone has become the industrial and commercial heartland of Canada. Urban centres encroach on remaining prime agricultural land as the population continues to grow. Settlement and resource extraction have dramatically altered the land.

Landforms and climate

Until the most recent continental ice sheet retreated 11,000 years ago, the Mixedwood Plains Ecozone was buried under more than a kilometer of ice. Following the ice age, the St. Lawrence and lower Ottawa valleys were covered by the Champlain Sea for another 1,200 years. Thick marine clay deposits in southern and southeastern Ontario and southwestern Quebec are the products of glacial action and the now extinct Champlain Sea.

Beneath the urban centres and agricultural fields are mesozoic and paleozoic sedimentary rock. Striking physical features break up the gently rolling plains of most of the ecozone. One of the most prominent is the Niagara Escarpment from Niagara Falls to the northern tip of the Bruce Peninsula and Manitoulin Island.

Limestone, shale, and sandstone are characteristic of the flat-lying St. Lawrence lowlands. Mount Royal rises to 227 meters above sea level from the widest and flattest sections of the Montreal Plain. Some visually dominant landforms in the area are the St. Narcisse terminal moraine on the north side of the St. Lawrence River, and the Drummondville and Highland Front moraines of the south shore.

Over 6,000 drumlins are scattered among the extensive sand and limestone plains in the ecozone’s southern stretches between lakes Huron, Ontario, and Erie.

The ecozone is endowed with abundant freshwater resources, including four of the Great Lakes — Superior, Huron, Erie, and Ontario — and the St. Lawrence River from Kingston to Quebec City. These Great Lakes constitute nearly 20% of the world’s fresh water. The outflow of the St. Lawrence is the greatest of any river in Canada and ranks thirteenth worldwide. Tributaries, such as the Ottawa, Maurice, and Saguenay, bolster the river’s flow along its 600-kilometre route to the gulf. Rivers and lakes occupy roughly 42% of the ecozone’s total surface cover.

Variations in climate, vegetation, and soils influence the land-use patterns. Podzol soils in
northern stretches, while generally useless for agriculture, are suited to forestry and recreation. In the south, grey-brown Luvisol soils, developed under forest vegetation from glacial deposits, are favoured for agricultural crops such as tobacco and fruit.

The climate of the Mixedwood Plains produces relatively warm summers and cool winters moderated by surrounding water bodies. Mean daily January temperatures range from -3°C to -12°C, whereas mean daily July temperatures are 18°C to 22°C. The ecozone supports a wide variety of agricultural activities with an average annual growing season, north to south, ranging from 1750 to 2500 growing degree days above 5°C. This region also receives 720 to 1000 mm of precipitation annually. Due to its location in the midst of a significant North American storm belt, weather in the plains can change rapidly. Several southern cities, such as Woodstock and Guelph, receive considerable amounts of snow.

**Plants**

Vast tracts of forest once blanketed most of the Mixedwood Plains. Areas to the north and east of Toronto were covered in the Great Lakes-St. Lawrence forest region, characterized by Eastern White Pine, Eastern Hemlock, Yellow Birch, and Red Pine. An abundance of broad-leaved species, such as Sugar Maple, Red Oak, Basswood, and White Elm, were also widely distributed throughout the area. A small portion of the deciduous, or Carolinian, forest region reaches its northern limits in southwestern Ontario between lakes Huron, Erie, and Ontario. Tuliptree, Blue Ash, Red Mulberry, and Kentucky Coffee-tree are confined largely to the warmest portions of the ecozone. These unique deciduous forests are intermixed with Black Walnut, Sycamore, and the more common Great Lakes-St. Lawrence forest species.

Very little of the original forest remains today. Centuries of agriculture, logging, and urbanization in particular, fragmented the landscape into isolated pockets of forest. In Ontario, many of these pockets are now farms, woodlots, urban forests, or protected areas. Heavily forested areas are, however, more common around the northern lakes. Presently, the ecozone’s forests consist of 12.8% mixedwood, 2.1% deciduous, and 0.2% coniferous trees.

Even though the Mixedwood Plains represent Canada’s smallest terrestrial ecozone, they contain over half the nation’s endangered and threatened species. The American Ginseng, designated as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), inhabits rich moist deciduous forests in southwestern Quebec and southern Ontario. Populations have been drastically reduced by excessive cattle grazing, logging, and the commercial harvest of its roots. In the late 1980s the Blue-eyed Mary disappeared from open woodland sites along waterways in south-central Ontario.

Influenced by the surrounding Great Lakes and tropical air from the Gulf of Mexico, the Carolinian forests are home to a unique combination of plants and wildlife. Stretching from Windsor in the west to the eastern border of Metropolitan Toronto, this zone represents one of Canada’s most vulnerable ecosystems. Today, forest cover ranges from a mere 3 to 16%, and 40% of Ontario’s rare plants are restricted to the region. Endangered species include the Prickly Pear Cactus, Small-whorled Pogonia, Cucumber Tree, and Wood Poppy.

