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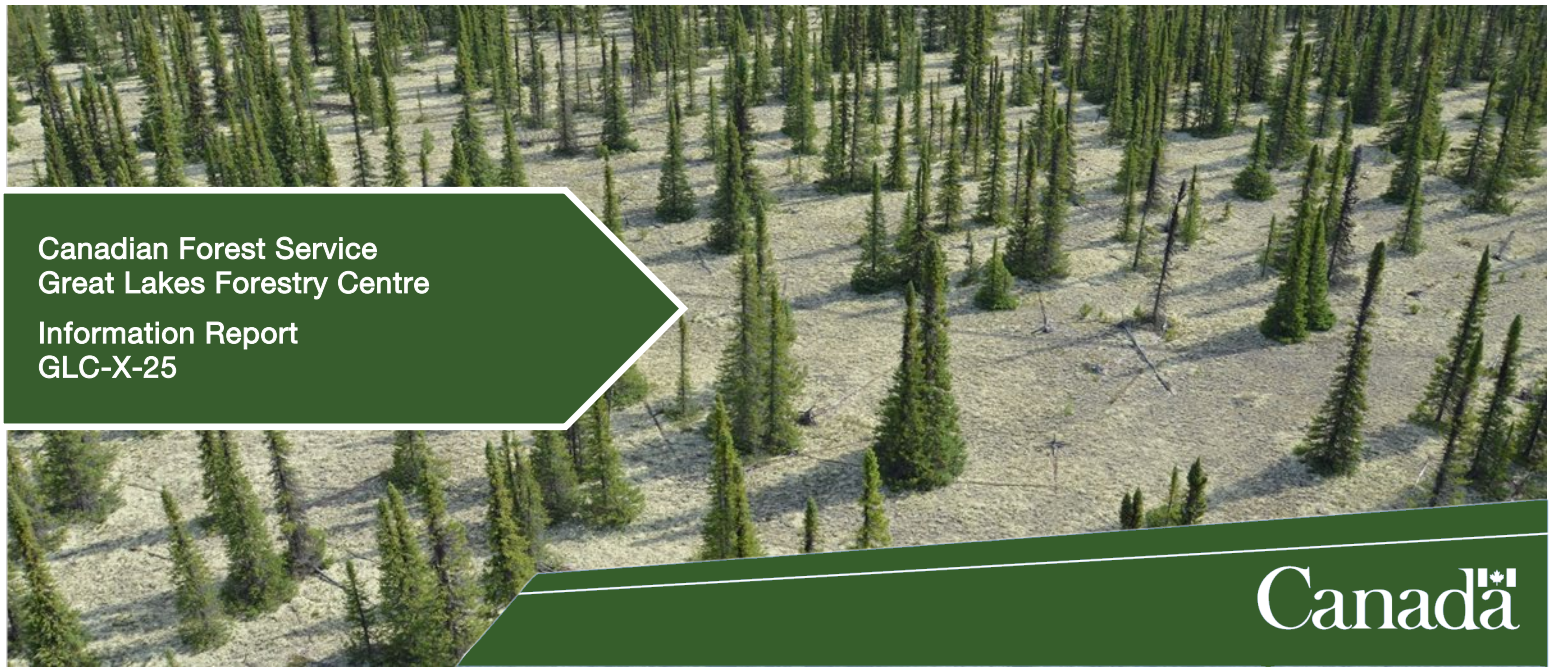
VEGETATION ZONES OF CANADA:
a Biogeoclimatic Perspective



Canadian Forest Service
Great Lakes Forestry Centre

Information Report
GLC-X-25

Canada

Cover Images: Top - Cypress Hills: Alberta Parks; **Middle** (*Left* – Acadian Temperate Forest: S. Basquill, Nova Scotia Department of Natural Resources, *Middle* – Subarctic Alpine Tundra: D. Downing retired private consultant, *Right* – Cordilleran Subboreal Forest: W. MacKenzie, British Columbia Ministry of Forests, Lands, Natural Resource Operations & Rural Development); **Bottom** – Northern Boreal Woodland: G. Racey, Ontario Ministry of Natural Resources and Forestry.

The Great Lakes Forestry Centre, Sault Ste. Marie, Ontario

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Vegetation Zones of Canada: a Biogeoclimatic Perspective

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Canada

Cataloguing information for this publication is available from Library and Archives Canada.

Vegetation Zones of Canada: a Biogeoclimatic Perspective. (Information Report, GLC-X-25).

Issued also in French under the title: “Zones de végétation du Canada : une perspective biogéoclimatique”.

Baldwin, K.[1*];Allen, L.[2*]; Basquill, S.[3]; Chapman, K.[1]; Downing, D.[4]; Flynn, N.[5]; MacKenzie, W.[6]; Major, M.[7]; Meades, W. [1*]; Meidinger, D.[8]; Morneau, C.[7]; Saucier, J-P.[7]; Thorpe, J.[9*]; Uhlig, P. [10*]
*** à la retraite**

Electronic monograph in PDF format.

Includes bibliographical references.

ISBN 978-0-660-34249-8 ISSN 2562-0738

Cat. no.: Fo123-2/25-2020E-PDF

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ACKNOWLEDGEMENTS AND PHOTO CREDITS

The authors are grateful for the contributions of numerous people to this map and report. Johanna Pfalz was the GIS analyst throughout the lengthy development period for the map. Her interest in the project over several years, despite numerous interruptions, maintained continuity in the treatment of spatial data of varying provenances. Ken Francis was the cartographic designer for the finished product, and cheerfully endured many revisions to already acceptable drafts. Kevin Lawrence provided additional GIS support, especially at the beginning of the project. Monique Wester assisted with finding photographs from various Ontario sources. Tony Trofymow and Elizabeth Campbell were early supporters of the work within the Canadian Forest Service. Comments on early draft material by Alain Belliveau, Sean Blaney, Laura Boisvert-Marsh, Richard Caners, Mae Elsinger, Steve Gordon, Cary Hamel, Paul LeBlanc, Kate MacQuarrie, Peter Neily, Rafael Otfinowski, Eugene Quigley and Tony Trofymow greatly improved descriptions for several of the level 2 vegetation zones.

Several people generously took time to search their collections for suitable photographs of the vegetation zones. We appreciate the use of these photo images for the report and acknowledge the contributors below:

Vegetation Zone	Contributor
High Arctic Sparse Tundra	D. Downing
Mid-Arctic Dwarf Shrub Tundra	D. Downing
Low Arctic Shrub Tundra	D. Downing
Subarctic Alpine Tundra	D. Downing
Western Boreal Alpine Tundra	Yukon Government
Cordilleran Alpine Tundra	W. MacKenzie
Pacific Alpine Tundra	W. MacKenzie
Eastern Alpine Tundra	C. Morneau
Subarctic Woodland-Tundra	C. Morneau
Northern Boreal Woodland	G. Racey
Northwestern Boreal Forest	Yukon Government
West-Central Boreal Forest	D. Downing
Eastern Boreal Forest	K. Baldwin
Atlantic Maritime Heathland	W. Meades
Pacific Maritime Rainforest	W. MacKenzie
Pacific Dry Forest	W. MacKenzie
Pacific Montane Forest	W. MacKenzie
Cordilleran Subboreal Forest	W. MacKenzie
Cordilleran Montane Forest	British Columbia Forest Service
Cordilleran Rainforest	D. Meidinger
Cordilleran Dry Forest	British Columbia Forest Service
Eastern Temperate Mixed Forest	S. Dobbyn
Eastern Temperate Deciduous Forest	V. Hard
Acadian Temperate Forest	S. Basquill
Rocky Mountains Foothills Parkland	D. Downing
Great Plains Parkland	L. Allen
Intermontane Shrub-Steppe	D. Meidinger
Rocky Mountains Foothills Fescue Grassland	R. McNeil

Vegetation Zone	Contributor
Great Plains Fescue Grassland	L. Allen
Great Plains Mixedgrass Grassland	L. Allen
Central Tallgrass Grassland	Minnesota Department of Natural Resources
Cypress Hills	Alberta Parks
Glaciers	S. Cannings

ABSTRACT

Vegetation Zones of Canada: a Biogeoclimatic Perspective maps Canadian geography in relation to gradients of regional climate, as expressed by potential vegetation on zonal sites. Compared to previous similar national-scale products, *Vegetation Zones of Canada* benefits from the work of provincial and territorial ecological classification programs over the last 30+ years, incorporating this regional knowledge of ecologically significant climatic gradients into a harmonized national map. This new map, reflecting vegetation and soils adapted to climates prior to approximately 1960, can serve as a broad-scale (approximately 1:5 M to 1:10 M) geospatial reference for monitoring and modeling effects of climatic changes on Canadian ecosystems.

Vegetation Zones of Canada: a Biogeoclimatic Perspective employs a two-level hierarchical legend. Level 1 vegetation zones reflect the global-scale latitudinal gradient of annual net radiation, as well as the effects of high elevation and west to east climatic and biogeographic variation across Canada. Within the level 1 vegetation zones, level 2 zones distinguish finer scale variation in zonal vegetation, especially in response to elevational and arctic climatic gradients, climate-related floristics and physiognomic diversity in the Great Plains, and maritime climatic influences on the east and west coasts. Level 2 zones constitute the map units in Figure 1.

INTRODUCTION

Vegetation expression at a particular time and location is a function of several interacting factors that encompass the physical environment (e.g., climate, soil/site, terrain/topography, geology /geochemistry), the biotic environment (e.g., floristics, species autecology, competition, herbivory, symbiosis), and temporal dynamics (e.g., disturbance regimes, successional patterns, time since perturbation). Actual vegetation at a specific location changes over time and is best monitored with repeated observations (e.g., ground sampling, remote sensing) over a period of years. Potential vegetation that could be supported at a particular location can be predicted, within stochastic bounds, with knowledge of the most influential of the above-noted factors at the selected location (e.g., Major 1951).

For natural ecosystems, climate is the overarching determinant of terrestrial vegetation potential. In Canada, regional climate is the appropriate context for examining differences in the broad-scale (approximately 1:5 M to 1:10 M) characteristics of natural vegetation. At this scale, average and extreme conditions of temperature and precipitation over long periods of time determine the dominant processes for soil development and nutrient cycling. They also establish the effective norms and limits of energy and moisture inputs that select for species success and drive vegetation dynamics.

Historically, regional vegetation patterns for Canada have mostly been described within the context of interpreted global, continental or national maps of biogeography (Takhtajan 1986), floristics (McLaughlin 2007), physiognomy (Whittaker 1970) or biophysical land classification (Bailey 1997; Ecological Stratification Working Group [ESWG] 1995; Li & Hélie 2014). Alternatively, vegetation zonation has been hypothesized as a derivative of direct climate modeling (Koppen 1900; Thornthwaite 1931; Sanderson 1948; McKenney et al. 2015; Rivas-Martinez & Rivas-Saenz 2017). Canadian vegetation has also been mapped as a component of land cover interpreted from remotely sensed data (e.g., Beaudoin et al. 2014).

Only two products have sought to represent Canadian vegetation explicitly in relation to, and as an indicator of, regional gradients of climate. In 1937, Halliday adapted the North American “climax formations” of Weaver and Clements (1929) to Canada, recognizing eight forest regions, two grassland regions and an arctic/alpine tundra region in a publication titled *A Forest Classification for Canada*. Halliday’s map and report were updated in 1959 by Brown and Rowe, retitled *Forest Regions of Canada*; Rowe further revised this report in 1972. To expand the information content of the Brown and Rowe map, Scoggan provided botanical interpretation of the forest regions, publishing maps of *Natural Vegetation Regions of Canada* (Scoggan 1957) and subsequently, *Floral Regions of Canada* (Scoggan 1966, 1978). Although linework has not been updated since 1959, Rowe’s 1972 version of *Forest Regions of Canada* continues to be the most widely available national-scale map of vegetation zonation in Canada.

In 1989, the Ecoregions Working Group (EWG) of the Canada Committee on Ecological Land Classification (CCELC) published *Ecoclimatic Regions of Canada* as part of a broad program of ecological classification activities for the country. Ecoclimatic regions were defined as “broad areas on the earth’s surface characterized by distinctive ecological responses to climate, as expressed by vegetation and reflected in soils, wildlife, and water” (EWG 1989). Ecoclimatic regions were differentiated along regional climatic gradients, as expressed by vegetation on similar soils and landforms.

To facilitate mapping of ecological responses to climate, the concept of “geobotanic zonality” (Budyko 1974) is invoked for comparing regions. The “zonal concept”, originally articulated for climatic influences

in regional soil development (Dokuchaev 1900), suggests that climatic zonation produces characteristic ecosystems on "zonal sites". Zonal sites ("normal sites" in EWG 1989) are defined as sites with deep loamy soils, neither lacking nor with an excess of soil nutrients, located in well-drained topographic positions with moderate slopes of neutral aspect (Pojar et al. 1987; EWG 1989; McLennan et al. 2018). In theory, the vegetation chronosequence on zonal sites best reflects the influence of regional climate on vegetation, free from confounding local effects of edaphic, topographic, geological or microclimatic extremes. In practice, when characterizing and mapping vegetation at a broad scale, stable late seral vegetation on zonal sites ("zonal vegetation") is used to represent the ecological potential of regional climates and to establish boundaries of bioclimatic zones (Vysotsky 1909; Walter 1954; Damman 1979; Walter & Breckle 1985; Stupar & Carni 2017). These are the theoretical constructs that underlie the delineation of *Vegetation Zones of Canada*.

Prior to the development of national ecoclimatic regions (EWG 1989), principles of zonality had been applied in provincial or regional ecological classifications in British Columbia (BC) (Krajina 1959, 1965; Pojar et al. 1987), Ontario (Hills 1958, 1964; Hills & Pierpoint 1960), Quebec (Ducruc et al. 1976) and Atlantic Canada (Loucks 1962; Damman 1983). Contemporary provincial or territorial classifications that use zonal principles include those in BC (Pojar et al. 1987; MacKenzie & Meidinger 2018), Quebec (Robitaille & Saucier 1998; Saucier et al. 2009), Alberta (Natural Regions Committee 2006) and Yukon (Environment Yukon 2016, 2017).

Both *Forest Regions of Canada* (Rowe 1972) and *Ecoclimatic Regions of Canada* (EWG 1989) suffered from a lack of detailed ground-based ecological information. Since 1989, all provinces and territories have developed ecological classifications, incorporating new spatially explicit knowledge of ecologically significant climatic gradients. The *Vegetation Zones of Canada* map and report synthesize the current state of this knowledge, using the principles articulated by the EWG (1989), and harmonize the linework of provincial and territorial ecological regionalizations to create a national map that reflects the distribution of natural vegetation in relation to regional-scale climate. This map can provide a baseline of ecological responses to climate in Canada, reflecting vegetation adapted to climates prior to approximately 1960. As such, it can serve as a broad-scale geospatial reference for monitoring and modeling effects of novel climate changes on Canadian ecosystems.

Selection of terminology is tricky in ecological classification. Since there are many ecological classification products available in Canada, the relatively small set of suitable terms has been liberally utilized, but without standardized application. Since we are talking about geographic areas of common ecological character, the terms "region" and "zone" are both suitable. However, the term "region" has been used for *Forest Regions of Canada* (Rowe 1972) and *Ecoclimatic Regions of Canada* (EWG 1989). As well, there is a plethora of "ecoregions" in various jurisdictions across Canada, none of which share the definition intended here[1]. Hence, we have chosen to call our map units "zones". Likewise, although we adopt the principles of ecoclimatic zonation that the EWG (1989) proposed, the term "ecoclimatic" was employed for that publication. Although this work falls under the broad rubric of "bioclimatic" regionalization, this term has been used in such widely varying ways in the literature that it is effectively non-specific and therefore avoided here. Since we are only reporting on vegetation responses to regional climate, as opposed to (for example) soil or other biotic characteristics that also respond to climate, we choose to call our units "vegetation zones". The term "biogeoclimatic" explicitly recognizes

[1] In particular, the "ecoregions" and "ecozones" of the *National Ecological Framework for Canada* (ESWG 1995; Li & Hélie 2014) are conceptually different from the map units defined here.

the focus on relationships between climate and biota under circumscribed edaphic conditions (zonal soils/sites) and is applicable to the principles and approach described here. Although this term is clearly associated with the provincial classification system in BC, it has not been used for a national-scale product in Canada and, with permission from the Biogeoclimatic Ecosystem Classification Program of BC (2018), we use this adjective for our subtitle.

Vegetation Zones of Canada employs a two-level hierarchical legend. The broad scale of the "level 1" vegetation zones is similar to those of the Halliday (1937), Rowe (1959, 1972) and Scoggan (1957) regions and to ecoclimatic provinces (EWG 1989), similarly reflecting (in part) latitudinal climatic gradients. "Level 2" vegetation zones represent updated knowledge of more finely scaled biogeoclimatic zonation, especially in response to elevational and arctic climatic gradients, climate-related floristics and physiognomic diversity in the Great Plains, and maritime climatic influences on the east and west coasts.

The detailed vegetation descriptions for the level 2 vegetation zones derive from linkages with the Canadian National Vegetation Classification (CNVC), which provides precise information on species composition and abundance in relation to ecological gradients across the country. Both the CNVC and *Vegetation Zones of Canada* have benefitted from the intensive collection of ground plot data by provinces and territories over the last 30+ years (i.e., since Rowe 1959, 1972 and EWG 1989) during development of jurisdictional ecological classifications and maps.