Trilliums, Clover, Black-eyed Susans, Goldenrod, and Wild Raspberry are common in the ecozone’s remaining forests. Thickets and abandoned fields give rise to successional species such as Staghorn Sumac, Highbush Cranberry, Red-osier Dogwood, and Willow. Various aquatic species inhabit the few remaining wetlands in the Great Lakes Basin and along the shorelines of Lake St. Clair, Lake Erie, and the St. Lawrence River. Native and exotic plants, such as cattails, water lilies, sedges, and the introduced Purple Loosestrife, can be found in wetlands as well.
Wildlife

The Great Lakes and St. Lawrence River were primary attractions for early settlers to the Mixedwood Plains, and not only as a travel route. The waterways supported a tremendous wealth of fish and other aquatic species that stimulated economic growth and regional development. The Great Lakes were once dominated by large, bottom-dwelling species such as Lake Trout, Whitefish, and Sturgeon. Walleye and Largemouth Bass flourished in sheltered bays and the warm, shallow Lake Erie.

For decades aquatic communities have suffered from the effects of intense commercial fishing and habitat destruction. Many spawning and feeding areas have been lost to siltation, pollution, and dredging. Centuries of overfishing forced the Great Lakes commercial fisheries to focus primarily on introduced non-native species, such as Rainbow Smelt, White Perch, and Common Carp. Today the St. Lawrence River and its marine habitats support a diverse collection of aquatic species, including Atlantic Tomcod, Northern Pike, baleen whales and the endangered Beluga Whale.

The introduction of various exotic species is also responsible for serious economic and ecological damage. Both the Sea Lamprey and Zebra Mussel, for example, have dramatically altered aquatic ecosystems. The Zebra Mussel, aggressively spreading through most of the ecozone’s waterways since 1986, has disrupted food chains by reducing phytoplankton and zooplankton populations.

Numerous bird species, including the Cardinal, Green Heron, and Carolina Wren, are unique to the ecozone. Typical residents of remnant forest patches and urban greenspace include Blue Jay, Whip-poor-will, Red-headed Woodpecker, and Baltimore Oriole populations. The Long Point Biosphere reserve in southern Ontario now plays a vital continental role in the protection of migratory bird habitat. Attracted to extensive marshes for staging and overwintering purposes, roughly 280 bird species have been banded in the region since 1960. For the Henslow’s Sparrow, however, habitat protection has been minimal. A native to meadows and abandoned agricultural fields in southern Ontario, the sparrow was declared endangered by COSEWIC in 1993. Long-term population declines are related to intense cultivation and urban sprawl.

Two of the three reptiles listed as threatened by COSEWIC reside within the ecozone. The eastern Massasauga Rattlesnake, commonly perceived as dangerous, is restricted to diminishing wetlands in Ontario. Stretches of the St. Lawrence River, as well as lakes St. Clair, Erie, Ontario, and Champlain, are home to the increasingly rare Spiny Softshell Turtle.

Forests and grasslands support a wide variety of terrestrial organisms in the Mixedwood Plains. Characteristic mammals include White-tailed Deer, Black Bear, eastern Cottontail, and Grey and Black Squirrels. Foxes and wolves make appearances outside urban settings, while coastal wetlands and tributaries provide crucial habitat for beaver and muskrat. Although many species have lost varying degrees of habitat to urban
expansion, a handful have proved resilient. Nuisance animals, such as raccoons, house mice, and groundhogs, have found special niches within urban ecosystems and thrive there.

**Human activities**

Most human activities in the ecozone, both past and present, are associated with urbanization. Containing 52% of Canada's 1991 population, it is the most densely populated ecozone in the country. Of the nation's 25 largest cities, 13 fall within the ecozone. The largest — Toronto, Montreal, Ottawa, and Quebec City — are connected by extensive networks of expressways. Between 1966 and 1991, Toronto’s population grew by 80%, and the Toronto metropolitan area now houses 14% of all Canadians, compared with 11.5% living in the Montreal area.

Even though 85% of residents live in urban areas, settlement patterns have changed from the traditional compact, centralized city to new suburbs spreading into surrounding countryside. Smaller cities are no exception. Kitchener-Waterloo, for example, grew by 57% between 1971 and 1991. Several outlying municipalities north and east of Montreal, such as St-Lazare and Blainville, also grew by over 40% from 1986 to 1991. Home to 11 million people in 1971, the entire ecozone grew to 14 million by 1991.

Intensive urban development in the Mixedwood Plains has led to severe environmental degradation. Relocation to the suburbs and urban fringe escalated dependency on private automobiles. Consequently, residents in the Windsor-Quebec City corridor now breathe some of the highest levels of air pollutants, including ground-level ozone and suspended particulates.

The area had an estimated Gross Domestic Product in 1991 of $325 billion, contributing 34% of Canada’s resource-based employment, and half of that number work in the agriculture and food industry. The ecozone’s service industry, constituting a third of the labour force, is immensely important to national and international trade and commerce. Oil refineries, power-line corridors and industrial parks dotting vast tracts of the landscape are evidence of the ecozone’s dominant service and manufacturing industries.

Fertile soils and a relatively mild climate have created excellent agricultural land. In fact, the ecozone contains over 50% of Canada’s class 1 agricultural land, and 62% of the land with a capability of classes 1, 2, and 3. The Niagara Peninsula, famous for its fruit orchards and vineyards, is the warmest and most intensively cultivated part of the ecozone. Corn, soybeans, and specialty crops such as tobacco and vegetables are concentrated in southern regions enjoying 2 000 to 2 500 growing degree days. The cultivation of mixed grains also enhances hog, dairy, and beef livestock production throughout the ecozone. Today, urban expansion is the primary reason for loss of prime agricultural land.

Tourism and recreation continue to strengthen the ecozone’s economy. Niagara Falls, the CN Tower in Toronto, and the historic cities of Montreal and Quebec are a few of the many popular tourist attractions. Numerous northern communities, once heavily dependent on logging and mining, have turned to tourism for additional sources of revenue. Cottage development along the Great Lakes and St. Lawrence shorelines has intensified as urban residents spend more of their leisure time beyond city limits. Marinas, resorts, and restaurants are now common sites in the countryside.
Table 17  Statistical Profile: Mixedwood Plains Ecozone

<table>
<thead>
<tr>
<th>Area = 194 430 Km$^2$ (2.0% of Canada)</th>
<th>Dominant Landcover Class</th>
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The Marine Ecozones of Canada

Figure 3  Map of Canadian marine ecozones

Legend

- Pacific Marine
- Arctic Archipelago
- Arctic Basin
- Northwest Atlantic
- Atlantic Marine
The waters of the Pacific Coast are perhaps best known to Canadians today because of the popularity of tourism and the prominent, but troubled, fishing industry. However the Pacific coast of British Columbia is also home to ancient indigenous cultures.

On his third voyage around the world in 1778, Captain James Cook became the first European to be recorded landing on the Pacific coast of present-day British Columbia. There he encountered the ancient communities of the "People of the Totem". Humans had already been living in coastal British Columbia and the Queen Charlotte Islands for at least 8,000 years. The heavily forested, mountainous terrain along the coast led to the emergence of a sea-dependent culture. In their own waters, the people of the Pacific coast had learned sea-faring and fishing skills superior to the first European explorers. The Haida, in particular, had a reputation for undertaking extended sea voyages.

The Pacific Marine Ecozone is home to abundant plant and wildlife, but is also coming under pressure from one the fastest growing human populations in North America. The Ecozone extends from the southern tip of Vancouver Island to Dixon Entrance, north of the Queen Charlotte Islands. However, from an ecological perspective, and ignoring international boundaries, this ecozone actually extends north to Alaska and the Bering Sea, and south along the coasts of the states of Washington and Oregon. The Pacific Marine Ecozone forms an important segment of the eastern Rim of the Pacific Ocean.

Landforms and Climate

The ecozone takes in all of Canada’s Pacific west coast beginning from the fjord-dominated coast and extending westward out to sea over a narrow continental shelf and slope which underlies the entire length of the ecozone. This shelf is the leading edge of the great North American continental tectonic plate. As the plate subducts the Pacific tectonic plate which forms the bottom of the Pacific Ocean, the geological forces at work along the edge of this shelf cause undersea volcanoes and earthquakes for which this region is famous.

Sea ice is generally absent in the Pacific Marine Ecozone. Due to the geographic barrier imposed by the Alaskan peninsula, cold currents do not flow down the west coast. There is little oceanic water exchanged between the Arctic and Pacific Ecozones. From south to north within Canada’s borders, ocean surface temperatures vary only about 3°C. Within the ecozone, ocean temperatures vary over the seasons within a narrow range of approximately 7°C, a striking contrast to the 20°C variation along the east coast. Seasonal ice can only be found outside Canada’s territorial waters at the northern boundary of the Bering Sea, in the Sea of Okhotsk, and in bays and inlets, especially where there are considerable flows of fresh water off the land. Based on its stable temperatures the Pacific Marine Ecozone may be considered a transition zone between the polar waters of the Arctic and the temperate waters of the mid-latitude Pacific Ocean.

Plants

Throughout this ecozone, freshwater discharges from rivers such as the Fraser, Skeena, and Nass carry nutrients to the ocean, stimulating the growth of Phytoplankton and algae, among others. Towards the southern end of Vancouver Island, deep water upwelling also encourages a prolific ocean environment. Unlike the Atlantic marine ecozones, the Pacific Marine Ecozone
has little geographical connection with the Arctic, so it has different populations and distributions of species than the Atlantic Ecozones. In the intertidal zones (between high and low tide and always underwater) lie vast forests of Macrocystis, or Giant Kelp along with several varieties of seaweeds and coral reefs. Soon after records of Captain Cook’s voyages were published in 1784, British and American traders sailed to the Pacific waters in search of sea otters. By the early 1930s, the Pacific population of sea otters was extirpated by hunting. As a result, sea urchin populations exploded, decimating many of the kelp forests and their associated algae communities. Today, otter populations are rising again. The kelp habitat may also recover. Along the water’s edge, coastal salt marshes and mudflats contain vast beds of eelgrass, important sites where Pacific herring schools lay their roe.

Wildlife

The Pacific Ecozone is home to about 3,800 species of marine invertebrates, a mixture of neritic (living in the tide waters and landwashes), oceanic, sub-polar and benthic (or bottom-dwelling) plankton. These populations make up 3.5% of all the marine invertebrates in the world. The large invertebrate populations provide rich food sources for fish. Approximately 220 fish species live within the ecozone. The Pacific Herring is the most abundant. Salmon, halibut, steelhead and dolly varden, among others form the backbone of commercial fisheries. Over the years, salmon and herring stocks have been overfished, and while herring stocks are rebounding, salmon stocks are still in dangerous decline.