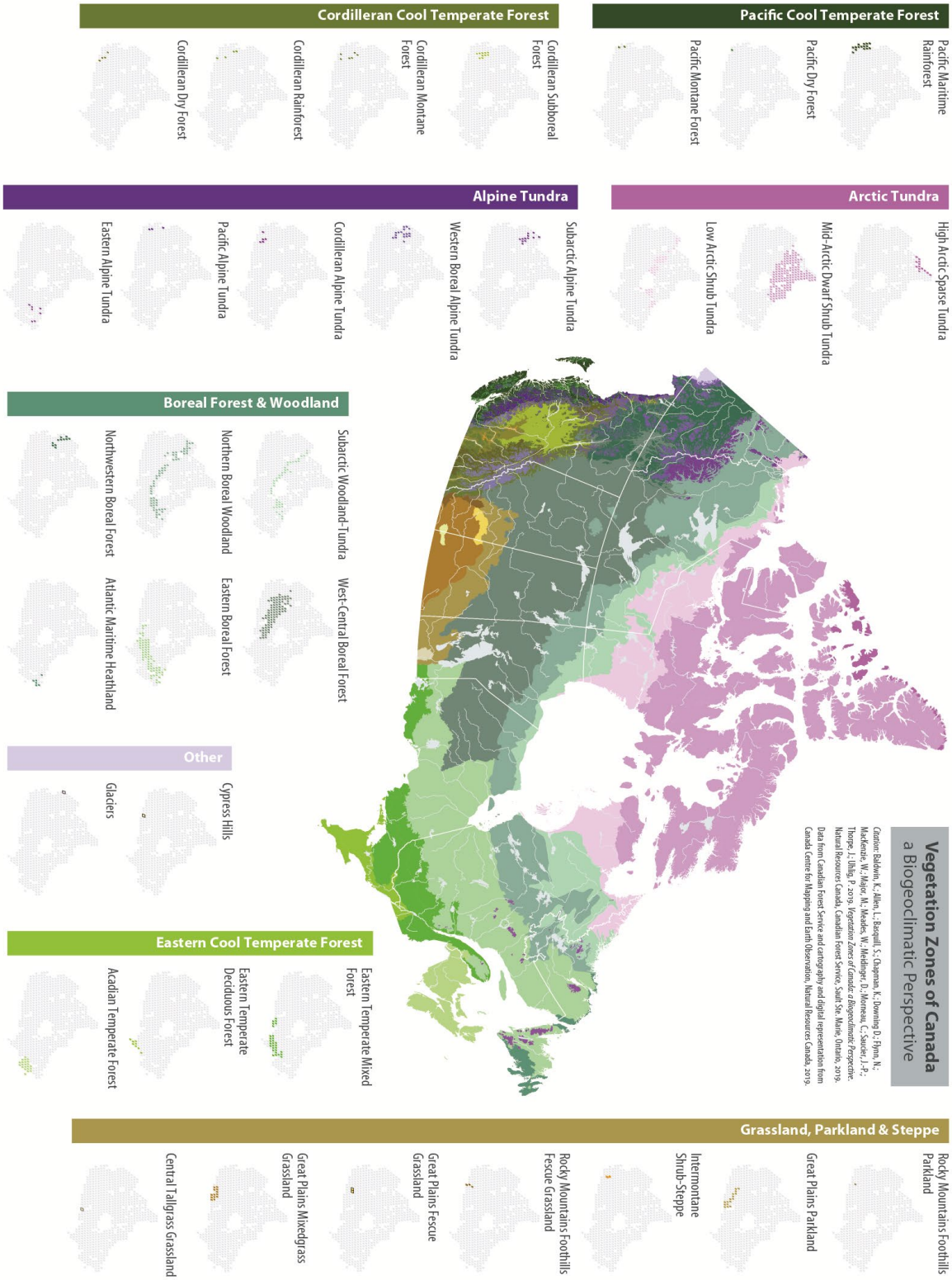


Figure 1. Vegetation zones of Canada

The interactive map and digital data files can be accessed at:
https://open.canada.ca/data/en/dataset/22b0166b-9db3-46b7-9baf-6584a3acc7b1

Relationship of Vegetation Zones to the Canadian National Vegetation Classification

The *Vegetation Zones of Canada* map and report are informed by classification types of the Canadian National Vegetation Classification (CNVC), which are themselves derived from provincial and territorial ground plot data and ecological classification types (Baldwin et al. 2019). The CNVC is a hierarchical ecological classification of natural vegetation communities in Canada that uses eight formal levels in its hierarchy to systematically progress from the broadest level of classification, Formation Class, to the finest level, Association. All vegetation conditions, including zonal (e.g., upland vegetation on zonal sites) and azonal (e.g., wetland and aquatic vegetation), are classified by the CNVC. Canadian vegetation zones link to mid-level CNVC types (e.g., Macrogroups) that contain zonal vegetation as expressed in their Canadian ranges.

The CNVC emphasizes the ecological context of vegetation types at all of its hierarchical levels. The upper three levels of the hierarchy, Formation Class, Formation Subclass and Formation, use dominant and diagnostic growth forms as criteria to reflect environmental gradients at global to continental scales (Faber-Langendoen et al. 2016). The Division level employs dominant and diagnostic growth forms, as well as broad sets of diagnostic species, that reflect continental-scale biogeography and environmental factors (Faber-Langendoen et al. 2014). In most cases, types within the top four hierarchical levels of the CNVC recognize vegetation conditions that extend beyond the boundaries of Canada. It is at the fifth level of the hierarchy, Macrogroup, that the CNVC begins to define types on the basis of characteristics expressed in their Canadian ranges (Baldwin et al. 2019). For upland vegetation, Macrogroups that contain zonal vegetation are distinguished by regional-scale plant species composition, abundance and/or dominance on zonal sites. The lowest three levels of the hierarchy, Group, Alliance and Association, use species dominance, diagnostic indicator value and overall floristic compositional similarity to describe vegetation variation along sub-regional and site-scale environmental gradients, such as soil nutrients and moisture (Baldwin et al. 2019).

Macrogroups are generalized taxonomic units that describe all vegetation expression (i.e., zonal and azonal) for a particular physiognomy (e.g., forests) within a broad ecological and regional context. Macrogroups that contain zonal vegetation describe regionally distinct vegetation patterns that reflect ambient regional climate. Typically, geographic ranges of these Macrogroups can be mapped at scales of approximately 1:5 M to 1:10 M using knowledge of geological/geomorphological characteristics, disturbance regimes, distribution and autecology of diagnostic plant species, and successional patterns on zonal sites. Availability of this information and knowledge of these ecological relationships form the basis for compilation of the vegetation zones reported here.

Methodology

General

Most provincial and territorial terrestrial ecological classifications are hierarchical systems that include one or more elements suitable for differentiating broad-scale ecological integration of climate and vegetation. Classifications vary among jurisdictions; they use different terminology and apply distinct classification and mapping criteria, however, all seek to subdivide their geography using knowledge of ecological relationships between biotic and abiotic features of the landscape.

CNVC Macrogroups that include zonal vegetation provided the conceptual guidance for defining level 2 vegetation zones. When constructing the *Vegetation Zones of Canada* map, provincial, territorial and federal ecological maps were reviewed for map classes that correlated conceptually with these Macrogroups. Once identified, polygons could be edge-matched across jurisdictional boundaries into national vegetation zones. The preferred approach was to maximize the use of linework that was available at the time of analysis. Only where linework satisfying these criteria did not exist were new map lines created using a variety of alternative source data and analytical methods.

Mapping Process

Spatial data and supporting documentation were obtained from provincial, territorial and federal sources (Table 1) with permission to incorporate source linework into the *Vegetation Zones of Canada*. All input data were transformed to the Atlas of Canada Lambert Conformal Conic NAD83 Projection (EPSG:3979); all final map products conform to this projection.

A national digital elevation model (DEM), with base resolution in southern Canada of 30 arcseconds, was acquired from Natural Resources Canada (Lawrence et al. 2008). The DEM was used to create contours at 100 m intervals, which were applied to various analyses.

The initial framework for the map was that of Brandt (2009). It was used to define the level 1 margins of boreal vegetation at the continental treeline in the north and, in the south, at the interface with temperate vegetation. Subsequently, some of Brandt's southern lines were revised with more recent information (see Appendix III).

Level 1 and 2 vegetation zones were delineated using existing linework in all areas of the country, with the following exceptions:

1) In the Cordilleran portion of the Northwest Territories (NWT) (Ecosystem Classification Group 2010), elevation analyses using the contoured DEM were employed to determine boundaries for level 2 vegetation zones *Subarctic Alpine Tundra, Western Boreal Alpine Tundra, Northern Boreal Woodland, Northwestern Boreal Forest* and *West-Central Boreal Forest* (see Appendix II).

2) In the alpine portions of insular Newfoundland, elevation analysis using the contoured DEM was employed to determine boundaries for *Eastern Alpine Tundra* and *Eastern Boreal Forest* level 2 vegetation zones (see Appendix I).

3) Elevation analysis was also used to circumscribe (at elevations >1000 mASL) the *Cypress Hills* level 2 map unit.

4) In southern Saskatchewan and Manitoba, mapping analysis and photo-interpretation of aerial imagery were commissioned to adjust the southern boundary of the *Great Plains Parkland* level 2 vegetation zone and to determine the placement of boundaries for the *Central Tallgrass Grassland* level 2 zone (see Appendix III).

5) In eastern Quebec and northern New Brunswick, analysis of plot data was employed to establish the western boundary of the *Acadian Temperate Forest* level 2 vegetation zone.

Detailed source information for each line on the *Vegetation Zones of Canada* map is provided in Appendix I.

Table 1. Primary sources of linework for *Vegetation Zones of Canada*.

Source	Level of Source Hierarchy Used	Citation
Circumpolar Arctic Vegetation Map	bioclimate subzone	Circumpolar Arctic Vegetation Map Team 2003
The Extent of the North American Boreal Zone	boreal extents	Brandt 2009
National Ecological Framework for Canada	ecoregion	Ecological Stratification Working Group 1995
Ecozones of Canada (revised)	ecozone	Li & Hélie 2014
Alberta Natural Regions and Subregions	subregion	Natural Regions Committee 2006
British Columbia Biogeoclimatic Ecosystem Classification	zone, subzone	Pojar et al. 1987; Meidinger and Pojar (eds) 1991; Biogeoclimatic Ecosystem Classification Program of British Columbia 2018
Natural Regions in Manitoba	ecoregion, ecozone	Manitoba Protected Areas Initiative 2005; Ecological Stratification Working Group 1995; Li & Hélie 2014
Ecological Land Classification of Labrador	land region	Lands Directorate, Atlantic Region 1977; Lopoukhine et al. 1978
Ecoregions of the Island of Newfoundland	ecoregion	Damman 1983
Ecological Regions of the Northwest Territories	level II, III, IV ecoregions	Ecosystem Classification Group 2007, 2008, 2010
Ecological Land Classification for Nova Scotia	ecoregion	Neily et al. 2017
Ecosystems of Ontario	ecoregion, ecodistrict	Crins et al. 2009; Wester et al. 2018
Ecological Regions of Quebec	ecological region, sub-region	Saucier et al. 1998
Bioclimatic Framework of Quebec	domain, sub-domain	Saucier et al. 2009
Alpine and Subalpine Zones of Quebec	étage	Major 2018
Ecoregions of Saskatchewan	ecoregion	Ecological Stratification Working Group 1995; Li & Hélie 2014; Acton et al. 1998
Bioclimate Zones of Yukon - Version 6	zone	Ecological and Landscape Classification Technical Working Group 2017

Summary of the Major Climatic Trends in Canada

There are three dominant continental-scale influences on the climates of Canada (Bryson and Hare 1974; Budyko 1974):

1) the latitudinal gradient of net solar radiation;
2) the generally dominant westerly flow of air; and
3) the Cordilleran physiographic region of high mountains in western North America (Bostock 1970).

A variety of secondary climatic influences are also regionally important. Flows of warm, humid subtropical air into eastern Canada and of Arctic air into southern Canada, both assisted by the generally flat terrain east of the Cordillera, contribute to significant modifications of climatic humidity and seasonal temperatures in much of the country. Regional orographic effects, especially in western Canada, override latitudinal climates. Maritime effects from Pacific, Atlantic and Arctic Oceans, as well as Hudson Bay and the Great Lakes, modify temperatures and precipitation in coastal areas (Hare and Hay 1974).

The latitudinal gradient of annual net radiation determines the amount of energy available for physical and biological processes. This is a global-scale climatic zonation that primarily results in reductions at higher latitudes of average temperature and length of growing season, although precipitation is also affected in relation to average ambient air temperatures. This south to north gradient translates into distinct differences in vegetation physiognomy, floristics and primary productivity. In Canada, there are three main latitudinal "macrobioclimates" (*sensu* Rivas-Martinez & Rivas-Saenz 2017[2]): Polar (Arctic)[3], Boreal and Temperate. Figure 2 illustrates the relationships between mean annual temperature and latitude along two south – north transects in different parts of Canada; latitudinal trends in additional climatic attributes along these and other transects are tabulated in Appendix IV.

For most of Canada, westerly air flows dominate atmospheric circulation patterns. Upon reaching North America, moist Pacific air carried by westerly winds immediately encounters the Cordillera, where orographic effects create a series of moist and dry climatic belts in BC, Yukon, Alberta and western Northwest Territories (NWT). East of the Cordillera, in both the Boreal and Temperate macrobioclimates, westerly air masses crossing NWT, western Nunavut, northeastern BC, Alberta, Saskatchewan and Manitoba remain relatively dry until, in northwestern Ontario, they intercept moist air flows from the southern United States (US) that contribute to more humid climatic conditions. Continuing eastward, maritime influences from Hudson Bay, the Great Lakes and the Atlantic Ocean create even more humidity. Thus, the primary longitudinal climatic gradient is precipitation and, consequently, annual moisture balance (see Figure 4 and Appendix V). The west – east diversity of vegetation across the Boreal and Temperate macrobioclimates of Canada largely reflects the variability of climatic moisture inputs.

In the Arctic macrobioclimate, air masses are generally cold and dry and minimally influenced by westerly circulation. Greater precipitation occurs in coastal areas of the eastern Arctic, partly aided by

[2]Bioclimatic terminology used in this report follows that of the Worldwide Bioclimatic Classification (WBC) System (Rivas-Martinez and Rivas-Saenz 2017); see Appendix VI for definitions.

[3] In Canada, the Arctic is the only Polar macrobioclimate, so "Arctic" is the term that will be used in the rest of the report.

orographic effects of the Davis, Baffin and Hall Uplands (see Figure 4 and Appendix V). Arctic air often flows southward into temperate Canada and the US, especially across the relatively level terrain in the Prairie provinces.

Local and regional climates, especially in the Cordilleran region and some parts of eastern Canada, may be strongly modified by orographic effects. Elevational gradients of temperature often mimic similar latitudinal gradients, but over much smaller distances. Precipitation is also influenced by elevational features, with high precipitation on windward slopes and low precipitation in leeward rain shadows; snowfall at higher elevations can be so heavy that it crushes vegetation. Over half of the level 2 vegetation zones reported here are, to a significant degree, the result of orographic effects on biogeoclimatic zonation (see Figure 5 and Appendix V).

In the proximity of large water bodies, temperature is typically moderated and precipitation increased by the onshore movement of air masses. Areas with maritime climatic influences tend to have less extreme minimum and maximum temperatures than do inland locations. Coastal areas often experience frequent fog and strong winds, and snowfall can be very heavy.

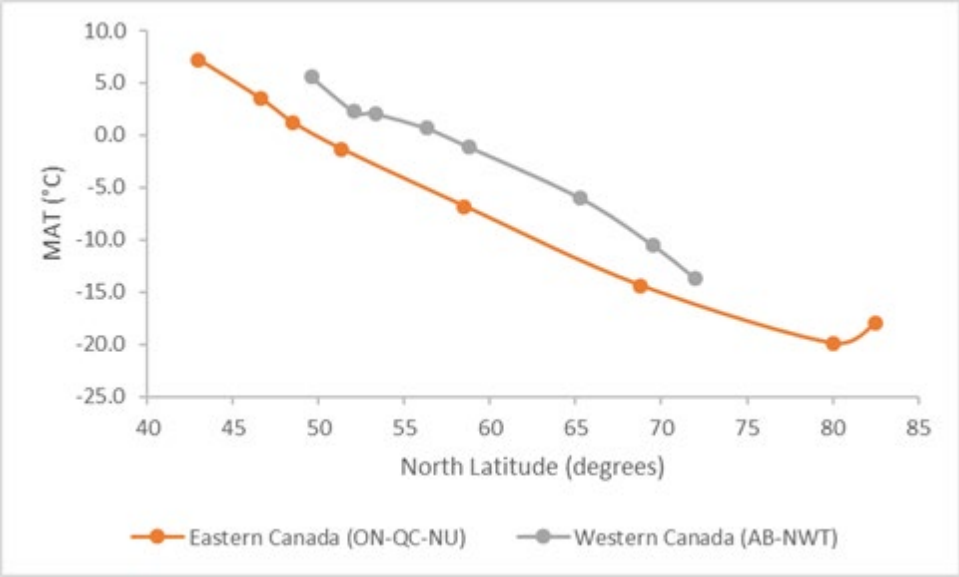


Figure 2. South – north transects of mean annual temperature (MAT) for selected locations in eastern and western Canada. The southern starting point for the eastern transect is in the *Eastern Temperate Deciduous Forest* level 2 vegetation zone; the southern starting point for the western transect is in the *Great Plains Mixedgrass Grassland* zone. Weather station locations are shown in Figure 3. See Appendix IV for the data values (Tables IV-b and IV-d), as well as tabulations of other climatic data along these and other south – north transects. Climate data are normals for the period 1961-1990 (Environment Canada 2019).

Figure 3. Map of locations along south – north climatic transects presented in Figure 2 and Appendix IV.