Marine mammals include Stellar sea lions, sea otters, northern fur seals, Orca and gray whales. Very large breeding bird populations include ducks and geese, petrels, guillemots, murrelets and auklets, with some puffins and murres. Several species of raptors, including bald eagles and osprey feed in the near-shore marine wetlands and rivers. All of the B.C. breeding populations of Brandt’s cormorants occur on the west coast of Vancouver Island.

Human Activities

The temperate climate, esthetically pleasing scenery, and booming economy have combined to make Canada’s Pacific Coast a desirable place for humans to live. As a result, the Pacific Coast is the fastest growing population centre in the country. By 2016, the population of greater Vancouver is expected to reach 5-million (B.C. Ministry of Environment, 1993). Throughout the ecozone, fishing, shipping, and marine recreation are the main human activities which contribute to the area’s high standard of living. But these lucrative activities, along with oil pollution from shipping, urban run-off, destruction of shore-line habitat, and industrial pollution, are also among the main human ecological impacts. In 1967, overfishing led to a collapse of the herring stocks. Government controls stopped almost all herring fishing, allowing the stocks to rebuild. By 1993, most of the Pacific herring stocks were in good condition. Today, salmon stocks are overfished and continue to decline to dangerously low levels.
This Ecozone defines the fjords, channels, straits and open waters that surround Canada’s northern archipelago - the hundreds of islands that make up the Queen Elizabeth chain. The islands of the archipelago form the Northern Arctic Terrestrial Ecozone. Since the Arctic Marine ecozone surrounds the islands, the ecozones are inextricably interrelated. The Marine Ecozone follows the northern continental shelf from Mackenzie Bay in the Beaufort north to the Lincoln Sea between Ellesmere Island and Greenland. It then curves southward through the Nares Strait, taking in all of Baffin Island, except for those section of the east coast which are part of the Northwest Atlantic Ecozone. The ecozone encompasses all waters to the south-west of Baffin Island, including the Gulf of Boothia, Foxe Basin, and then on south into one of Canada’s most prominent geographic features, Hudson Bay.

**Landforms and Climate**

Scoured by glaciers, the Arctic Archipelago is characterized by precipitous fjords and channels. Water depths average 200 to 500 meters, however deep water runs down to 900 meters around the Queen Elizabeth Islands. Sea ice jammed fast to the land and glaciers are abiding features of the area. On eastern Ellesmere Island, glaciers which extend into the sea break off, or “calve” huge icebergs into the Nares Strait. In the Northwestern Archipelago, sea ice exists all year-round. The rest of the ecozone is an area of seasonal ice cover. Through most of the ecozone, maximum ice thickness is reached in May, followed by spring breakup. By September, most of the ice has either melted or been carried away to the south by currents. Polynyas, places where currents and upwellings create open water, can occur throughout the ecozone. In summer, shore leads and areas of open water can be found farther north. From year to year, ice conditions are variable and unpredictable.

The short cool summers of the Land of the Midnight Sun give way to long cold winters. Long periods of daylight in the summer help to stretch the short summer growing season, however the air temperature never gets very warm. Even in July, mean daily temperatures average only 10°C. In winter, temperatures average about -30°C, and can get much colder.

In the southern range of the ecozone lie Hudson and James Bays. Their more southern latitudes, shallower waters and more temperate climates encourage a proliferation of vegetation and wildlife.

**Plants**

In the high Arctic, sea ice covered with snow absorbs much of the solar radiation necessary for photosynthesis. But by late summer, the ice has thinned out enough to allow a seasonal Phytoplankton bloom. The largest natural upwelling of sea water in the ecozone is the North Water Polynya. It occurs in northern Baffin Bay near the Nares Strait, encouraging an earlier and more prolific bloom of Phytoplankton than is found in the rest of the ecozone. Further south in the ecozone, intertidal zones support large forests of kelp.

**Wildlife**

During the few weeks of Arctic summer, dozens of species of migrating birds make use of the unpredictable sections of open water which appear in the ecozone. As the ice breaks up, the ice edges become very important areas for
mammals and seabirds. Feeding, staging, and moulting are some of the critical annual activities performed in the ecozone by small numbers of loons, Tundra Swans, Geese, ducks, and several species of shorebirds, jaegers, gulls, Arctic terns, alcids, and fulmars.

Polar bear and ringed seals roam throughout the region. Bearded and harp seals are found along the east coast of Ellesmere Island, especially where open waters promise easy breathing. In winter, the unfrozen North Water Polynya serves as a refuge for these air-breathing mammals. Early in the 20th century Arctic bowhead whales were hunted almost to extinction. While numbers have rebounded somewhat in the western Arctic, the eastern stock is still severely depleted.

Large schools of small Arctic Cod exist across the ecozone supporting populations of seals, beluga whales and narwhals. It has been estimated that 148,000 tonnes of these fish are consumed annually by seabirds and marine mammals in Lancaster Sound alone. Arctic char are plentiful in the Queen Maude Gulf. Shrimp live in the south Baffin and Hudson Strait waters, and scallops are found off south Baffin Island and in Hudson Bay.