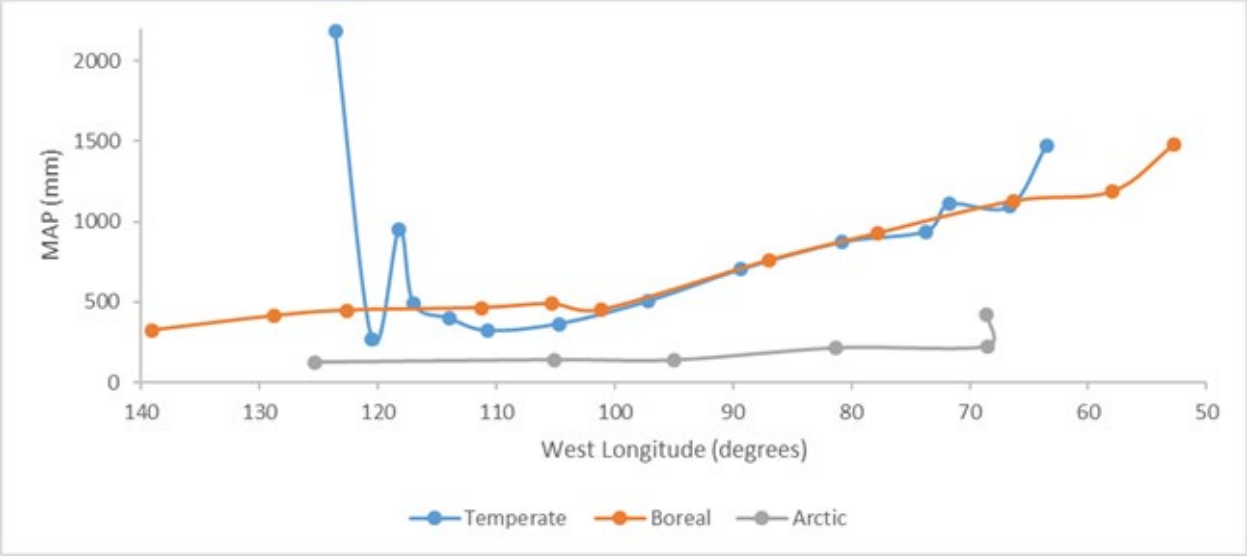


Figure 4. West – east transects of mean annual precipitation (MAP) for temperate, boreal and mid-arctic Canada. Weather station locations are shown in Figure 6. See Appendix V for data values (Tables V-a, V-b and V-c), as well as tabulations of other climatic data along these west – east transects. Climate data are normals for the period 1961-1990 (Environment Canada 2019).

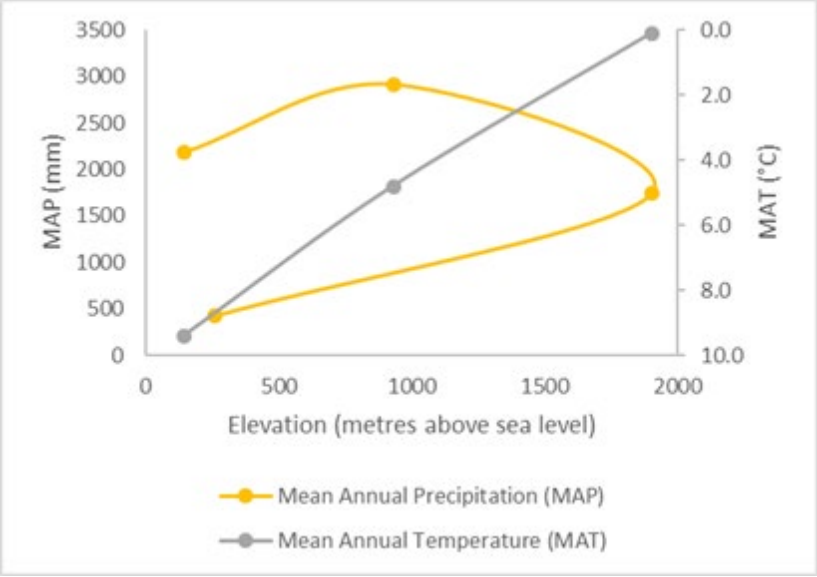


Figure 5. West – east transect of mean annual precipitation (MAP) and mean annual temperature (MAT) across an elevational gradient in the southern Coast Mountains. The higher precipitation value at low elevations is on the windward (western) side of the mountains, the lower value on the leeward side. Weather station locations are shown in Figure 6. See Appendix V (Table V-d) for data values, as well as tabulations of other climatic data along this transect. Climate data are normals for the period 1961-1990 (Environment Canada 2019).

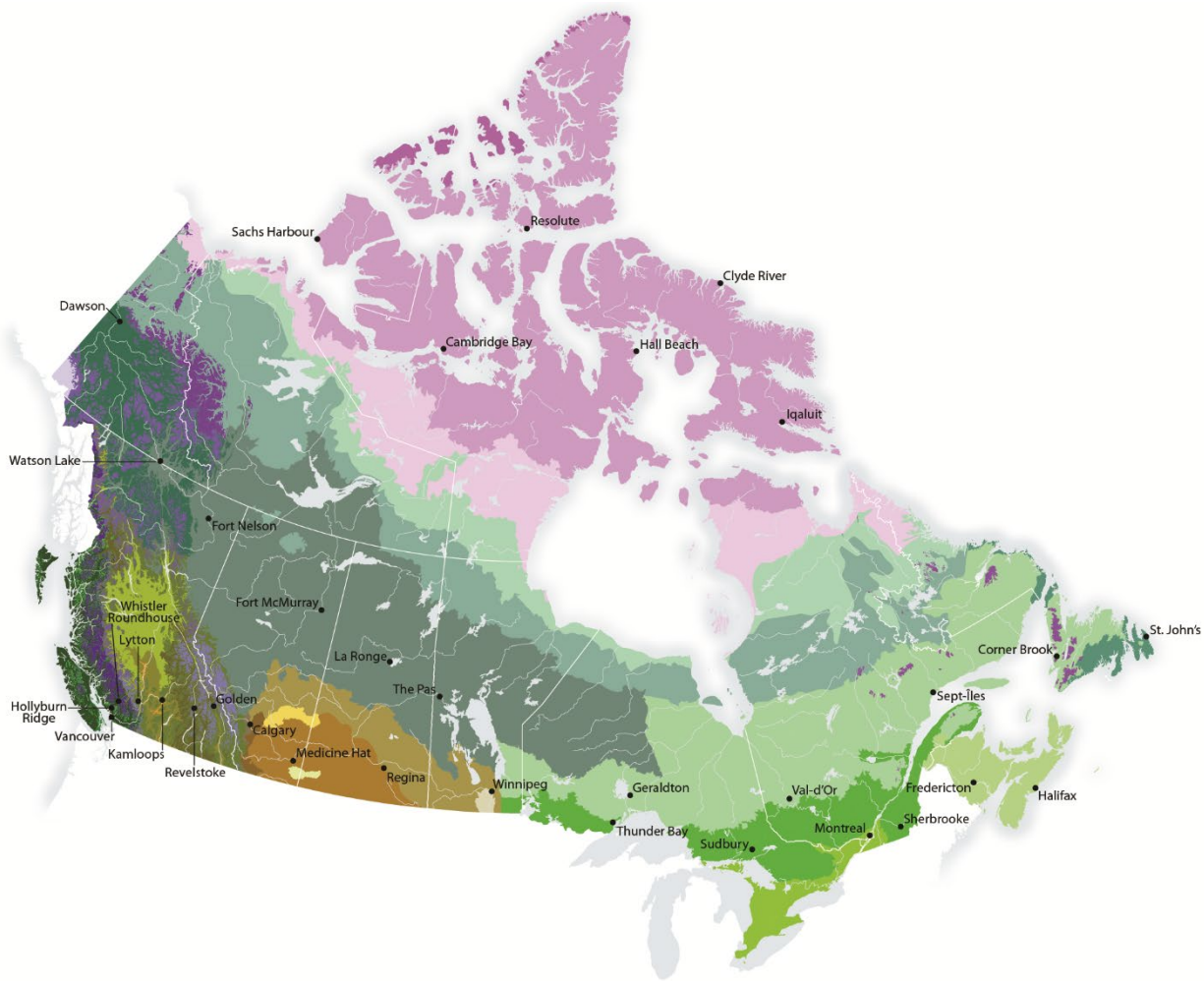


Figure 6. Map of locations along west – east climatic transects presented in Figures 4 and 5, and in Appendix V.

Overview of the Vegetation Zones

Vegetation Zones of Canada reflects the major climatic influences discussed in the previous section. The global Arctic, Boreal and Temperate macrobioclimates divide the country into three broad latitudinal bands (Figure 1). A single level 1 vegetation zone incorporates the biogeoclimatic diversity in each of the Arctic (*Arctic Tundra*) and the Boreal (*Boreal Forest & Woodland*) macrobioclimates. The Temperate macrobioclimate is subdivided into four level 1 vegetation zones (*Pacific Cool Temperate Forest*; *Cordilleran Cool Temperate Forest*; *Grassland, Parkland & Steppe*; and *Eastern Cool Temperate Forest*) on the basis of strong distinctions in physiognomy and/or diagnostic species in zonal vegetation. This level 1 diversity reflects the effects of west to east climatic variation, orographic influences in the Cordilleran physiographic region of western Canada, and biogeographic species distinctions between the temperate forests of western Canada and those of the east. High elevation effects on zonal vegetation in both the Temperate and Boreal macrobioclimates are recognized in the level 1 vegetation zone *Alpine Tundra*, as well as in the *Other* category, which includes two unique Canadian elevational features (the Cypress Hills and the ice fields of the St. Elias Mountains). Within the level 1 vegetation zones, level 2 zones distinguish finer scale variation in zonal vegetation. See Table 2 for the hierarchy of level 1 and 2 vegetation zones.

Arctic Tundra

Biogeoclimatic diversity of the Arctic macrobioclimate is mainly distinguished by variation in amount of vegetated land cover, total number of plant species and dominant zonal growth forms, primarily reflecting the thermal effects of latitude. The *Arctic Tundra*[4] level 1 vegetation zone comprises three level 2 zones. In the *High Arctic Sparse Tundra* level 2 zone, vegetation occurs only in sheltered, moist locations and is dominated by a cryptogamic crust of lichens, cyanobacteria and bryophytes with very few vascular plant species. The *Mid-Arctic Dwarf Shrub Tundra* and *Low Arctic Shrub Tundra* zones have increasingly greater numbers of species southward, with dominant zonal vegetation transitioning from prostrate dwarf shrub tundra in the *Mid-Arctic Dwarf Shrub Tundra* zone to erect woody growth forms in the *Low Arctic Shrub Tundra* zone, where shrubs and stunted trees can reach heights of >2 m on protected sites near the continental treeline.

Alpine Tundra

The *Alpine Tundra* level 1 vegetation zone comprises five level 2 zones that reflect the diversity, primarily in species composition, of alpine vegetation within various regional climates across Canada. These include the *Subarctic Alpine Tundra, Western Boreal Alpine Tundra, Cordilleran Alpine Tundra, Pacific Alpine Tundra* and *Eastern Alpine Tundra*.

Boreal Forest & Woodland

The *Boreal Forest & Woodland* level 1 vegetation zone describes the biogeoclimatic diversity of the Boreal macrobioclimate. Six level 2 vegetation zones are delineated. Three of these distinguish west to east variation in species composition of zonal vegetation, reflecting latitudinal and elevational effects in BC and Yukon (*Northwestern Boreal Forest*) and the longitudinal humidity gradient from southeastern Yukon to Newfoundland (*West-Central Boreal Forest* and *Eastern Boreal Forest*). Level 2 zones also describe the south to north physiognomic gradient from closed forests (3 zones previously noted) to lichen woodlands (*Northern Boreal Woodland*) to woodland-tundra (*Subarctic Woodland-Tundra*) near the continental treeline. The *Atlantic Maritime Heathland* zone characterizes the low elevation, low

[4] Development of new biogeoclimatic subdivisions of the Canadian arctic is proposed (McLennan et al. 2018) and it is expected that the results of this work will generate a new level 2 treatment of arctic zonation in the near future.

latitude occurrence of arctic-alpine vegetation associated with stunted boreal forests in the exposed coastal areas of Newfoundland and southern Labrador.

Pacific Cool Temperate Forest
Maritime climatic influences and orographic effects of the North American Cordillera on westerly air flows from the Pacific Ocean dominate biogeoclimatic zonation in the coastal portions of BC. The coniferous forests of the *Pacific Cool Temperate Forest* level 1 vegetation zone occur primarily on the windward side of the westernmost Cordillera, including on Vancouver Island and Haida Gwaii, in proximity to the Pacific Ocean where the climate is characterized by moderate temperatures and high precipitation. Three level 2 vegetation zones reflect regional elevation and rain shadow effects. The *Pacific Maritime Rainforest* zone occupies the majority of the area, occurring at low to mid-elevations where snowfall is uncommon. At higher elevations in the windward coastal mountains, the *Pacific Montane Forest* zone is colder and receives much of its precipitation as snow. In the rain shadow of the Olympic and Vancouver Island Mountains along the southern BC coast, the *Pacific Dry Forest* zone exhibits vegetation characteristics of a cool Mediterranean climate.

Cordilleran Cool Temperate Forest
The conifer-dominated forests of the *Cordilleran Cool Temperate Forest* level 1 vegetation zone are found in the subhumid to dry conditions of the BC interior and western Alberta. Continental climatic conditions result in greater extremes of temperatures than on the BC coast and orographic effects from the various Cordilleran mountain ranges create distinct precipitation zones. Four level 2 vegetation zones reflect regional gradients of latitude, elevation and precipitation. The *Cordilleran Subboreal Forest* zone occurs at low to mid-elevations on the intermontane plateaux of central BC, in a generally subhumid climate created by the rain shadow of the Coast Mountains. In south-central BC, the *Cordilleran Dry Forest* zone contains some of the driest areas in Canada that are able to support forest vegetation. At higher elevations in the BC interior and the Alberta Rocky Mountains, the extensive *Cordilleran Montane Forest* zone is characterized by highly variable distribution of precipitation (especially snow), depending on local orographic influences. At low to mid-elevations in portions of northwestern and southeastern BC, where high precipitation occurs east of the Coast Mountains, the *Cordilleran Rainforest* zone describes vegetation of the “interior wet belt”.

Eastern Cool Temperate Forest
Forests of the *Eastern Cool Temperate Forest* level 1 vegetation zone are characterized by broad-leaved cold-deciduous species, especially sugar maple (*Acer saccharum*). The temperate climate in eastern Canada is strongly influenced by northward flows of warm humid air and, at its eastern extent in Atlantic Canada, maritime effects of the Atlantic Ocean. Two level 2 vegetation zones distinguish west to east variation in temperate forests east of Lake Winnipeg (*Eastern Temperate Mixed Forest* and *Acadian Temperate Forest*), mostly reflecting this climatic humidity gradient. Another level 2 vegetation zone delineates the southward gradient in Ontario and Quebec towards forests containing species with more southern affinities (*Eastern Temperate Deciduous Forest*).

Grassland, Parkland & Steppe
The *Grassland, Parkland & Steppe* level 1 vegetation zone characterizes temperate areas of Canada with insufficient precipitation to support forests on zonal sites. Regional variation is described by seven level 2 vegetation zones. The majority of these occur in the dry to subhumid continental climate of southern Alberta, Saskatchewan and Manitoba. These zones reflect gradients of climatic temperature and moisture, driven by elevation (*Rocky Mountains Foothills Parkland* and *Rocky Mountains Foothills Fescue*), latitude (*Great Plains Parkland*, *Great Plains Fescue Grassland* and *Great Plains Mixedgrass*

Grassland) or longitude (*Central Tallgrass Grassland*). The *Intermontane Shrub-Steppe* zone occurs in the driest, hottest valleys in south-central BC.

Other

In the level 1 category *Other*, two areas with unique local vegetation characteristics are represented as map units (rather than as formal level 2 vegetation zones). The *Glaciers* map unit delineates the perpetually glaciated high elevation landscape of the windward St. Elias Mountains, where there is little vegetation cover. *Cypress Hills* is a map unit that circumscribes (at elevations >1000 mASL) an elevational landscape complex containing multiple zonal vegetation conditions that are observable on the ground but that cannot be individually represented at the scale of mapping employed in *Vegetation Zones of Canada*.

Table 2. **Level 1** and **Level 2** vegetation zones.

Level 1	Level 2
Arctic Tundra	**High Arctic Sparse Tundra** **Mid-Arctic Dwarf Shrub Tundra** **Low Arctic Shrub Tundra**
Alpine Tundra	**Subarctic Alpine Tundra** **Western Boreal Alpine Tundra** **Cordilleran Alpine Tundra** **Pacific Alpine Tundra** **Eastern Alpine Tundra**
Boreal Forest & Woodland	**Subarctic Woodland-Tundra** **Northern Boreal Woodland** **Northwestern Boreal Forest** **West-Central Boreal Forest** **Eastern Boreal Forest** **Atlantic Maritime Heathland**
Pacific Cool Temperate Forest	**Pacific Maritime Rainforest** **Pacific Dry Forest** **Pacific Montane Forest**
Cordilleran Cool Temperate Forest	**Cordilleran Subboreal Forest** **Cordilleran Montane Forest** **Cordilleran Rainforest** **Cordilleran Dry Forest**
Eastern Cool Temperate Forest	**Eastern Temperate Mixed Forest** **Eastern Temperate Deciduous Forest** **Acadian Temperate Forest**
Grassland, Parkland & Steppe	**Rocky Mountains Foothills Parkland** **Great Plains Parkland** **Intermontane Shrub-Steppe** **Rocky Mountains Foothills Fescue Grassland** **Great Plains Fescue Grassland** **Great Plains Mixedgrass Grassland** **Central Tallgrass Grassland**
Other	**Cypress Hills** **Glaciers**

Level 2 Vegetation Zone Descriptions

The following nomenclature standards are used in the vegetation zone descriptions:

1) Soil nomenclature follows the Canadian System of Soil Classification (Soil Classification Working Group 1998; see Appendix VII for definitions of soil orders).

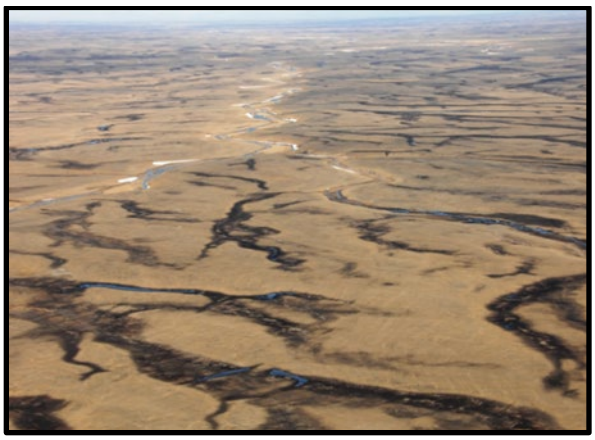
2) Botanical nomenclature follows:
    a. For bryophytes – Anderson 1990; Anderson et al. 1990; Flora of North America Editorial Committee 2007+; Stotler & Crandall-Stotler 1977.
    b. For lichens – Esslinger 2015.
    c. For vascular plants – Brouillet et al. 2010+.

Arctic Tundra

Three **Level 2** descriptions in this section:

- **High Arctic Sparse Tundra**
- **Mid-Arctic Dwarf Shrub Tundra**
- **Low Arctic Shrub Tundra**

High Arctic Sparse Tundra



General Description

The *High Arctic Sparse Tundra* zone includes several islands, as well as the northern coastal portions of others, at the northwestern edge of the Canadian Arctic Archipelago. Altogether, it covers an area of approximately 50,000 km². The largest islands in the zone are Amund Ringnes, Ellef Ringnes, King Christian, Borden, Lougheed, Brock, Mackenzie King and Prince Patrick. This is a polar desert, with a very cold and very dry high arctic climate. Landcover is mostly exposed soil and rock, scattered patches or streaks of cryptogamic vegetation, and occasional small water bodies. Continuous permafrost actively modifies the surface expression of the landscape.

Vegetation

Vegetation development is severely curtailed by the extreme climate and is distributed according to micro-environmental conditions. On upland sites, the ground is mostly barren of vegetation. A cryptogamic crust of lichens, cyanobacteria and bryophytes develops in shallow depressions where there is some moisture. Within these crusts, occasional vascular plants reach heights of 2-3 cm. Continuous carpets of bryophytes and lichens, with scattered grasses, rushes and forbs up to 10 cm tall, develop on sites where snowmelt water accumulates, such as drainage channels, small troughs between permafrost features and moist fine-textured soils. There are no dwarf shrubs or sedge species in this zone; cushion growth forms are common for the few forbs that occur. Permafrost action affects surface substrate expression, which in turn influences vegetation distribution on the landscape. Bedrock and surficial geology affect the species composition.

Vegetation cover is very sparse on sites that dry quickly in summer and have little or no winter snow cover. Crustose lichens dominate on soil and dead vegetation, including Wulfen's lichen (*Lecidella wulfenii*), false sunken disc lichen (*Megaspora verrucosa*), grey-rimmed firedot lichen (*Caloplaca cerina*), orange lichen (*Parvoplaca tiroliensis*), tundra goldspeck lichen (*Candelariella terrigena*), unequal saucer lichen (*Ochrolechia inaequatula*), wart lichen (*Pertusaria octomela*) and pepper-spore lichen (*Rinodina terrestris*). On rock surfaces, species include rocktripe lichens (*Umbilicaria* spp.), tile lichens (*Lecidea* spp.) and map lichens (*Rhizocarpon* spp.). Occurrence of vascular plant species is restricted to widely scattered individuals of narrow alkaligrass (*Puccinellia angustata*), purple mountain saxifrage (*Saxifraga oppositifolia*), polar poppy (*Papaver dahlianum*), abbreviated bluegrass (*Poa abbreviata*) or Baffin Bay draba (*Draba corymbosa*).

On upland sites with some moisture, bryophyte mats and cryptogamic crusts include erect-fruited iris moss (*Distichium capillaceum*), mountain groove moss (*Aulacomnium turgidum)*, rock mosses (*Racomitrium* spp.), frostwort (*Gymnomitrion corallioides*), alpine haircap moss (*Polytrichastrum alpinum*), flexible cow-hair moss (*Ditrichum flexicaule*), smoky shield lichen (*Parmelia omphalodes*), firedot

lichens (*Caloplaca* spp.) and star jelly (*Nostoc* spp.). The main vascular component consists of small clumps of alpine foxtail (*Alopecurus magellanicus*) and two-glumed rush (*Juncus biglumis*). Scattered individuals of nodding saxifrage (*Saxifraga cernua*), leafy stem saxifrage (*Micranthes foliolosa*), polar poppy, northern woodrush (*Luzula confusa*), arctic woodrush (*L. nivalis*) and long-stalked starwort (*Stellaria longipes*) may also occur.

On moist to wet fine-textured soils, including floodplains, drainage channels, glaciolacustrine deposits and hill slopes where late-melting snow provides moisture, brightly coloured moss carpets often develop. Prominent species include golden erect-capsule moss (*Orthothecium chryseum*), rusty hook moss (*Scorpidium revolvens*), twiggy spear moss (*Warnstorfia sarmentosa*) and flexible cow-hair moss. Icegrass (*Phippsia algida*) is often the most abundant vascular plant on these sites, sometimes with scattered occurrences of nodding saxifrage, purple mountain saxifrage, polar poppy, alpine foxtail, Canada arctic draba (*Draba oblongata*) or arctic cinquefoil (*Potentilla hyparctica*). These sites occasionally accumulate a thin layer of organic matter, but wetlands are generally absent.

Climate

The *High Arctic Sparse Tundra* zone occurs at very high latitudes (approximately 76°N to 78°N) on the northwest side of the Canadian Arctic Archipelago. The islands of the zone are permanently surrounded by sea ice and are exposed to constant winds blowing off the frozen Arctic Ocean. During summer months, cold fog further lowers temperatures and reduces insolation on the windward sides of islands as water vapour from meltwater ponds on the sea ice condenses near the shorelines. Overall, the high arctic climate is very cold and very dry, with an extremely short growing season and persistent snow for at least 10 months of the year. Mean annual temperature is approximately -20°C. The short growing season is enhanced by long daylengths, however frost or snow can occur any day of the year. This is the driest vegetation zone in Canada, with mean annual precipitation averaging between 90 and 120 mm. Most precipitation falls as snow.

There is considerable variation in the micro-scale expression of temperature, moisture and growing season length. The arctic environment is windy, and snow is significantly redistributed from exposed locations. Snow cover protects vegetation from extreme winter cold and abrasion by wind-driven ice particles, and snowmelt provides moisture into the growing season. Slope, aspect and wind exposure significantly influence growing conditions, controlling site-scale patterns of insolation, snow deposition and melting. Southerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions favour the survival of plant species in this marginal climate. On this arid landscape, late-lying snowbeds are critical sources of water for vegetation during the growing season.

Physiography, Geology, Topography and Soils

This zone lies mostly in the Innuitian physiographic region (Sverdrup Lowland), but the northwestern portions of Prince Patrick, Borden, Brock, Meighen and Ellef Ringnes Islands occur in the Arctic Coastal Plain physiographic region. Geology is dominated by level Mesozoic sedimentary rocks. Topography is mostly an undulating low-relief lowland with elevations <150 mASL, although there are a few minor uplands. The entire zone has been glaciated, either in the latest Pleistocene event or during previous glaciations. Much of the surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. After the last glaciation, coastal areas were inundated.

On the coastal plains, alluvial and marine sediments generally occur at elevations <60 mASL. Inland from the coastal plains, bedrock may be exposed or covered by a shallow mantle of till or colluvium. The plains and soft bedrock are often dissected by drainage networks that now carry little water but provide sheltered microhabitats for vegetation. Organic deposits

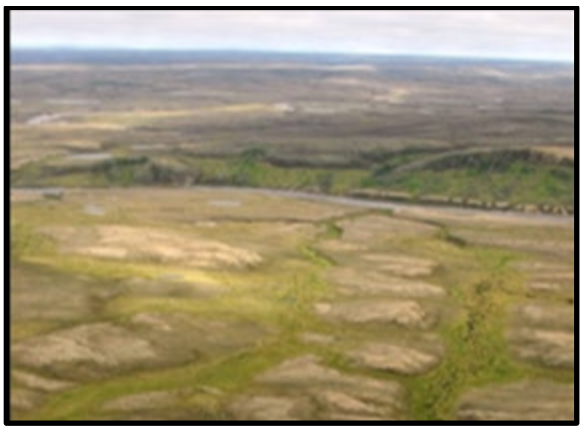
are rare and are usually confined to seepage areas below late-lying snowbeds; they rarely exceed a few centimetres in thickness. Soils are predominantly Cryosols.

All portions of the zone are underlain by deep, continuous permafrost, which creates variable patterns within the surface mineral substrates. Ice wedge polygons are the most common permafrost features, but sorted and unsorted circles and earth hummocks provide microrelief in some areas.

Notes

The *High Arctic Sparse Tundra* zone is surrounded by the Arctic Ocean, except on a few islands (e.g., Prince Patrick Island) where, to the east and south, it borders the *Mid-Arctic Dwarf Shrub Tundra.*

Mid-Arctic Dwarf Shrub Tundra



General Description

The *Mid-Arctic Dwarf Shrub Tundra* zone encompasses most of the Canadian arctic, covering an area of approximately 1,910,000 km². It includes the northernmost mainland in Nunavut, Quebec and NWT, the islands in northern Hudson Bay and the vast majority of the Canadian Arctic Archipelago. The climate is characterized by very long, very cold winters and short, cool summers; annual precipitation is very low for most of the zone. Landcover on upland sites is a mosaic of patchy to continuous prostrate vegetation and exposed soil and rock. Wetlands and numerous small water bodies are prevalent in the southern portion of the zone on low-relief terrain. Continuous permafrost actively modifies the surface expression of the landscape and significantly influences vegetation distribution.

Vegetation

Vegetation is distributed according to micro-environmental conditions; cover can be sparse in harsh environments, grading to continuous on favourable sites. Tundra vegetation is dominated by dwarf shrubs, graminoids, bryophytes and lichens; forbs are most common and abundant on moist sites. In the northernmost parts of the zone, exposed upland sites are typically barren of vegetation other than patchy cover of crustose lichens. On moist protected sites in these areas, cryptogamic crusts of lichens and cyanobacteria develop in association with bryophyte mats and prostrate (<10 cm tall) dwarf shrubs, graminoids and forbs. In southern parts of the zone, vascular plant species diversity is richer and shrub height can approach 40 cm on moist, wind-sheltered sites. Permafrost action affects surface substrate expression, which in turn influences vegetation distribution on the landscape. Bedrock and surficial geology affect the species composition.

Especially in northern and western parts of the zone, wind-exposed sites that dry quickly in summer have very sparse vegetation cover. Lichens dominate, including Wulfen's lichen (*Lecidella wulfenii*), false sunken disc lichen (*Megaspora verrucosa*), tundra goldspeck lichen (*Candelariella terrigena*), heath tube lichen (*Hypogymnia subobscura*), rim lichens (*Lecanora* spp.), saucer lichens (*Ochrolechia* spp.), wart lichens (*Pertusaria* spp.), shield lichens (*Parmelia* spp.) and pepper-spore lichens (*Rinodina* spp.). On rock surfaces, species include rocktripe lichens (*Umbilicaria* spp.), tile lichens (*Lecidea* spp.) and map lichens (*Rhizocarpon* spp.). Scattered occurrences of vascular plants include purple mountain saxifrage (*Saxifraga oppositifolia*), polar poppy (*Papaver dahlianum*), arctic willow (*Salix arctica*), northern woodrush (*Luzula confusa*), arctic woodrush (*L. nivalis*), narrow alkaligrass (*Puccinellia angustata*), abbreviated bluegrass (*Poa abbreviata*), reddish stitchwort (*Sabulina rubella*) or Baffin Bay draba (*Draba corymbosa*). On calcareous sites, entire-leaved mountain avens (*Dryas integrifolia*) is the dominant vascular species on dry snow-scoured sites, typically in association with purple mountain

saxifrage and arctic willow; Ellesmere Island draba (*Draba subcapitata*), grey-leaved draba (*D. cinerea*), nard sedge (*Carex nardina*) and rock sedge (*C. rupestris*) are diagnostic associate species on these sites.

In northern parts of the zone, wind-protected upland sites with moderate winter snow cover, or sites that receive some snowmelt seepage in the growing season, have greater plant cover. Vegetation is dominated by prostrate dwarf shrubs, forbs and bryophytes. Common vascular species include arctic willow, polar willow (*Salix polaris*), entire-leaved mountain avens, northern woodrush, arctic woodrush, alpine foxtail (*Alopecurus magellanicus*), wide-leaved polargrass (*Arctagrostis latifolia*), two-glumed rush (*Juncus biglumis*), purple mountain saxifrage, nodding saxifrage (*Saxifraga cernua*), tufted saxifrage (*S. cespitosa*), leafy stem saxifrage (*Micranthes foliolosa*), polar poppy, mountain-sorrel (*Oxyria digyna*) and long-stalked starwort (*Stellaria longipes*). Bryophytes and lichens often form patches of continuous cover. Frequently occurring bryophyte species include mountain groove moss (*Aulacomnium turgidum*), frostwort (*Gymnomitrion corallioides*), alpine haircap moss (*Polytrichastrum alpinum*), rock mosses (*Racomitrium* spp.), flexible cow-hair moss (*Ditrichum flexicaule*) and erect-fruited iris moss (*Distichium capillaceum*). In addition to the species noted above, lichens include reindeer lichens (*Cladina* spp.), clad lichens (*Cladonia* spp.), snow lichens (*Flavocetraria* spp.), Iceland lichens (*Cetraria* spp., *Cetrariella delisei*), whiteworm lichens (*Thamnolia* spp.), arctic butterfingers lichen (*Dactylina arctica*), zoned dust lichen (*Lepraria neglecta*) and green witch's hair lichen (*Alectoria ochroleuca*).

More continuous vegetation occurs on moist to wet sites, often with fine-textured soils, that are associated with late-melting snowbeds, seepage slopes, valley bottoms and river floodplains. In addition to species mentioned above, dwarf hairgrass (*Deschampsia sukatschewii*), icegrass (*Phippsia algida*), narrow-leaved cottongrass (*Eriophorum angustifolium*), fragile sedge (*Carex membranacea*), short-leaved sedge (*C. fuliginosa*), Canada arctic draba (*Draba oblongata*), alpine draba (*D. alpina*), arctic cinquefoil (*Potentilla hyparctica*), alpine bistort (*Bistorta vivipara*), long-stalked starwort and snow buttercup (*Ranunculus nivalis*) occur in these communities. Wetland mosses are usually prominent, including golden erect-capsule moss (*Orthothecium chryseum*), golden fuzzy fen moss (*Tomentypnum nitens*), rusty hook moss (*Scorpidium revolvens*), twiggy spear moss (*Warnstorfia sarmentosa*), sickle moss (*Sanionia uncinata*), Holmen's bloom moss (*Schistidium holmenianum*) and stairstep moss (*Hylocomium splendens*).

Four-angled mountain heather (*Cassiope tetragona*) is characteristic of late-melting snowbeds on acidic mineral substrates (e.g., Shield-derived till), often in association with arctic willow, polar willow and snowbed willow (*Salix herbacea*). Entire-leaved mountain avens dominates sites with calcareous substrates. On sites with permafrost-derived earth hummocks, entire-leaved mountain avens typically dominates the tops of hummocks with four-angled mountain heather in the depressions.

In the southernmost portions of the zone, on upland wind-protected sites that receive some winter snow cover, vegetation includes erect low shrubs and erect forms of dwarf shrubs (up to 40 cm tall). On acidic substrates, species include arctic dwarf birch (*Betula nana*), glandular birch (*B. glandulosa*), net-veined willow (*Salix reticulata*), grey-leaved willow (*S. glauca*), bog bilberry (*Vaccinium uliginosum*), mountain cranberry (*V. vitis-idaea*), black crowberry (*Empetrum nigrum*), four-angled mountain heather and northern Labrador tea (*Rhododendron tomentosum*). On dry to mesic calcareous substrates, entire-leaved mountain avens dominates in association with red bearberry (*Arctous rubra*), tufted saxifrage, purple mountain saxifrage, Lapland rosebay (*Rhododendron lapponicum*), net-veined willow, arctic willow and several sedge (*Carex* spp.) and lousewort species (*Pedicularis* spp.).

On moist sites with better nutrient status and winter snow cover in southern areas, erect shrubs include Richardson's willow (*Salix richardsonii*), grey-leaved willow, diamond-leaved willow (*S. pulchra*) and Alaska willow (*S. alaxensis*). Here, willows can form thickets up to 2 m tall along stream margins.

Wetlands are common, especially in the southern portion of the zone. Drainage of meltwater can be impeded both by topography and by permafrost, and depressions in bedrock or frozen ground collect water throughout the growing season. Fens and shallow marshes are the predominant wetland classes, although nutrient-poor fens occur in southern areas where peat accumulation can be significant. Cryogenic features (e.g., low-centre polygons) are typical of wet terrain and affect the distribution of vegetation communities by influencing drainage patterns and substrate forms. Hummocky terrain often contains wetland vegetation on the wetter microsites, while vegetation favouring drier conditions occurs on the elevated microsites.

Shallow marshes and wetter fens are typically dominated by graminoids and bryophytes. Graminoids include water sedge (*Carex aquatilis*), pendant grass (*Arctophila fulva*), Fisher's tundra grass (*Dupontia fisheri*), narrow-leaved cottongrass, Scheuchzer's cottongrass (*Eriophorum scheuchzeri*), Chamisso's cottongrass (*E. chamissonis*), sheathed cottongrass (*E. vaginatum*), fragile sedge and wide-leaved polargrass. In southern areas, creeping sedge (*C. chordorrhiza*) and tufted clubrush (*Trichophorum cespitosum*) are often present. Other vascular species include arctic willow, alpine bistort, yellow marsh saxifrage (*Saxifraga hirculus*), nodding saxifrage, long-stalked starwort, Regel's chickweed (*Cerastium regelii*), Sudeten lousewort (*Pedicularis sudetica*) and Nyman's bittercress (*Cardamine polemonioides*). Mosses are usually prominent components of these communities, including mountain groove moss, yellow starry fen moss (*Campylium stellatum*), golden fuzzy fen moss, flexible cow-hair moss, golden erect-capsule moss, northern lantern-moss (*Cinclidium arcticum*), giant spear moss (*Calliergon giganteum*), rusty hook moss and sickle moss.