Important herds of the endangered Beluga whale spend their summers along the west coast of Hudson Bay. The largest population of polar bears in Canada builds dens along the coast of Hudson Bay near Churchill, Manitoba. The tidal flats and salt marshes of Hudson Bay welcome some of the world’s largest concentrations of breeding and migrating waterfowl. One of the largest known populations of Peregrine falcons in the world is found along the northwest coast of Hudson Bay.

**Human Activities**

The waters of the Arctic Archipelago Ecozone wash the shores of three Canadian provinces and two Territories. Biologically, the Arctic Archipelago Ecozone is as productive, or more productive than the adjacent terrestrial surfaces. Canadian Inuit find most of their traditional food in this ecozone, so hunting and fishing are significant human activities. Arctic char and Greenland Halibut (turfot) support commercial fisheries in Baffin Bay. Oil and gas exploration and development continue to be major sources of potential ecological stress in the ecozone, especially in the Beaufort Sea. As mineral prospectors gain more experience operating in the north, large new mineral deposits may be found, raising questions about mine waste and tailings that may find their way into the sea. To the south, it seems inevitable that hydro-electric development will continue on the rivers which drain into James Bay. Changes in water flows, salt content, and the presence of heavy metals disturbed by dam construction will create unpredictable impacts on the marine ecology of the southern portion of the ecozone. As human populations continue to grow, the impacts of urbanization will also continue, especially in the more southerly reaches of the ecozone. The long-range transport of pollutants into the Arctic, such as PCBs, mercury and DDT is a serious problem here, as in other parts of the Arctic.
Arctic Basin Ecozone

Most of Canada’s Arctic is defined by the Arctic Basin Ecozone. It extends from the southern edge of the permanent ice-pack in the Beaufort Sea north and east over the Canada Basin of the Arctic Ocean. It skirts the Queen Elizabeth Islands of the Arctic Archipelago, touches the coast of Ellesmere Island, and reaches almost to the northwest coast of Greenland. The overwhelming ecological characteristic of this ecozone is its permanent 90 - 100% cover of pack ice, the giant ice cap floating on the ocean at the top of the world. The entire ice pack slowly rotates in a counter-clockwise pattern roughly centered around the North Pole. The rotation is driven by the Arctic Ocean Gyre, one of the main Arctic Ocean currents. The heavily ridged ice reaches a thickness of 2 meters and more. Islands of ice, several kilometers square, are common.

Landforms and Climate

The Arctic Basin Ecozone is a true oceanic ecozone in that it touches almost no land except at the north coast of Ellesmere Island. The undersea geography is dominated by the deep water of the Canada Basin, which plummets to an average depth of about 3600 meters. The Canada Basin extends from the Beaufort Sea almost to the North Pole, where it is bounded by the Lomonosov Ridge, a submarine mountain range rising to 1000 meters below the ocean surface. Near the southern margin of the permanent ice pack, the Mackenzie River discharges a considerable plume of fresh water into Mackenzie Bay in the neighboring Arctic Archipelago ecozone.

The climate is extremely cold and dry. In January, mean daily temperatures range from -30 to -35°C. In summer, the mean daily temperature only rises to a chilly 5°C. Annual precipitation ranges from 100 to 200 mm - sparse compared to Canada’s wettest place on land, St. John’s, Newfoundland with its 1500 mm a year. And yet, against these most strenuous of extremes, there is life in Canada’s Arctic.

Plants

The icy conditions in this ecozone provide a daunting habitat. Because of the constant ice cover, and almost no tides, the waters of the Arctic Basin are not mixed, so there is no opportunity for nutrients to arrive from other places. In fact, the biological productivity of the ecozone is only 1% of the well-mixed Atlantic Ocean. But despite the rigorous conditions, ice algae grows on the underside of sea ice in the summer. Biological “hotspots” consisting of blooms of microscopic plants called Phytoplankton occur in spring and summer along the edges of the pack-ice, or in places called Polynyas where currents are strong enough to keep the water from freezing. These blooms provide the basis of the Arctic food chain.

Wildlife

Thanks to the Phytoplankton and algae blooms, higher animal species survive in this hostile environment and are adapted to life on or near the permanent ice pack. Along the edges of the ice pack live walrus, polar bear, beluga whales, narwhals, and bearded, harp, ringed and harbour seals. Migratory birds pass through the ecozone, and the hardy and aggressive ivory gull lives year-round along the edges of the ice pack. This scavenging bird will eat fish, crustaceans, dead whales and seals. A polar bear kill provides a rare bonanza.
Beneath the ice, life is present, but sparse. About 130 fish species occur across the Arctic. The greatest numbers occur in the west and south, with schools of Arctic cod and ogac, Arctic char, sculpin, eelpout, and snailfish being the most common. It is estimated that 50% of the living creatures in the Arctic are benthic organisms like anemones, clams, sea worms and sea stars. Even today, there has been little research so almost nothing is known about these creatures except that they are crucial players in the Arctic food web.