Especially in southern parts of the zone, peat mosses (*Sphagnum* spp.) dominate wet sites with acidic chemistry, leading to shallow (<50 cm) peat accumulations in some areas. Vegetation on these sites includes sheathed cottongrass along with prostrate dwarf shrub species like arctic dwarf birch, bog bilberry, mountain cranberry, black crowberry, northern Labrador tea and cloudberry (*Rubus chamaemorus*).

Coastal shorelines, beaches, tidal flats and salt marshes are dominated by salt-tolerant species such as Hoppner's sedge (*Carex subspathacea*), creeping alkaligrass (*Puccinellia phryganodes*), saltmarsh starwort (*Stellaria humifusa*), Greenland silverweed (*Potentilla anserina* ssp. *groenlandica*), marsh groundsel (*Tephroseris palustris*), oysterleaf (*Mertensia maritima*) and seabeach sandwort (*Honckenya peploides*).

Climate

The *Mid-Arctic Dwarf Shrub Tundra* zone occurs across a wide range of latitudes in the Canadian arctic (approximately 62°N to 83°N). At the northern extent of the zone, it occurs on islands that are surrounded by sea ice for most (or all) of the year. In southern areas, summer ice-free periods exist in ocean waters adjacent to the zone.

Overall, the arctic climate is very cold and dry with an extremely short growing season and persistent snow for at least 10 months of the year. Mean annual temperatures vary from approximately -18°C in the north to -9°C in the south. Growing degree days above 5°C vary from <30 at Alert, on the northern tip of Ellesmere Island, to approximately 200 in southern parts of the zone. The short growing season is enhanced by long daylengths, however frost or snow can occur any day of the year. Mean annual precipitation is generally <150 mm, except in easternmost areas where it averages >200 mm and can exceed 400 mm along the Atlantic coast. Most precipitation falls

as snow.

There is considerable variation in the micro-scale expression of temperature, moisture and growing season length. The arctic environment is windy and snow is significantly redistributed from exposed locations. Snow cover protects vegetation from extreme winter cold and abrasion by wind-driven ice particles, and snowmelt provides moisture into the growing season. Slope, aspect and wind exposure control site-scale patterns of insolation, snow deposition and melting. Southerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions favour the survival of plant species at their northern range limits. Late-lying snowbeds are important sources of water for vegetation during the growing season.

Physiography, Geology, Topography and Soils

This zone occupies all of the Arctic Lowlands and portions of the Innuitian and Arctic Coastal Plain physiographic regions. Most of the eastern and south-central portions of the zone lie on the Precambrian Shield, occurring in the Kazan, James and Davis regions.

The northern extent of the zone lies on the Eureka and Parry Plateaux of the Innuitian region. Geology is dominated by Mesozoic and Paleozoic sedimentary rocks. Topography is mostly a series of ridged and dissected plateaux with elevations <1000 mASL. The Arctic Coastal Plain, occurring on western Banks Island, is an undulating lowland with elevations <100 mASL.

The Arctic Lowlands lie in the centre of the zone, between the Arctic Coastal Plain and the Innuitian Region to the north and west, and the Shield to the south and east. Geology of the Lowlands is dominated by level Paleozoic sedimentary, often calcareous, rocks. Topography is mostly a series of undulating lowlands and low plateaux, often dissected by river valleys and erosion channels, with elevations generally <400 mASL. The Shaler Mountains in central Victoria Island reach 750 mASL.

In the northern and eastern portions of the zone, mountain ranges on Baffin, Ellesmere and Axel Heiberg Islands can exceed 2000 mASL. In the highest areas, permanent ice fields and valley glaciers exist. Most of the geology is Precambrian crystalline rocks, part of the Davis region of the Shield, but the northernmost Grantland and Axel Heiberg Mountains lie in the Innuitian region and consist mainly of folded Mesozoic and Paleozoic strata. Local relief is extremely rugged, in places >1000 m, and the terrain is deeply dissected with long fjords reaching inland from the sea. The western part of Baffin Island slopes gradually to the southwest from mountains in the northeast.

On the Precambrian Shield in southern Nunavut and northern Quebec, the Kazan and James Uplands exhibit characteristic Shield landscapes, with broad expanses of rolling terrain containing numerous wetlands and lakes, and local relief rarely exceeding 100 m. The Davis region is more rugged, including the Baffin, Frobisher and Hall Uplands of Baffin Island and the Melville Plateau, in addition to the arctic mountain ranges. The geology consists of Precambrian sedimentary and crystalline rocks.

The entire zone has been glaciated, either in the latest Pleistocene event or during previous glaciations. The surficial landscape expression is mostly dominated by glacial features and bedrock-controlled terrain. Typically, exposed bedrock and shallow till veneers prevail on upland sites, while deeper deposits fill landscape depressions. Tills are often modified by permafrost action on soils and frost-shattering of exposed rocks. Soils are frequently calcareous in areas not underlain by Shield bedrock. After the last glaciation, coastal areas were inundated. On the coastal plains of Banks Island and the NWT mainland, alluvial and marine sediments generally occur at elevations <60 mASL. In southern parts of the zone, peat accumulates wherever there is standing water during most of the growing season; peat depths are usually <50 cm. Mineral and organic soils are predominantly Cryosols.

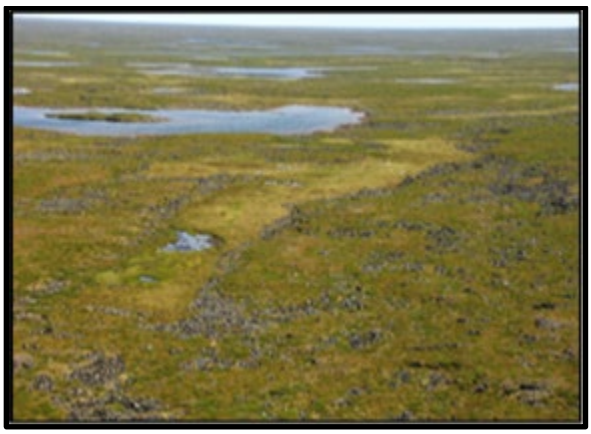
All portions of the zone are underlain by

continuous permafrost, which creates variable patterns within the surface mineral and organic substrates. In many places, surficial expression is strongly modified by permafrost features such as sorted and non-sorted circles and stripes; hummocks and mounds; and ice wedge, low-centre and high-centre polygons. Depth to permafrost affects the temperature of the active soil layer and thus, the effective growing season for vegetation.

Notes

The *Mid-Arctic Dwarf Shrub Tundra* zone is primarily bounded by the *Low Arctic Shrub Tundra* to the south, while the *High Arctic Sparse Tundra* is situated to the northwest. Otherwise, the coastlines of the Beaufort Sea, Arctic Ocean, Atlantic Ocean and Hudson Bay form the zone boundaries.

Low Arctic Shrub Tundra



General Description

The *Low Arctic Shrub Tundra* zone covers an area of approximately 670,000 km² in a band of varying width that extends from the Alaska border in northernmost Yukon to the western coast of Hudson Bay, and then from the eastern coast of Hudson Bay to the northern Labrador coast. The southern boundary of the zone approximates the continental treeline. The low arctic climate has very long, cold winters and short, cool summers. Landcover on upland sites is a mosaic of patchy to continuous low vegetation and exposed soil and rock. Extensive wetlands and numerous small water bodies are common throughout the zone, but particularly prevalent on the coastal plains of Yukon and western NWT. Continuous permafrost actively modifies the surface expression of the landscape and significantly influences vegetation distribution.

Vegetation

Vegetation is distributed according to micro-environmental conditions; cover can be sparse in harsh environments, grading to continuous on favourable sites. Tundra vegetation is characterized by a mixture of low and dwarf shrubs, graminoids, forbs, bryophytes and lichens. Shrub height is dependent on wind exposure, soil conditions and winter snow cover, and often exceeds 40 cm on moist, nutrient-rich sites in the southern portion of the zone. Permafrost action affects surface substrate expression, which in turn influences vegetation distribution on the landscape. Bedrock and surficial geology affect the species composition.

On dry to moist acidic mineral substrates (e.g., Shield-derived till) with some winter snow cover, vegetation is dominated by low or dwarf shrubs, including shrub birches (especially arctic dwarf birch [*Betula nana*] and glandular birch [*B. glandulosa*]), willows (e.g., net-veined willow [*Salix reticulata*], grey-leaved willow [*S. glauca*], bearberry willow [*S. uva-ursi*]), black crowberry (*Empetrum nigrum*), bog bilberry (*Vaccinium uliginosum*), mountain cranberry (*V. vitis-idaea*) and northern Labrador tea (*Rhododendron tomentosum*). Green alder (*Alnus viridis*) occurs on wind-protected moist sites, especially in the western part of the zone. Herb species include moss campion (*Silene acaulis*), creeping sibbaldia (*Sibbaldia procumbens*), Bigelow's sedge (*Carex bigelowii*), northern woodrush (*Luzula confusa*) and arctic lupine (*Lupinus arcticus*). Bryophytes include red-stemmed feathermoss (*Pleurozium schreberi*) and stairstep moss (*Hylocomium splendens*).

At the southern margin of the zone (i.e., near treeline), scattered occurrences of stunted trees (especially black spruce [*Picea mariana*], white spruce [*P. glauca*], tamarack [*Larix laricina*] and balsam poplar [*Populus balsamifera*]) are found in sheltered river valleys and on some south- or west-facing slopes where micro-topography favours the establishment of snowbeds.

On dry, more wind-exposed sites with acidic substrates, alpine bearberry (*Arctous alpina*) and, in the east, Lapland diapensia (*Diapensia lapponica*) occur. In Labrador, hoary rock moss (*Racomitrium lanuginosum*) may be the only the

species on the most exposed ridges. Four-angled mountain heather (*Cassiope tetragona*) and snowbed willow (*Salix herbacea*) are found on sites with late-melting snowbeds.

On dry to mesic calcareous substrates, entire-leaved mountain avens (*Dryas integrifolia*) dominates the vegetation in association with red bearberry (*A. rubra*), tufted saxifrage (*Saxifraga cespitosa*), purple mountain saxifrage (*S. oppositifolia*), Lapland rosebay (*Rhododendron lapponicum*), net-veined willow, arctic willow (*Salix arctica*) and several sedge (*Carex* spp.) and lousewort species (*Pedicularis* spp.).

On rock surfaces and snow-scoured sites (e.g., bedrock, boulders, frost-shattered rock, permafrost patterned ground, peat hummocks), lichens characterize the vegetation. Common ground species include reindeer lichens (*Cladina* spp.), clad lichens (*Cladonia* spp.), snow lichens (*Flavocetraria* spp.), whiteworm lichens (*Thamnolia* spp.), arctic butterfingers lichen (*Dactylina arctica*) and green witch's hair lichen (*Alectoria ochroleuca*). Species on rock surfaces include rocktripe lichens (*Umbilicaria* spp.) and map lichens (*Rhizocarpon* spp.).

Wetlands and small water bodies are common features on the landscape. Drainage can be impeded both by topography and by permafrost, and depressions in bedrock or frozen ground collect water throughout the growing season, promoting the establishment of hydrophytic vegetation (e.g., peat mosses [*Sphagnum* spp.]) and leading to peat accumulation. Fens predominate, although marshes occur at the shallow margins of water bodies; peat depths are usually shallow (<1 m). Cryogenic features (e.g., low-centre polygons) are typical of wet terrain and affect the distribution of vegetation communities by influencing drainage patterns and substrate forms.

Nutrient-poor fens and bogs are dominated by low or dwarf shrub species such as northern Labrador tea, mountain cranberry, bog rosemary (*Andromeda polifolia*), small cranberry (*Vaccinium oxycoccos*), cloudberry (*Rubus chamaemorus*), black crowberry and bog bilberry. On sites with slightly richer nutrient status, shrub birches (e.g., glandular birch, arctic dwarf birch, bog birch [*Betula pumila*]), willows (e.g., tea-leaved willow [*Salix planifolia*], diamond-leaved willow [*S. pulchra*]) or tussock cottongrass (*Eriophorum vaginatum*) are often abundant. Peat mosses dominate the moss layer, with red-stemmed feathermoss, stairstep moss or lichens on the drier tops of hummocks.

Shallow marshes and wetter fens are typically dominated by sedges and grasses, with willows and shrub birches on slightly drier sites. Water sedge (*Carex aquatilis*) is ubiquitous in most of these communities, occurring in association with a variety of other graminoids such as creeping sedge (*C. chordorrhiza*), narrow-leaved cottongrass (*Eriophorum angustifolium*), Scheuchzer's cottongrass (*E. scheuchzeri*), tufted clubrush (*Trichophorum cespitosum*), pendant grass (*Arctophila fulva*) and Fisher's tundra grass (*Dupontia fisheri*). Mosses are usually prominent components of these communities, including peat mosses, scorpion mosses (*Scorpidium* spp.), mountain groove moss (*Aulacomnium turgidum*), yellow starry fen moss (*Campylium stellatum*) and golden fuzzy fen moss (*Tomentypnum nitens*).

Coastal shorelines, beaches, tidal flats and salt marshes are dominated by salt-tolerant species such as Hoppner's sedge (*Carex subspathacea*), creeping alkaligrass (*Puccinellia phryganodes*), arctic lymegrass (*Leymus mollis* ssp. *villosissimus*), oysterleaf (*Mertensia maritima*), saltmarsh starwort (*Stellaria humifusa*), Greenland silverweed (*Potentilla anserina* ssp. *groenlandica*) and seabeach sandwort (*Honckenya peploides*).

Climate

The low arctic climate of the *Low Arctic Shrub Tundra* zone is generally characterized by very long, cold winters and short, cool summers. Continental effects prevail in the west-central portion of the zone. Mean annual temperatures vary from approximately -11°C at the western

end of the zone to -7°C in the east. Growing degree days above 5°C average <300 across the zone. The short growing season is enhanced by long daylengths, however frost or snow can occur any day of the year. Mean annual precipitation generally follows a west to east gradient, increasing from <300 mm in the west to approximately 800 mm in Labrador.

There is considerable variation in the micro-scale expression of temperature, moisture and growing season length. The arctic environment is windy, and snow is significantly redistributed from exposed locations. Snow cover protects vegetation from extreme winter cold and abrasion by wind-driven ice particles, and snowmelt provides moisture into the growing season. Slope, aspect and wind exposure control site-scale patterns of insolation, snow deposition and melting. Southerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions favour the survival of plant species at their northern range limits. Northerly aspects are cooler; snowmelt occurs later, delaying the onset of the growing season.

Physiography, Geology, Topography and Soils

In western Canada, this zone occurs in portions of the Cordilleran, Arctic Coastal Plain and Interior Plains physiographic regions. The majority of the zone lies in the Kazan, James and Davis regions of the Precambrian Shield, although there is a small expression at Cape Churchill in the Hudson region.

In Yukon, the zone occurs on the Yukon Coastal Plain, in the British and northern Richardson Mountains, and on the northern portion of the Porcupine Plateau. Geology consists of Paleozoic and Mesozoic sedimentary rocks. The topography varies from rugged mountains with elevations >1000 mASL to more subdued rounded hills to a gently sloping coastal plain that reaches sea level at the Beaufort Sea. In the western NWT, the zone occurs on the Anderson and Horton Plains as well as on a portion of the Mackenzie Delta. These are underlain by level Paleozoic and late Proterozoic sedimentary rocks. The topography is mostly a level to undulating plain with elevations <300 mASL, although there are several low elevation hills.

On the Precambrian Shield in eastern NWT, Nunavut, Quebec and Labrador, elevations are generally <600 mASL, except in northern Labrador where a series of mountain ranges reach 1650 mASL. The Kazan and James Uplands exhibit characteristic Shield landscapes, with broad expanses of rolling terrain containing numerous wetlands and lakes, and local relief rarely exceeding 100 m. The Davis region includes the higher George Plateau and Labrador Highlands, containing the Torngat Mountains. Shield geology comprises Precambrian sedimentary and crystalline rocks. On the Hudson Bay Lowland, Paleozoic carbonate-rich strata overlie the Precambrian rocks creating a level plain with low relief.

The majority of the zone was affected by late Pleistocene glaciation, with the exception of northern Yukon which remained unglaciated during this period (Beringia). In glaciated areas, surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. In the unglaciated areas of northern Yukon, surficial materials comprise colluvium from weathering of ancient bedrock, and alluvial or marine deposits, often covered by peat, along the coastal plain. The Mackenzie Delta consists of recent and ancient alluvial and fluvial-marine sediments. On the Shield and raised plateaux of the Interior Plains, shallow till veneers often overlie bedrock on upland sites, while deeper deposits fill landscape depressions. Tills are often modified by permafrost action on soils and frost-shattering of exposed rocks. Peatlands are common and sometimes extensive in poorly drained areas; peat depths are usually <1 m. Mineral and organic soils are predominantly Cryosols.