**Human Activities**

Most of the Canadian Arctic remains unexplored. Since the Arctic Basin Ecozone touches almost no land, human presence is limited to small-scale hunting expeditions along the edges of the pack ice and to adventurers who risk the ice. In recent years, aircraft and ice-breaking ships have been used to transport scientists, and tourists into the area. Scientific studies have largely concentrated on finding areas of potential oil and gas development inshore along the edges of the ice pack, however the permanent ice pack offshore poses formidable obstacles to petroleum exploration and drilling.

Toxic chemicals have spread through the food chain in the Arctic. Substances, such as PCBs and mercury, are released in distant industrial centers and are transported to the Arctic by global weather systems. These dangerous substances tend to build up in the bodies of the marine mammals upon which Canada’s aboriginal peoples depend as a major source of food. PCBs are a known contaminant of human breast milk in the Arctic. Commercial over-harvesting of mammals and birds has endangered the wildlife populations, especially the bowhead whale. Subsistence hunting by Canadian Inuit has also been affected by commercial exploitation of traditional country foods.
The Northwest Atlantic Ecozone and the Atlantic Marine Ecozone encompass almost the entire eastern Canadian continental seaboard, from the Arctic to the Gulf of Maine - some 52,000 kilometers of coastline, representing about 21% of all of Canada's coasts. Early explorers to Canada's Atlantic coasts returned to Europe disappointed that they had not found a route to Asia. However, their stories of fish so plentiful they could be scooped up in baskets led to further exploration and eventual settlement. The east coast ecozones contain some of Canada's richest and most imperiled ecosystems. The consequences of overfishing in the Atlantic ecozones are now well known, but further understanding of the ecology of these areas is essential if there is to be hope of restoring sustainable commercial fisheries in the region.

The Northwest Atlantic Ecozone begins in Canada's far north at the mouth of the Nares Strait between Ellesmere Island and Greenland. It continues south along the western edge of the permanent ice pack, then touches Baffin Island at Cape Dyer. It takes in the remaining coast of Baffin Island rounding Resolution Island and then west to the Hudson Strait. Arcing eastward again, the ecozone follows through Ungava Bay. It takes in all of the Labrador Coast, the west and north-east coasts of Newfoundland, and the entire Quebec, New Brunswick, P.E.I. and Nova Scotia coasts of the Gulf of St. Lawrence. Offshore, the ecozone follows the line of the underwater continental shelf, descending south from the permanent ice sheet near the Davis Strait to come ashore at Newfoundland's Avalon Peninsula.

**Landforms and Climate**

Much of the coastline contained in the Northwest Atlantic Ecozone is characterized by fjords, cliffs, and bald rock created by repeated glaciation. There are over 440,000 islands along the coasts. Offshore, the continental shelf extends to a distance of about 150 kilometers, with water depths ranging to 200 meters. Within the ecozone, tidal fluctuations range from 9 to 12 meters. In parts of the Gulf of St. Lawrence, tidal action is much smaller, with average fluctuations of less than one meter. However, tides to challenge the Bay of Fundy occur in Ungava Bay.

Major ocean currents flow through the ecozone. The Labrador current transports cold water from the north. Near the Grand Banks, this cold-water flow merges with the warmer flow of the Gulf Stream from the south. Like the Pacific Marine Ecozone, the Northwest Atlantic Ecozone forms a transition between the cold northern waters and the more temperate southern waters. Average temperatures differ by more than 20°C between the Arctic waters and the Gulf Stream. In August, surface temperatures vary between 3 and 8°C. Below the ocean surface, temperatures remain below 0°C all year round. Sea salt keeps the sub-surface waters from freezing. In the Gulf of St. Lawrence, salt levels are lower due to the fresh water flowing from the St. Lawrence River. Depending on the season and latitude, sea ice is a feature throughout much of the ecozone. In November or December, sea ice begins to form in the Labrador Sea. By February or March, the sea ice regularly reaches the northeast coast of Newfoundland and onto the Grand Banks, accompanied by thousands of icebergs. Most years, the St. Lawrence River freezes, closing shipping. In May or June, the ice begins to clear,
and by July, the coasts are ice-free well north on the coast of Labrador.

**Plants**

In the northern reaches of this Ecozone, sea ice predominates, limiting botanical productivity to species of algae and benthic plants like anemones. Further south, conditions are favorable for many varieties of Phytoplankton, algae, kelp and sea weeds. Coastal intertidal zones are especially productive. The intertidal zones provide shelter and food for a diverse community of marine animals that include mussels, lobster and crab.

**Wildlife**

The waters over the continental shelf of the Northwest Atlantic Marine Ecozone are famous for their prolific range of marine mammals, birds, and fish. This ecozone is home for part of the year to the endangered Northern Cod. Twenty-two species of whale, and six species of seal occur in the ecozone. Pods of humpbacks, bluefins, and minke whales feed near shore, and sperm whales can be found further offshore. Killer whales, porpoises and dolphins also occur, but are not common. Millions of harp seals live along the coasts. There is debate as to whether harp seals are partially to blame for the decline of the cod stocks.