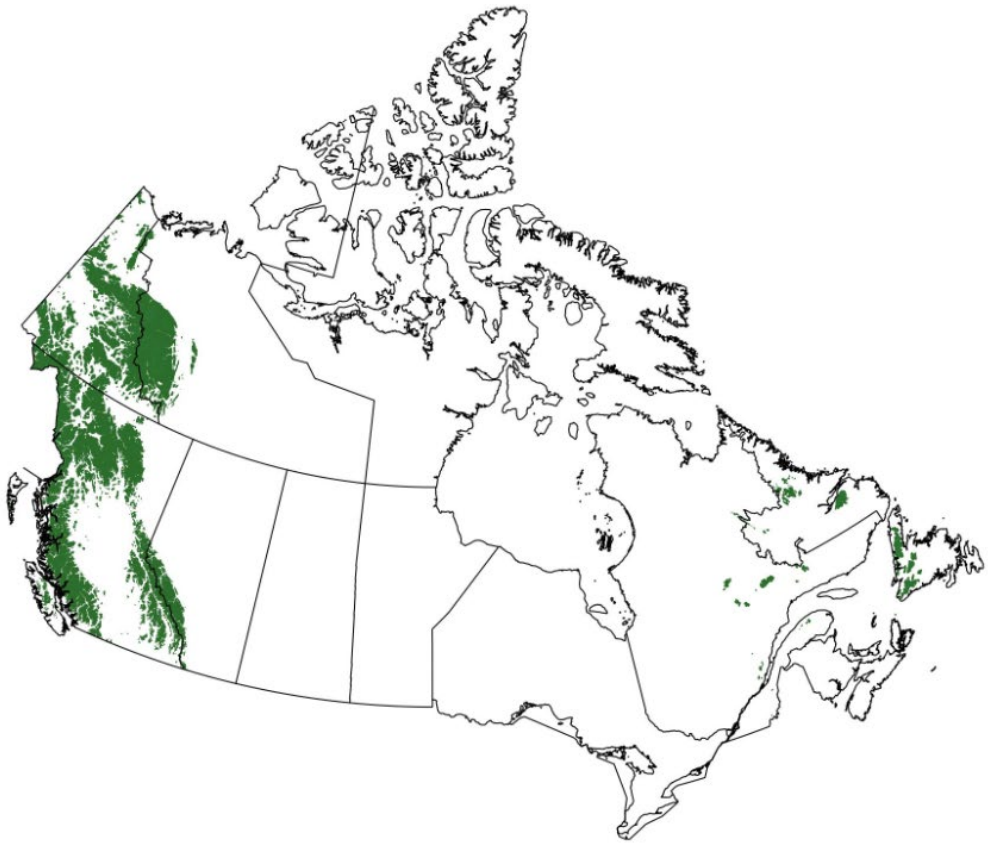
All portions of the zone are underlain by continuous permafrost, which creates variable patterns within the surface mineral and organic substrates. In many places, surficial expression

is strongly modified by permafrost features such as sorted and non-sorted circles and stripes; hummocks, mounds, pingos and palsas; and ice wedge, low-centre and high-centre polygons. Depth to permafrost affects the temperature of the active soil layer and thus, the effective growing season for vegetation.

Notes

In inland areas, the *Low Arctic Shrub Tundra* zone is bounded to the north by the *Mid-Arctic Dwarf Shrub Tundra*. In parts of Yukon and western NWT, this zone extends to the Beaufort Sea and, in western Nunavut, it reaches the coast of the Coronation Gulf. In the central part of the zone, it is divided by Hudson Bay, where it includes the islands along the eastern shore. In eastern Quebec and Labrador the northern boundary is Ungava Bay, and its eastern boundary is the Atlantic Ocean. To the south, the zone transitions into the *Subarctic Woodland-Tundra*, except in northern Yukon where it borders directly on the *Northern Boreal Woodland* and, at higher elevations, parts of the *Subarctic Alpine Tundra* where latitudinal and elevational treelines merge.

Alpine Tundra



Five **Level 2** descriptions in this section:

- **Subarctic Alpine Tundra**
- **Western Boreal Alpine Tundra**
- **Cordilleran Alpine Tundra**
- **Pacific Alpine Tundra**
- **Eastern Alpine Tundra**

Subarctic Alpine Tundra

General Description

The *Subarctic Alpine Tundra* zone covers an area of approximately 94,000 km² near and above elevational treeline in the mountains of central and northern Yukon and western NWT. In the northern Richardson Mountains, this zone meets the *Low Arctic Shrub Tundra* zone as elevational and latitudinal treelines merge. The climate is characterized by very cold temperatures and wind. Landcover is a mosaic of patchy to continuous low vegetation, exposed soil and rock, and snow or ice. Continuous permafrost actively modifies the surface expression of the landscape and significantly influences vegetation distribution.

Vegetation

Vegetation is distributed according to micro-environmental conditions; cover can be sparse in harsh environments, grading to continuous on favourable sites. Tundra vegetation is characterized by a mixture of low and dwarf shrubs, graminoids, forbs, bryophytes and lichens. In the alpine, shrub height rarely exceeds 25 cm, but subalpine shrublands are taller. Bedrock and surficial geology, as well as permafrost action, affect vegetation distribution and species composition.

Entire-leaved mountain avens (*Dryas integrifolia*) and/or Alaska mountain avens (*D. alaskensis*) often dominate. Other common vascular species include moss campion (*Silene acaulis*), blackish locoweed (*Oxytropis nigrescens*), alpine bistort (*Bistorta vivipara*), net-veined willow (*Salix reticulata*), skeleton-leaved willow (*S. phlebophylla*) and purple mountain saxifrage (*Saxifraga oppositifolia*). Northern rough fescue (*Festuca altaica*) is sometimes abundant. Graceful mountain sedge (*Carex podocarpa*) is common on moist sites. Ground lichens are often abundant, including crinkled snow lichen (*Flavocetraria nivalis*), curled snow lichen (*F. cucullata*), limestone sunshine lichen (*Vulpicida tilesii*), arctic butterfingers lichen (*Dactylina arctica*) and awl-shaped whiteworm lichen (*Thamnolia subuliformis*).

Heath vegetation dominated by four-angled mountain heather (*Cassiope tetragona*) occupies sites with late-melting snowbeds, often with entire-leaved mountain avens, black crowberry (*Empetrum nigrum*), bog bilberry (*Vaccinium uliginosum*), bryophytes and clad lichens (*Cladonia* spp.).

Where rock surfaces are the predominant substrate (e.g., talus, boulder colluvium, bedrock, frost-shattered rock), lichens dominate the vegetation. Species include netted rocktripe lichen (*Umbilicaria proboscidea*), sandpaper rocktripe lichen (*U. rigida*), yellow map lichen (*Rhizocarpon geographicum*), superficial map lichen (*R. superficiale*), sporastatia lichen (*Sporastatia testudinea*), curled snow lichen, crinkled snow lichen, green witch's hair lichen (*Alectoria ochroleuca*), arctic butterfingers lichen and limestone sunshine lichen. Hoary rock moss (*Racomitrium lanuginosum*) or curly heron's-bill moss (*Dicranum fuscescens*) may also be present.

In the northern Ogilvie Mountains, several species associated with Beringia are endemic. Examples include Yukon podistera *(Podistera yukonensis),* arctic-alpine forget-me-not (*Eritrichium aretioides*), Ogilvie Mountains draba (*Draba ogilviensis*), Jurtzev's smelowskia (*Smelowskia porsildii*) and Walpole's poppy (*Papaver walpolei*).

Wetlands are associated with late-melting snowbeds and seepage areas. Sedges dominate these communities, including tussock cottongrass (*Eriophorum vaginatum*), beautiful cottongrass (*E. callitrix*), narrow-leaved cottongrass (*E. angustifolium*) and spruce muskeg sedge (*Carex bigelowii* ssp. *lugens*). Peat mosses (*Sphagnum* spp.), golden fuzzy fen moss (*Tomentypnum nitens*), acutetip groove moss (*Aulacomnium acuminatum*), intermediate hook-moss (*Scorpidium cossonii*) and/or stairstep moss (*Hylocomium splendens*) are usually present.

Shrublands, together with patches of stunted trees, dominate at lower elevations in the transition to subarctic woodlands. Arctic dwarf birch (*Betula nana*) and glandular birch (*B. glandulosa*) are the main species, often in association with bog bilberry, northern Labrador tea (*Rhododendron tomentosum*) and various willows (e.g., Alaska willow [*Salix alaxensis*], Barclay's willow [*S. barclayi*], grey-leaved willow [*S. glauca*], low blueberry willow [*S. myrtillifolia*], Richardson's willow [*S. richardsonii*]). Tree species include white spruce (*Picea glauca*) and black spruce (*P. mariana*).

Climate

The high elevation – high latitude subarctic alpine climate has short, cool summers and very long, cold winters. Mean annual temperatures vary from approximately -9°C to -5°C. The growing season is very short and frost can occur at any time. Precipitation is generally low and snowpacks are light. Mean annual precipitation varies between approximately 400 and 1000 mm, with the driest areas occurring in the NWT. Over half of total precipitation falls as snow.

There is considerable variation in the micro-scale expression of temperature, moisture and growing season length. The alpine environment is windy, and snow is significantly redistributed from exposed locations. Snow cover protects vegetation from extreme winter cold and abrasion by wind-driven ice particles, and snowmelt provides moisture into the growing season. Slope, aspect and wind exposure control site-scale patterns of insolation, snow deposition and melting. Southerly and westerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions are more favourable for species at the limit of their environmental tolerance. Northerly and easterly aspects are cooler; wind deposition of snow is often greater and snowmelt occurs later, delaying the onset of the growing season.

Physiography, Geology, Topography and Soils

The *Subarctic Alpine Tundra* zone occurs in northern portions of the Cordilleran physiographic region in Yukon and NWT, including the British, Richardson, Mackenzie and Franklin Mountains, the North Ogilvie region, and also the Old Crow Range. The lower elevation of the zone lies between 800 — 1200 mASL in the south and 600 mASL in the Richardson Mountains at the northern limit.

Geology and topography are diverse. The geology is primarily of sedimentary origin, although igneous intrusions are present in some areas. The terrain is a complex of high plateaux and mountains (up to 2800 mASL). Karst features are common in limestone areas, including sinkholes, caves and deep canyons.

High mountain terrain is generally steep and rugged; rock, ice and snow dominate much of the landscape. Steep slopes can result in mass substrate movement, such as landslides or talus deposition; debris flows are exacerbated by melting permafrost. The cold climate results in frequent freeze-thaw cycles, causing rocks to fracture. Rock fragments, bouldery colluvium and talus are common, especially in areas of limestone and sandstone.

Much of the eastern portion of the zone was

glaciated during the most recent Pleistocene ice age, either by continental or alpine ice sheets. However, there are significant areas that remained unglaciated during this period (Beringia), especially in west-central Yukon, the British and western Richardson Mountains, and portions of the southern and north-central Mackenzie Mountains. In the unglaciated areas, surficial materials consist of colluvium from weathering of ancient bedrock. In glaciated areas, surficial materials are mostly shallow stony tills, often modified by colluvium, slope movement or permafrost action.

Continuous permafrost occurs in most parts of the zone, creating variable patterns within the surface substrates. In many places, surficial expression is strongly modified by permafrost features, especially sorted and non-sorted circles and stripes. Solifluction occurs where surface permafrost melts during the summer and slowly moves downslope. Soils are mostly Cryosols, with Brunisols and Regosols on well-drained, coarse-textured sites.

Notes

The *Subarctic Alpine Tundra* zone is mainly bounded at lower elevations by the *Northern Boreal Woodland.* To the north, it shares a short boundary with the *Low Arctic Shrub Tundra*, where latitudinal and elevational treelines merge. At alpine elevations, it abuts the *Western Boreal Alpine Tundra* zone to the south. To the west, it continues into the US.

Western Boreal Alpine Tundra

General Description

The *Western Boreal Alpine Tundra* zone covers an area of approximately 200,000 km² near and above treeline on high elevation plateaux and mountains in central and northern BC, southern Yukon and southwestern NWT. This zone represents the Canadian portion of boreal alpine tundra and subalpine shrubland in western North America, extending into Alaska. Cold temperatures and wind characterize the climate. Landcover is a mosaic of patchy to continuous low vegetation, exposed soil and rock, snow or ice, and scattered small water bodies. Discontinuous permafrost occurs sporadically.

Vegetation

Vegetation is distributed according to micro-environmental conditions; cover can be sparse in harsh environments, grading to continuous on favourable sites. Tundra vegetation is characterized by a mixture of low and dwarf shrubs, graminoids, forbs, bryophytes and lichens. In the alpine, shrub height is variable, depending on elevation, site fertility and wind exposure, but rarely exceeds 40 cm. Subalpine shrublands are taller, up to 1 m (>1 m in moist ravines or at lower elevations). Bedrock and surficial geology, as well as permafrost action, affect vegetation distribution and species composition.

On dry to moist mineral soils with some winter snow cover, net-veined willow (*Salix reticulata*) and small-awned sedge (*Carex microchaeta*) are usually dominant, often in association with mountain sagewort (*Artemisia norvegica* ssp. *saxatilis*), northern rough fescue (*Festuca altaica*), small black-tip ragwort (*Senecio lugens*) and moss campion (*Silene acaulis*). Various lichens and mosses, including crinkled snow lichen (*Flavocetraria nivalis*), stairstep moss (*Hylocomium splendens*) and mountain groove moss (*Aulacomnium turgidum*), are often present. At higher elevations, polar willow (*Salix polaris*) and crinkled snow lichen dominate.

Drier sites are characterized by northern rough fescue, often occurring with mountain sagewort, short-leaved fescue (*Festuca brachyphylla*), spiked woodrush (*Luzula spicata*), alpine bistort (*Bistorta vivipara*) and creeping sibbaldia (*Sibbaldia procumbens*). On these sites, haircap mosses (*Polytrichum* spp.), clad lichens (*Cladonia* spp.) and reindeer lichens (*Cladina* spp.) are common. In the driest climates, or in the Rocky Mountains where calcareous soils occur, entire-leaved mountain avens (*Dryas integrifolia*) is dominant, while Alaska mountain avens (*D. alaskensis*) is common in Yukon and northern BC, and Hooker's mountain avens (*D. hookeriana*) in northwestern BC.

On exposed snow-scoured sites, typical species include entire-leaved mountain avens, mouse-tail bog sedge (*Carex myosuroides*), inflated locoweed (*Oxytropis podocarpa*), purple mountain saxifrage (*Saxifraga oppositifolia*), three-toothed saxifrage (*S. tricuspidata*), moss campion and lichens (e.g., crinkled snow lichen). On high alpine ridges with some snow cover, moss campion is the main species, often

occurring with mountain sagewort, spiked woodrush, alpine bluegrass (*Poa alpina*) and haircap mosses. Where rock surfaces are the predominant substrate (e.g., talus, boulder colluvium, bedrock, frost-shattered rock), sparse lichen cover is typical (e.g., rocktripe lichens [*Umbilicaria* spp.], map lichens [*Rhizocarpon* spp.]).

On cold aspects with permafrost, vegetation is dominated by net-veined willow, entire-leaved mountain avens, small-awned sedge and yellow marsh saxifrage (*Saxifraga hirculus*). These sites typically have a deep turfy moss layer of stairstep moss and wrinkle-leaved moss (*Rhytidium rugosum*).

Heath vegetation occupies sites where snow accumulates; white mountain heather (*Cassiope mertensiana*) and partridgefoot (*Luetkea pectinata*) are common heath species in the south, while four-angled mountain heather (*C. tetragona*) is the dominant species in northern areas (often occurring with polar willow). Where deeper snow accumulates on unstable scree and talus, providing growing season moisture, mountain-sorrel (*Oxyria digyna*) occurs, sometimes associated with moss campion or small-rooted sedge (*Carex micropoda*).

Meadows occur on moist sites, often with mobile soils through processes like soil creep, ravelling or bioturbation that limit establishment of heath species and encourage herb growth. High elevation meadows are characterized by mountain monkshood (*Aconitum delphiniifolium*), mountain sagewort, large-awned sedge (*Carex macrochaeta*), woolly geranium (*Geranium erianthum*), Asian forget-me-not (*Myosotis asiatica*), fringed grass-of-Parnassus (*Parnassia fimbriata*), western buttercup (*Ranunculus occidentalis*), Canada burnet (*Sanguisorba canadensis*), arrow-leaved ragwort (*Senecio triangularis*), Sitka valerian (*Valeriana sitchensis*) and Wormskjold's alpine speedwell (*Veronica wormskjoldii*).

Wetlands are associated with late-melting snowbeds and seepage areas. Black alpine sedge (*Carex nigricans*) dominates shallow hollows that accumulate snow and remain wet well into the growing season. Tussock cottongrass (*Eriophorum vaginatum*) and spruce muskeg sedge (*Carex bigelowii* ssp. *lugens*) occur in the northern part of the zone. Peat mosses (*Sphagnum* spp.), golden fuzzy fen moss (*Tomentypnum nitens*), ribbed bog moss (*Aulacomnium palustre*), hook mosses (*Drepanocladus* spp.) and tufted fen moss (*Paludella squarrosa*) are often present. Seeps are characterized by white marsh marigold (*Caltha leptosepala*) or arctic sweet coltsfoot (*Petasites frigidus*). River beauty (*Chamaenerion latifolium*) and fountain apple moss (*Philonotis fontana*) occur in snowmelt rivulets.

Shrublands, together with patches of stunted trees, dominate at lower elevations in the transition to high montane forests and woodlands. Arctic dwarf birch (*Betula nana*) and glandular birch (*B. glandulosa*) are the most common species, although grey-leaved willow (*Salix glauca*) and arctic willow (*S. arctica*) can also occur. Associated species in subalpine shrublands include northern rough fescue, mountain sagewort, black crowberry (*Empetrum nigrum*) and feathermosses (especially stairstep moss and red-stemmed feathermoss [*Pleurozium schreberi*]). Tree species include subalpine fir (*Abies lasiocarpa*), white spruce (*Picea glauca*) and Yukon lodgepole pine (*Pinus contorta* var. *yukonensis*), depending on location.

Climate

Latitudinal and orographic influences significantly modify the boreal alpine climate across the *Western Boreal Alpine Tundra* zone, generating highly variable regional to local climates. Overall, temperatures are cold, precipitation is low to moderate and snowpacks are light.

Mean annual temperatures vary from approximately -5°C to -1°C. The growing season is short, averaging <400 growing degree days above 5°C, however frost or snow can occur any day of the year. Mean annual precipitation

varies between about 750 mm and 2200 mm, with the driest areas occurring in the northern portion of the zone in Yukon and NWT. Over half of total precipitation falls as snow.

There is considerable variation in the micro-scale expression of temperature, moisture and growing season length. The alpine environment is windy; snow, which provides protection for vegetation from extreme winter cold and abrasion by wind-driven ice particles, is significantly redistributed from exposed locations. Slope, aspect and wind exposure control site-scale patterns of insolation, snow deposition and melting. Southerly and westerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions are more favourable for species at the limit of their environmental tolerance. Northerly and easterly aspects are cooler; wind deposition of snow is often greater and snowmelt occurs later, delaying the onset of the growing season.