The steep, rocky cliffs and thousands of islands in this ecozone, provide excellent habitat to some of the largest sea bird colonies in the world. Concentrations occur on the Gannet Islands off the southern Labrador coast, and on the Funk Islands off Newfoundland's northeast coast. Large colonies are also found in the Gulf of St. Lawrence on Anticosti Island, Bonaventure Island, and the Magdalen Islands. Colonies often include puffins, petrels, cormorants, thick-billed murrels, and many varieties of gull.

**Human Activities**

The richness of the Atlantic Ocean lured 16th century Europeans in search of wealth. Legendary quantities of fish were scooped out of the waters off the east coast. It became a comfortable, and lucrative notion that there were more fish in the sea than could ever be taken out. The sea provided a sometimes meager living for fishing families, while enriching merchants and financiers. But by the 1990s, commerce and politics, mixed with uncertain science practically wiped out Canada's cod stocks. A way of life that had supported the people of eastern Canada for 400 years was seriously undermined. In 1992, the Government of Canada imposed a moratorium on cod fishing in most Atlantic Canadian waters. It is hoped that eased fishing pressure will allow the stocks to rebuild.

The northern reaches of this ecozone are sparsely populated. Small towns and villages are dotted along the Newfoundland and Labrador coasts and Baffin island. Human activities in the ecozone include seal hunting, subsistence fishing, resource exploration and burgeoning tourism. But offshore factory-freezer trawlers still fish the ecozone taking their official quotas, and sometimes more, of any commercially valuable fish they can find. Concern is
now emerging about the ecological impact of exploitation of the giant mineral deposits that have been found at Voisey’s Bay near Nain, on the northern coast of Labrador.

Further south in the ecozone population density increases dramatically along the shores of the Gulf of St. Lawrence. Industrial pollution and municipal sewage flow into this ecozone. Endangered marine mammals, such as beluga whales are sensitive to toxins in the water. Urban sprawl along the banks of the St. Lawrence River, and around coastal cities has destroyed much wildlife habitat. Municipal garbage dumps have encouraged gull populations to rise, forcing out other species.
Atlantic Marine Ecozone

With the exception of the Grand Banks and the Scotian Shelf, the Atlantic Marine Ecozone is defined by deep water. About half of the ecozone is located well out to sea, the remainder extends to the east coast. The Ecozone’s offshore boundary extends along the edge of the eastern continental shelf. It begins in the Davis Strait, then follows the Labrador Shelf south around the Flemish Cap seamount, taking in the Grand Banks, and coming ashore at the north-eastern tip of Newfoundland’s Avalon Peninsula. The inshore boundary takes in all of Newfoundland’s south coast, Nova Scotia’s east coast, extends into the Bay of Fundy, and south to the Gulf of Maine. Icebergs as big as small mountains, with 90% of their mass underwater are not uncommon in the ecozone and have been feared by mariners for centuries. Because of the danger of collisions with icebergs, sailors named the stretch of ocean from Greenland to south of Newfoundland “Iceberg Alley”.

Landforms and Climate

Off the coast of Labrador, The Atlantic Marine Ecozone essentially begins at the drop-off of the continental shelf and extends on eastward out to sea. But east and south off Newfoundland lie the relative shallows of the Grand Banks, the trailing edge of the North American tectonic plate. Whereas average water depths outside the shelf can range down to thousands of meters, depths on the Grand Banks are 150 meters and less over broad areas. Tidal ranges within the ecozone are normally one to two meters, but the Bay of Fundy is the exception with its famous tidal bores which can top 12 meters.

The ecozone is generally temperate due to the influence of the Gulf Stream. Prevailing winds from the west and southwest also serve to moderate the ocean climate. In August, surface water temperatures can vary between 10 and 23°C. However, like the Northwest Atlantic ecozone, winter and early spring ice can be plentiful along the east coast of the Avalon Peninsula, and in the Cabot Strait between Newfoundland and Nova Scotia. Icebergs are a common sight in late winter and spring off the Newfoundland coast and on the Grand Banks. The mainland coast of Nova Scotia and the Bay of Fundy (except for its northernmost reaches) are essentially ice-free. Off Newfoundland, mixing of the warm currents from the south and the Labrador current from the north creates conditions favorable for famously dense fogs.

Plants

Phytoplankton blooms that can turn the water green with life every spring are the first link in the food chain of the Atlantic Marine Ecozone. Other marine plants, such as seaweeds and kelp are prolific, especially in intertidal zones. Extensive salt marshes occur throughout the zone, particularly in New Brunswick, Nova Scotia, and Prince Edward Island, less so in Newfoundland and Labrador. These tidal wetlands are home to the highly salt resistant saltmarsh cord grass (Spartina alterniflora) and marsh meadow grass (Spartina patens). The salt marshes can also support a variety of other plants, including spike grass, wild barley, sea lavender and sea plantain.

Wildlife

The Grand Banks are among the most biologically productive marine areas in the world. The confluence of the Labrador Current and the Gulf Stream, and the tidal mixing of the water column on the shallows of the continental...
shelf provide ideal feeding and spawning conditions for thousands of species.

Benthic communities are diverse with a huge variety of invertebrates such as barnacles, sea stars, crab, lobster, sponges, scallops, clams and jellyfish, just to name a few. Common fish populations historically included cod, halibut, redfish, herring, silver hake, and turbot. The northern cod spends part of its life-cycle migrating between the Atlantic and the Northwest Atlantic Marine Ecozones. Chronic overfishing by Canada and other nations has reduced many of these species to below commercial productivity, and there are fears that the once-rich Grand Banks cod fishery may not recover to commercial levels.

Common marine mammals in this ecozone include harbour and grey seals, harbour porpoises, and dolphins. Several species of whale are indigenous or migratory in the ecozone, including northern bottlenose, blue, pilot, beluga, fin, minke, and humpback. Significant proportions of the North American or world populations of several species of seabird live within this ecozone. Large numbers of seabirds overwinter on the open ocean off Newfoundland and Nova Scotia, only coming ashore to breed. Among them can be found northern fulmar, greater shearwater, dovekie, and common and thick-billed murres. Breeding colonies for Leach’s storm petrel, kittiwakes, puffins, and common murres can be found on Newfoundland’s Baccalieu Island and Witless Bay islands. Cape St. Mary’s hosts gannets, kittiwakes and common murres. Machias Seal Island in the Bay of Fundy supports large colonies of puffins and Arctic terns. And there are large populations of shearwaters, gulls, eiders and cormorants throughout the region.

The low-lying beaches, salt marshes and tidal flats of the Upper Bay of Fundy, and the southern Gulf of St. Lawrence, are dominated by burrowing crustaceans, such as Corophium and annelid worms. These are extremely abundant at or just below the surface of the tidal mudflats, and are fed upon by migratory birds and other shorebirds. This habitat is the product of the huge tidal fluctuations in the Upper Bay of Fundy, which reach over 12 meters.

Estuaries, where fresh river waters mix with seawater, are productive habitats. They serve as “nursery areas” for the planktonic larvae of many benthic invertebrates such as mollusks and crustaceans, as well as for juvenile fish. For example, the estuaries of the Gulf of Maine are thought to be vital to about 70% of the fish species of commercial importance along the Gulf Coast (Van Dusen and Johnson Hayden 1989).

**Human Activities**

The Grand Banks of Newfoundland lie within the Atlantic Marine Ecozone. The Grand Banks were world renowned for their seemingly limitless populations of cod. But humans reached the limits in the early 1980s. Four hundred years of relentlessly evolving technology driven by steadily increasing demand created a pressure on the cod stocks that could not be sustained. Canadian and foreign fishing fleets depleted the...
ocean of fish. With the commercial extinction of cod a grim possibility, Canada banned cod fishing in 1992 in hopes the stocks would recover. The cod moratorium, a political solution to an essentially ecological problem, put 40 000 people out of work in Atlantic Canada. Sharing endangered status with the cod, the people of Atlantic Canada cope with the loss of a traditional way of life.

Fishing for other species such as lobster, shrimp and crab still provides a livelihood for some families. Aquaculture is starting to become more widespread with experiments in salmon, scallop and cod farming happening in New Brunswick, Nova Scotia, and Newfoundland. But the real hope for future economic development in this ecozone now lies with offshore oil and gas production. The immensely rich Hibernia and Terra Nova oil and gas fields lie within this ecozone, as do lesser discoveries off Nova Scotia along the Scotian Shelf.
CONCLUSION

How do we encourage a more integrated understanding of ecosystems? How do we protect representative samples of Canada's ecosystem diversity? There are many barriers in applying an ecosystem approach. It is typical to find that the science is lacking, monitoring systems are inadequate, information is wanting, and assessment capabilities are youthful (Wiken, 1995). Organizations like the CCEA and Canadian Society for Landscape Ecology and Management (CSLEM) have been effective in promoting a new type of synergy amongst professionals and agencies. Where mandates in government departments have been barriers, where many university disciplines have narrowed down the scope of thinking, where the artificial boundaries of jurisdictions have been impediments, and where effective strategies and policies have often been skin deep, the CCEA has been very effective in critiquing past approaches and proposing new ones. Both looking back to what has been problems and issues, and forward to what is emerging are critical. This isn't an abstraction of thought but a reality in Canadian life. Generation by generation, everything we do is overshadowed by ecosystem relationships and characteristics. Having protected places ensures that there will not be a loss of future benefits from native ecosystems nor will there be a lost opportunity to understand the carrying capacity of nature.

Canada needs to further advance its strategic leadership in understanding ecosystems. Many other countries have become a victim of not acquiring and applying this ecosystem knowledge.
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### Ecological classification of subsystems of ecozones

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* Map scales should not be taken too restrictively, as they will vary with the setting and objectives of the survey.

** More so than others, this level is frequently subdivided into phases to indicate a passing or temporary state (e.g., seral).
Terrestrial and Marine Ecozones Map

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Terrestrial Ecozones Map

Legend

- Arctic Cordillera
- Boreal Plains
- Northern Arctic
- Boreal Shield
- Southern Arctic
- Boreal Cordillera
- Taiga Plains
- Pacific Maritime
- Taiga Shield
- Montane Cordillera
- Prairies
- Hudson Plains
- Atlantic Maritime
- Mixedwood Plains
Marine Ecozones Map

Legend

Marine

- Pacific Marine
- Arctic Archipelago
- Arctic Basin
- Northwest Atlantic
- Atlantic Marine