Physiography, Geology, Topography and Soils

The *Western Boreal Alpine Tundra* zone occurs in north-central portions of the Cordilleran physiographic region, including the Selwyn, Wernecke, Pelly, Omineca, Cassiar and northern Rocky Mountains of BC, Yukon and NWT, as well as on the Stikine and Yukon Plateaux of northwestern BC and central Yukon. The lower elevation of the zone lies between 1600 and 2000 mASL in BC, and between 750 and 1450 mASL in Yukon and NWT.

Although there is some bedrock of volcanic origin (e.g., the Omineca Mountains), the geology is mostly faulted and folded Paleozoic, Mesozoic or Tertiary sedimentary, often carbonate-rich, rocks. The terrain is a complex of high mountains (up to 3000 mASL) with intervening plateaux and hill systems.

High mountain terrain is generally steep and rugged; rock, ice and snow dominate much of the landscape. Wetlands and tarns occur in poorly drained topographic depressions. On steep slopes where deep snowpacks exist, avalanches are common. Steep slopes also result in other mass substrate movement, such as landslides or talus deposition; debris flows can be exacerbated by melting permafrost.

All of the zone, except a small portion in west-central Yukon, was affected by late Pleistocene glaciation. The prevalent surficial material is shallow, stony glacial till, often modified with fragments of weathered bedrock or colluvium. The cold climate results in frequent freeze-thaw cycles that can cause cryoturbation or rock fracturing. Discontinuous permafrost occurs at many locations. Soils are mostly Brunisols, Regosols and Cryosols.

Notes

The *Western Boreal Alpine Tundra* zone is mostly bounded at lower elevations by the *Northwestern Boreal Forest*, except in the south where it occurs above the *Cordilleran Montane Forest*. At alpine elevations, it abuts the *Pacific Alpine Tundra* on the leeward slopes of the Coast Mountains, the *Cordilleran Alpine Tundra* along its southern boundary, and the *Subarctic Alpine Tundra* along its northern boundary. To the northwest, it continues into the US.

Cordilleran Alpine Tundra

General Description

The *Cordilleran Alpine Tundra* zone covers an area of almost 29,000 km² above treeline on high elevation plateaux and mountains in central and southern BC and west-central to southwestern Alberta. This zone represents the northern portion of temperate North American Cordilleran alpine tundra found throughout the Rocky Mountains and Intermountain West region of North America, extending south to New Mexico. Cold temperatures, wind and snow characterize the climate. Landcover is a mosaic of patchy to continuous low vegetation, exposed soil and rock, snow or ice, and scattered small water bodies.

Vegetation

Vegetation is distributed according to micro-environmental conditions; cover can be sparse in harsh environments, grading to continuous on favourable sites. Tundra vegetation is characterized by a mixture of low and dwarf shrubs, graminoids, forbs, bryophytes and lichens. Shrub height is variable, depending on elevation, site fertility and wind exposure, but rarely exceeds 40 cm. Bedrock and surficial geology affect vegetation distribution and species composition.

Heath vegetation characterizes much of this zone, absent only from areas where the climate is driest. White mountain heather (*Cassiope mertensiana*), pink mountain heather (*Phyllodoce empetriformis*) and woolly pussytoes (*Antennaria lanata*) are the typical species. In snowier areas, partridgefoot (*Luetkea pectinata*) also occurs, sometimes with yellow mountain heather (*Phyllodoce glanduliflora*). Bryophytes include leafy liverworts (*Barbilophozia* spp.) and broom mosses (*Dicranum* spp.).

On exposed snow-scoured sites, typical vascular species include moss campion (*Silene acaulis*), alpine stitchwort (*Cherleria obtusiloba*), dwarf cinquefoils (*Potentilla* spp.), spotted saxifrage (*Saxifraga bronchialis*) and nard sedge (*Carex nardina*). Dry, rocky substrates are characterized by lichens and mosses, including yellow map lichen (*Rhizicarpon geographicum*), rocktripe lichens (*Umbilicaria* spp.), crinkled snow lichen (*Flavocetraria nivalis*), orange chocolate chip lichen (*Solorina crocea*), haircap mosses (*Polytrichum* spp.), rock mosses (*Racomitrium* spp.) and sidewalk screw moss (*Syntrichia ruralis*).

Graminoid dominated vegetation frequently occurs on dry sites, mostly on well-developed soils with light winter snow cover. Species composition is variable, but timber oatgrass (*Danthonia intermedia*) and short-leaved fescue (*Festuca brachyphylla*) usually dominate. Associated graminoid species include Rocky Mountain fescue (*F. saximontana*), spike trisetum (*Trisetum spicatum*), alpine bluegrass (*Poa alpina*), single-spike sedge (*Carex scirpoidea*) and black-and-white-scale sedge (*C. albonigra*). Hooker's mountain avens (*Dryas hookeriana*) is common on calcareous parent materials in drier regions, often occurring with dwarf snow willow (*Salix nivalis*).

Meadows occur on moist sites, often with mobile soils through processes like soil creep, raveling or bioturbation, that limit establishment of heath species and encourage herb growth. Alpine meadows are common in this zone on warm slopes with moderate snow conditions, generally comprising a diversity of tall forbs with showy flowers. Common species include Sitka valerian (*Valeriana sitchensis*), arrow-leaved ragwort (*Senecio triangularis*), wandering fleabane (*Erigeron peregrinus*), paintbrushes (*Castilleja* spp.) and green false hellebore (*Veratrum viride*). Floristics vary geographically: showy sedge (*Carex spectabilis*) can be abundant in meadows of snowier areas, western pasqueflower (*Pulsatilla occidentalis*) often dominates in the Rocky Mountains, and arctic lupine (*Lupinus arcticus*) is characteristic of areas in the lee of the Coast Mountains.

Avalanche tracks are usually initiated in the alpine zone. Vegetation in the upper portions of avalanche tracks is similar to that of alpine meadows, often comprising Sitka valerian, showy sedge, green false hellebore and fireweed (*Chamaenerion angustifolium*).

Wetlands are associated with late-melting snowbeds and seepage areas. Black alpine sedge (*Carex nigricans*) dominates shallow hollows that accumulate snow and remain wet well into the growing season. Seeps are characterized by white marsh marigold (*Caltha leptosepala*) and white globeflower (*Trollius albiflorus*). On fine-textured slopes below areas of snow accumulation, Piper's woodrush (*Luzula piperi*) occurs with haircap mosses.

Scattered stunted trees occur at lower alpine elevations just above treeline. Species include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), whitebark pine (*Pinus albicaulis*) and subalpine larch (*Larix lyallii*).

Climate

Within the cold temperate alpine climate of the *Cordilleran Alpine Tundra* zone there is considerable variation in annual precipitation. Areas of high orographic precipitation result when westerly air flows are forced over the mountains of interior BC and the Rocky Mountains. In the lee of these mountain ranges, as well as of the Coast Mountains, rain shadow effects create relatively dry conditions. These climatic differences result in significant variation in depth and density of the snowpack across the zone.

Mean annual temperatures vary from approximately -3°C to +1°C. The growing season is short, averaging <500 growing degree days above 5°C, however frost or snow can occur any day of the year. Mean annual precipitation varies between about 650 mm and 3500 mm, with the driest areas occurring in the southern portion of the zone. Over half of total precipitation falls as snow.

There is considerable variation in the micro-scale expression of temperature, moisture and growing season length. The alpine environment is windy; snow, which provides protection for vegetation from extreme winter cold and abrasion by wind-driven ice particles, is significantly redistributed from exposed locations. Slope, aspect and wind exposure control site-scale patterns of insolation, snow deposition and melting. Southerly and westerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions are more favourable for species at the limit of their environmental tolerance. Northerly and easterly aspects are cooler; wind deposition of snow is often greater and snowmelt occurs later, delaying the onset of the growing season.

Physiography, Geology, Topography and Soils

This zone occurs in the southern portion of the Cordilleran physiographic region, including the Columbia Mountains, the southern Rocky Mountains, the southern Omineca and Skeena Mountains, and the eastern sides of the Cascade and southern Coast Mountains. The lower elevation of the zone ranges from approximately 2400 – 2500 mASL in southern dry climate areas to about 1800 mASL in the north.

The Coast and Omineca Mountains consist predominantly of crystalline igneous and metamorphic rocks, while the rest of the Interior Eastern Systems of the Cordillera comprise faulted and folded Paleozoic, Mesozoic or Tertiary sedimentary, often carbonate-rich, rocks. The terrain is a complex of high mountains (up to 3900 mASL) with intervening plateaux and hill systems.

High mountain terrain is generally steep and rugged; rock, ice and snow dominate much of the landscape. Wetlands and tarns occur in poorly drained topographic depressions. On steep slopes where deep snowpacks exist, avalanches are common. Steep slopes also result in other mass substrate movement, such as landslides or talus deposition.

All of the zone was affected by late Pleistocene glaciation. The prevalent surficial material is shallow, stony glacial till, often modified with fragments of weathered bedrock or colluvium. The cold climate results in frequent freeze-thaw cycles that can cause cryoturbation or rock fracturing. Permafrost is not present in this zone. Soils are mostly Brunisols, Regosols and Podzols.

Notes

The *Cordilleran Alpine Tundra* zone is bounded at lower elevations by the *Cordilleran Montane Forest*. At alpine elevations, it abuts the *Pacific Alpine Tundra* on the leeward slopes of the Coast Mountains and the *Western Boreal Alpine Tundra* along its northern boundary. To the south, it continues into the US.

Pacific Alpine Tundra

General Description

The *Pacific Alpine Tundra* zone covers an area of approximately 35,000 km² above treeline in the Coast and Cascade Mountains of BC, and on Vancouver Island and Haida Gwaii. This zone represents the central portion of North American Pacific alpine tundra, extending from northern California to the Aleutian Islands. The climate is characterized by wind, heavy snowfall and cold temperatures. Landcover is a mosaic of patchy to continuous low vegetation, exposed soil and rock, snow or ice, and scattered small water bodies.

Vegetation

Vegetation is distributed according to micro-environmental conditions; cover can be sparse in harsh environments, grading to continuous on favourable sites. Tundra vegetation is characterized by a mixture of low and dwarf shrubs, graminoids, forbs, bryophytes and lichens. Shrub height is variable, depending on elevation, site fertility and wind exposure, but rarely exceeds 40 cm. Bedrock and surficial geology affect vegetation distribution and species composition.

Because of the snowy climate, heath vegetation is characteristic of this zone, mostly comprising moss heathers (*Cassiope* spp.) and mountain heathers (*Phyllodoce* spp.). A variety of bryophytes (e.g., curly heron's-bill moss [*Dicranum fuscescens*] and alpine haircap moss [*Polytrichastrum alpinum*]) occur with the heaths. White mountain heather (*Cassiope mertensiana*) and pink mountain heather (*Phyllodoce empetriformis*) dominate the heaths of the southern portion of the zone. The north is typified by Alaska moss heather (*Harrimanella stelleriana*), together with white mountain heather. On Haida Gwaii, heaths are dominated by yellow mountain heather (*Phyllodoce glandulifora*). Black crowberry (*Empetrum nigrum*), bog bilberry (*Vaccinium uliginosum*) and partidgefoot (*Luetkea pectinata*) are common associates.

Dry, rocky substrates are dominated by lichens and mosses, including yellow map lichen (*Rhizocarpon geographicum*), netted rocktripe (*Umbilicaria proboscidea*) and awned haircap moss (*Polytrichum piliferum*). Snow-scoured rock outcrops and ridge-tops can also include Davidson's beardtongue (*Penstemon davidsonii*) and stunted clumps of common juniper (*Juniperus communis*).

Alpine meadows are common at lower elevations on moist sites, often with mobile soils through processes like soil creep, ravelling or bioturbation that limit establishment of heath species and encourage herb growth. These communities are dominated by showy sedge (*Carex spectabilis*), often with Sitka valerian (*Valeriana sitchensis*).

Wetlands are associated with late-melting snowbeds and seepage areas. Black alpine sedge (*Carex nigricans*) dominates shallow hollows that accumulate snow and remain wet well into the growing season. Areas with the latest snowmelt are typified by snow rustwort (*Marsupella brevissima*). Seeps are characterized by white marsh marigold (*Caltha*

leptosepala), leather-leaved saxifrage (*Leptarrhena pyrolifolia*) and deer cabbage (*Nephrophyllidium crista-galli*), along with black alpine sedge. Drummond's rush (*Juncus drummondii*), Tolmiei's saxifrage (*Micranthus tolmiei*), creeping sibbaldia (*Sibbaldia procumbens*) and Piper's woodrush (*Luzula piperi*) occur on rocky slopes below areas of snow accumulation.

Scattered stunted trees occur at lower alpine elevations on sites with less snow deposition (e.g., steep slopes). Mountain hemlock (*Tsuga mertensiana*) is the characteristic tree species, although subalpine fir (*Abies lasiocarpa*) and yellow-cypress (*Callitropsis nootkatensis*) also occur.

Climate

At high elevations in the coastal mountains of BC, wet Pacific air masses generate very heavy orographic snowfall, resulting in the deep long-lying snowpacks that characterize the *Pacific Alpine Tundra* zone. These snow conditions effectively lower the treeline by shortening the growing season at elevations where trees would otherwise prevail at these latitudes, as is the case in interior BC where snowpacks are not as deep. In general, the alpine maritime temperate climate is cold, windy and wet. Local climates vary, though, and the hypermaritime portions of the zone on Haida Gwaii and the outer mainland coast are characterized by very wet conditions, warmer temperatures and longer growing seasons.

Mean annual temperatures vary from approximately -4°C to +4°C. Growing degree days above 5°C average <600, but are generally higher in the hypermaritime portions of the zone. In most locations, frost can occur at any time during the growing season. Mean annual precipitation varies between about 1800 and 4700 mm over most of zone, but can be up to 7100 mm in hypermaritime areas. Generally, almost 3/4 of total precipitation falls as snow, except in hypermaritime areas where snow accounts for less than half of the total. In many locations, rain can occur in the winter months.

There is considerable variation in the micro-scale expression of temperature, moisture and growing season length. The alpine environment is windy, and snow is significantly redistributed from exposed locations. Snow cover provides protection for vegetation from extreme winter cold and abrasion by wind-driven ice particles, but heavy snowpacks can also crush plants. Slope, aspect and wind exposure control site-scale patterns of insolation, snow deposition and melting. Southerly and westerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions are more favourable for species at the limit of their environmental tolerance. Northerly and easterly aspects are cooler; wind deposition of snow is often greater and snowmelt occurs later, delaying the onset of the growing season.

Physiography, Geology, Topography and Soils

This zone occurs in the westernmost Cordillera, where it occupies the highest elevations of the windward portions of the Coast Mountains in BC, including the Pacific Ranges, the Kitimat Ranges and the Boundary Ranges. It also occurs in the insular mountains of Vancouver Island and Haida Gwaii. Minor portions of the zone occur in the Cascade Mountains of southwestern BC and the St. Elias Mountains of northwestern BC. The lower elevation of the zone is approximately 1600 mASL in the south, 1000 mASL in the north, and about 850 mASL on Haida Gwaii.

The geology of the Coast, Cascade and St. Elias Mountains is primarily crystalline igneous and metamorphic rocks. The Vancouver Island and Queen Charlotte Ranges comprise mostly folded and faulted volcanic and sedimentary Tertiary rocks. The terrain is a complex of high mountains (some >4000 mASL) and ice fields.

High mountain terrain is generally steep and rugged; rock, ice and snow dominate much of the landscape. Wetlands and tarns occur in poorly drained topographic depressions. On steep slopes where deep snowpacks exist, avalanches are common. Steep slopes also

result in other mass substrate movement, such as landslides or talus deposition.

All of the zone was affected by late Pleistocene glaciation, mostly by alpine rather than continental glaciers. Many alpine glaciers still exist in the Coast Mountains. The prevalent surficial material is shallow, stony glacial till, often modified with fragments of weathered bedrock or colluvium. The cold climate results in frequent freeze-thaw cycles that can cause cryoturbation or rock fracturing. Permafrost is not present in this zone. Soils are mostly Folisols, Brunisols and Regosols.

Notes

The *Pacific Alpine Tundra* zone is bounded at lower elevations by the *Pacific Montane Forest*. At alpine elevations on the leeward side of the Coast Mountains, it adjoins the *Western Boreal Alpine Tundra* (in the north) and the *Cordilleran Alpine Tundra* (in central and southern areas). To the south and northwest, it continues into the US.

Eastern Alpine Tundra

General Description

The *Eastern Alpine Tundra* zone comprises several disjunct high elevation areas in Quebec and Newfoundland and Labrador, where alpine and subalpine vegetation occurs. Altogether, the zone totals more than 19,000 km² in over 25 separate locations, ranging from south-central Quebec to western Newfoundland to mid-Labrador. This zone includes the majority of occurrences of eastern North American alpine and subalpine vegetation, except for a few locations in the northeastern US. Cold temperatures, high winds, cloud, fog and snow characterize the climate. Landcover is a mosaic of patchy to continuous low vegetation, exposed soil and rock, snow or ice, and scattered small water bodies. Discontinuous permafrost occurs sporadically.

Vegetation

Vegetation is distributed according to micro-environmental conditions; cover can be sparse in harsh environments, grading to continuous on favourable sites. Tundra vegetation typically consists of a mixture of low and dwarf shrubs, graminoids, forbs, bryophytes and lichens. Often, because of low overall elevations, patches of krummholtz also occur in the alpine mosaic. Shrub height rarely exceeds 40 cm in the alpine, but subalpine shrublands are taller, up to 2 m in sheltered locations. Bedrock and surficial geology, as well as permafrost action, affect vegetation distribution and species composition.

On dry to moist acidic mineral substrates with some winter snow cover, vegetation is dominated by low and dwarf shrubs such as glandular birch (*Betula glandulosa*), bog bilberry (*Vaccinium uliginosum*), early lowbush blueberry (*V. angustifolium*), dwarf bilberry (*V. cespitosum*), mountain cranberry (*V. vitis-idaea*), common Labrador tea (*Rhododendron groenlandicum*), alpine bearberry (*Arctous alpina*), purple, pink and black crowberries (*Empetrum atropurpureum, E. eamesii* and *E. nigrum*), alpine azalea (*Kalmia procumbens*), bearberry willow (*Salix uva-ursi*), purple mountain heather (*Phyllodoce caerulea*) and creeping sibbaldia (*Sibbaldia procumbens*). Bigelow's sedge (*Carex bigelowii*) and highland rush (*Oreojuncus trifidus*) are common associates. Various lichens and mosses, especially reindeer lichens (*Cladina* spp.) and rock mosses (*Racomitrium* spp.), are typically present.

Exposed snow-scoured sites are characterized by Lapland diapensia (*Diapensia lapponica*), often with crowberries, bog bilberry and highland rush. Sparse lichen cover (especially map lichens [*Rhizocarpon* spp.]) is typical on rock surfaces.

In areas of calcareous substrates, entire-leaved mountain avens (*Dryas integrifolia*), Drummond's mountain avens (*D. drummondii*), Lapland rosebay (*Rhododendron lapponicum*), tufted saxifrage (*Saxifraga cespitosa*), purple mountain saxifrage (*S. oppositifolia*), yellow mountain saxifrage (*S. aizoides*), red-tipped lousewort (*Pedicularis flammea*) and snow draba (*Draba nivalis*) are prevalent.

On serpentine substrates, vegetation cover is very sparse, with only scattered occurrences of species that are tolerant of the ultramafic geochemistry. The main shrub species are common juniper (*Juniperus communis*) and stunted black spruce (*Picea mariana*) and tamarack (*Larix laricina*), although Arctic willow (*Salix arctica*) and grey-leaved willow (*S. glauca*) are sometimes present. Herb/dwarf shrub species that are characteristic of serpentine soils include Aleutian maidenhair fern (*Adiantum aleuticum*), serpentine stitchwort (*Cherleria marcescens*), alpine catchfly (*Viscaria alpina*), small-flowered anemone (*Anemone parviflora*), creeping sandwort (*Arenaria humifusa*), reddish stitchwort (*Sabulina rubella*), sea thrift (*Armeria maritima*) and boreal wormwood (*Artemisia borealis*).

Graminoid dominated alpine meadows develop on sites where snow accumulates. Common species include Bigelow's sedge, tufted hairgrass (*Deschampsia cespitosa*) and bluejoint reedgrass (*Calamagrostis canadensis*). Boreal forb species often occur in these meadows, including bunchberry (*Cornus canadensis*), Canada burnet (*Sanguisorba canadensis*), large-leaved goldenrod (*Solidago macrophylla*) and yellow clintonia (*Clintonia borealis*). Other snowbed species include creeping sibbaldia, snowbed willow (*Salix herbacea*) and moss heather (*Harrimanella hypnoides*).

Wetlands associated with late-melting snowbeds and seepage areas are often dominated by tufted clubrush (*Trichophorum cespitosum*). Especially on the high Shield plateaux of Quebec, bogs and fens occur where shallow *Sphagnum* peat deposits have developed on sites with restricted drainage. In these cases, plant species composition is similar to that of boreal bogs and fens in the surrounding *Eastern Boreal Forest* zone.

At lower elevations, in the transition to high montane forests, shrublands and open woodlands are the dominant vegetation. In sheltered areas (e.g., ravines), trees can be taller than 5 m, but in exposed areas they are stunted and often occur only as patches of krummholtz in the lee of boulders or ridges. The main tree species are balsam fir (*Abies balsamea*), white spruce (*Picea glauca*) and black spruce; tamarack and heart-leaved birch (*Betula cordifolia*) are occasionally present at treeline and in krummholtz patches in the alpine tundra. The most common shrub species are green alder (*Alnus viridis*), glandular birch, bog bilberry, Bartram's serviceberry (*Amelanchier bartramiana*), tea-leaved willow (*Salix planifolia*) and Labrador willow (*S. argyrocarpa*). On the Gaspé Peninsula, subalpine meadows are usually dominated by graminoids (especially tufted hairgrass and bluejoint reedgrass) but often contain high abundance of fern species, including common lady fern (*Athyrium filix-femina*), common oak fern (*Gymnocarpium dryopteris*) and interrupted fern (*Osmunda claytoniana*).

Climate

At high elevations in proximity to the Atlantic Ocean, the alpine temperate climate is characterized by cold temperatures, very high wind velocities and heavy orographic snowfall. Prolonged cloud (fog) immersion is a feature of many of these sites (especially those closest to the ocean), which contributes to the overall moist environment and also results in the accumulation of rime ice that damages exposed vegetation. The wind, snow and ice regimes combine to create treeline conditions at elevations where montane forests would otherwise prevail at these latitudes.

Mean annual temperatures are below 0°C (-1.4°C at the Chic-Choc and McGerrigle Mountains in the Gaspé Peninsula; between –1.9°C and -4.3°C at the Mealy Mountains in Labrador). Growing degree days above 5°C vary from <700 in the Mealy Mountains to >900 in the mountains of Gaspésie, but frost can occur at any time in the growing season. Mean annual precipitation is typically >1000 mm (>2000 mm in the Mealy Mountains), with over half of total precipitation falling as snow.

There is considerable variation in the micro-

scale expression of temperature, moisture and growing season length. The alpine environment is windy; snow, which provides protection for vegetation from extreme winter cold and abrasion by wind-driven ice particles, is significantly redistributed from exposed locations. Slope, aspect and wind exposure control site-scale patterns of insolation, snow deposition and melting. Southerly and westerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions are more favourable for species at the limit of their environmental tolerance. Northerly and easterly aspects are cooler; snowmelt occurs later, delaying the onset of the growing season.

Physiography, Geology, Topography and Soils

The majority of the *Eastern Alpine Tundra* zone occurs in the James and Laurentian physiographic regions of the east-central Precambrian Shield, including the Groulx, Otish and Mealy Mountains as well as the Laurentides. South and east of the Shield, in the Appalachian physiographic region, alpine and subalpine conditions occur on western Newfoundland (including the Long Range Mountains and Gros Morne) and at the highest elevations of the Chic-Choc and McGerrigle Mountains of the Gaspé Peninsula. The lower elevation of the zone varies among locations: approximately 500 – 650 mASL at the Mealy Mountains, the Long Range Mountains and Gros Morne; 900 – 1000 mASL at the Groulx, Otish and Blanche Mountains; and 1000 – 1150 at the Chic-Choc and McGerrigle Mountains.

The geology of the Shield consists of Precambrian sedimentary and crystalline rocks. The Appalachian physiographic region is more diverse, with many subdivisions. Highland and mountainous areas on the Gaspé Peninsula and in western Newfoundland are rugged, often deeply dissected plateaux with steep slopes, developed in Precambrian or Paleozoic rocks. In some areas, carbonate-rich strata or serpentine intrusions dominate the geochemistry. Most highland landforms are characterized by erosion-resistant rocks; alpine locations typically occur on high plateaux with rounded summits.

High mountain terrain is generally steep and rugged; rock, ice and snow dominate much of the landscape. Wetlands and tarns occur in poorly drained topographic depressions. On steep slopes where deep snowpacks exist, avalanches are common. Steep slopes also result in other mass substrate movement, such as landslides or talus deposition; debris flows can be initiated by torrential rainfall events.

All of the zone was affected by late Pleistocene glaciation. The predominant surficial material is shallow, stony glacial till, often modified with fragments of weathered bedrock or colluvium. The cold climate results in frequent freeze-thaw cycles that can cause cryoturbation or rock fracturing. Discontinuous permafrost occurs at many locations. Mineral soils are mostly Brunisols or Regosols; Cryosols occur in areas with permafrost. Shallow (<1 m) peat deposits with Organic soils occur in poorly drained locations.

Notes

The *Eastern Alpine Tundra* zone is mostly bounded at lower elevations by the *Eastern Boreal Forest*, although the northernmost occurrences are surrounded by the *Northern Boreal Woodland* and the *Subarctic Woodland-Tundra*. In southern Newfoundland, the low elevation *Atlantic Maritime Heathland* abuts the *Eastern Alpine Tundra* zone in a few locations.

Boreal Forest and Woodland

Six **Level 2** descriptions in this section:

- **Subarctic Woodland-Tundra**
- **Northern Boreal Woodland**
- **Northwestern Boreal Forest**
- **West-Central Boreal Forest**
- **Eastern Boreal Forest**
- **Atlantic Maritime Heathland**

Subarctic Woodland Tundra

General Description

The *Subarctic Woodland-Tundra* zone covers an area of approximately 630,000 km² at the transition between boreal woodlands and arctic tundra. It forms a band of varying width that extends from the Mackenzie River delta in northwestern NWT to the central Labrador coast. The northern boundary of the zone approximates the continental treeline. The subarctic climate has very long, cold winters and short, cool summers. Landcover on upland sites is a mosaic of shrub tundra, scattered patches of woodland, and exposed soil and rock. Extensive wetlands and numerous small water bodies occupy much of the overall landscape. Especially in western parts of the zone, permafrost actively modifies the surface expression of the landscape.

Vegetation

Upland sites exhibit a parkland mosaic of tundra and woodland, with the treed component decreasing northward. Tree growth is favoured by warm aspects, wind-sheltered locations or sites where snow accumulates. Patches of woodland with small trees and understories of low shrubs and lichens are typical of lower slopes and sheltered valleys, while non-treed tundra communities occupy more exposed topographic positions. Woodland stands often occur as tree islands or ribbons in a shrubland matrix, where vegetative layering can maintain dense patches of stunted trees. Wind-exposed trees develop characteristic krummholtz growth forms as a result of physical damage by extreme cold and blowing ice crystals. Woodlands comprise evergreen coniferous tree species, and understories are typically dominated by cold-deciduous broad-leaved shrubs, conifer regeneration and lichens or bryophytes. Tundra vegetation is characterized by a mixture of low and dwarf shrubs, graminoids, forbs, bryophytes and lichens. Bedrock and surficial geology, as well as permafrost action, affect vegetation distribution and species composition.

In woodland communities, the dominant tree species are black spruce (*Picea mariana*) and white spruce (*P. glauca*). Black spruce is the main species on the Shield and on raised peat formations, while white spruce is more often prevalent in the western portion of the zone. Tamarack (*Larix laricina*) occurs in some stands. Balsam poplar (*Populus balsamifera*) occasionally occurs on warm moist, nutrient-rich sites, especially in river valleys.

Common woodland understory species include shrub birches (mainly arctic dwarf birch [*Betula nana*] and glandular birch [*B. glandulosa*]), black crowberry (*Empetrum nigrum*), common Labrador tea (*Rhododendron groenlandicum*), northern Labrador tea (*R. tomentosum*), bog bilberry (*Vaccinium uliginosum*), mountain cranberry (*V. vitis-idaea*) and fireweed (*Chamaenerion angustifolium*). Lichen species diversity is high, but the most common mat-forming species are reindeer lichens (*Cladina* spp.) and foam lichens (*Stereocaulon* spp.). Feathermosses, usually red-stemmed feathermoss (*Pleurozium schreberi*) or stairstep moss (*Hylocomium splendens*), occur when tree

canopies are closed. On raised peat formations, peat mosses (*Sphagnum* spp.) form part of the ground layer.

On acidic substrates (e.g., Shield-derived till), tundra vegetation typically includes shrub birches, willows (e.g., net-veined willow [*Salix reticulata*], grey-leaved willow [*S. glauca*]), black crowberry, bog bilberry, mountain cranberry, northern Labrador tea, moss campion (*Silene acaulis*), creeping sibbaldia (*Sibbaldia procumbens*), Bigelow's sedge (*Carex bigelowii*), arctic lupine (*Lupinus arcticus*), alpine bearberry (*Arctous alpina*) and, in the east, Lapland diapensia (*Diapensia lapponica*).

On dry to mesic calcareous substrates, entire-leaved mountain avens (*Dryas integrifolia*) dominates tundra vegetation, often in association with red bearberry (*A. rubra*), tufted saxifrage (*Saxifraga cespitosa*), purple mountain saxifrage (*S. oppositifolia*), Lapland rosebay (*Rhododendron lapponicum*), net-veined willow, arctic willow (*Salix arctica*) and several sedge (*Carex* spp.) and lousewort species (*Pedicularis* spp.).

On rock surfaces and snow-scoured sites (e.g., bedrock, boulders, frost-shattered rock, permafrost patterned ground, peat hummocks), lichens characterize the vegetation. Common ground species include reindeer lichens, clad lichens (*Cladonia* spp.), snow lichens (*Flavocetraria* spp.), whiteworm lichens (*Thamnolia* spp.), arctic butterfingers lichen (*Dactylina arctica*) and green witch's hair lichen (*Alectoria ochroleuca*). Species on rock surfaces include rocktripe lichens (*Umbilicaria* spp.) and map lichens (*Rhizocarpon* spp.).

Wetlands and small water bodies are common features on the landscape. Drainage can be impeded both by topography and by permafrost, and depressions in bedrock or frozen ground collect water throughout the growing season, promoting the establishment of hydrophytic vegetation (e.g., peat mosses) and leading to peat accumulation. Fens and bogs are the predominant wetland classes, although marshes occur at the shallow margins of water bodies; peat depths are usually shallow (<1 m). Permafrost dynamics often result in peat formations that are raised above the water table, permitting bog islands to develop within a wetter fen matrix.

Bogs and nutrient-poor fens are dominated by low or dwarf shrub species such as northern Labrador tea, mountain cranberry, bog rosemary (*Andromeda polifolia*), small cranberry (*Vaccinium oxycoccos*), cloudberry (*Rubus chamaemorus*), black crowberry and bog bilberry. On sites with slightly richer nutrient status, shrub birches (e.g., glandular birch, arctic dwarf birch, bog birch [*Betula pumila*]), willows (e.g., tea-leaved willow [*Salix planifolia*], diamond-leaved willow [*S. pulchra*]) or tussock cottongrass (*Eriophorum vaginatum*) are often abundant. Peat mosses dominate the moss layer, with red-stemmed feathermoss, stairstep moss or lichens on the drier tops of hummocks.

Shallow marshes and wetter fens are typically dominated by sedges and grasses, with willows, shrub birches and possibly stunted tamarack on slightly drier sites. Water sedge (*Carex aquatilis*) is ubiquitous in most of these communities, occurring in association with a variety of other graminoids such as creeping sedge (*C. chordorrhiza*), narrow-leaved cottongrass (*Eriophorum angustifolium*), Scheuchzer's cottongrass (*E. scheuchzeri*), tufted clubrush (*Trichophorum cespitosum*), pendant grass (*Arctophila fulva*) and Fisher's tundra grass (*Dupontia fisheri*). Mosses are usually prominent components of these communities, including peat mosses, scorpion mosses (*Scorpidium* spp.), mountain groove moss (*Aulacomnium turgidum*), yellow starry fen moss (*Campylium stellatum*) and golden fuzzy fen moss (*Tomentypnum nitens*).

On coastal shorelines, beaches, tidal flats and salt marshes along the Hudson Bay coast, salt-tolerant species such as Hoppner's sedge (*Carex subspathacea*), creeping alkaligrass (*Puccinellia phryganodes*), arctic lymegrass (*Leymus mollis* ssp. *villosissimus*), common mare's-tail (*Hippuris vulgaris*) and Greenland silverweed (*Potentilla anserina* ssp. *groenlandica*) occur.

Climate

The subarctic climate of the *Subarctic Woodland-Tundra* zone is generally characterized by very long, cold winters and short, cool summers. Continental effects prevail in central Quebec and most of the western portion of the zone, but maritime influences become pronounced in the vicinity of Hudson Bay and James Bay, and in Labrador. Mean annual temperatures vary from approximately -10°C in Inuvik, NWT to -5°C in Labrador and southern Hudson Bay. Growing degree days above 5°C average approximately 400 across the zone. The short growing season is enhanced by long daylengths, however frost or snow can occur any day of the year. Mean annual precipitation generally follows a west to east gradient, increasing from <300 mm in the west to approximately 800 mm in Labrador.

There is considerable variation in the micro-scale expression of temperature, moisture and growing season length. The subarctic environment is windy, and snow is significantly redistributed from exposed locations. Snow cover protects vegetation from extreme winter cold and abrasion by wind-driven ice particles, and snowmelt provides moisture into the growing season. Slope, aspect and wind exposure control site-scale patterns of insolation, snow deposition and melting. Southerly and westerly aspects are warmer; snowmelt on these sites occurs earlier in the spring and microclimatic thermal conditions favour the survival of plant species at their northern range limits. Northerly aspects are cooler; snowmelt occurs later, delaying the onset of the growing season.

Physiography, Geology, Topography and Soils

The westernmost portion of this zone occurs primarily in the Interior Plains physiographic region, although a small part of the Mackenzie Delta is also included. The majority of the zone lies on the Precambrian Shield (Kazan, Hudson, James and Davis regions).

In the western NWT, the zone occurs on the Anderson, Horton and Great Bear Plains. These are underlain by level Paleozoic, Mesozoic and late Proterozoic sedimentary rocks. The topography is mostly a level to undulating plain with elevations <300 mASL, although there are several low elevation hills.

On the Precambrian Shield in eastern NWT, Nunavut, Manitoba, Ontario, Quebec and Labrador, elevations are generally <600 mASL. Most of the Shield landscapes are characterized by broad expanses of rolling terrain containing numerous wetlands and lakes, with local relief rarely exceeding 100 m. The geology consists of Precambrian sedimentary and crystalline rocks. On the Hudson Bay Lowland, Paleozoic carbonate-rich strata overlie the Precambrian rocks creating a level plain with low relief and extensive wetlands.

The entire zone was affected by late Pleistocene glaciation, and surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. The Mackenzie Delta consists of recent and ancient alluvial and fluvial-marine sediments. On the Shield and raised plateaux of the Interior Plains, shallow till veneers often overlie bedrock on upland sites, while deeper deposits fill landscape depressions. Tills are often modified by permafrost action on soils and frost-shattering of exposed rocks. On the Hudson Bay Lowland, raised sandy beach ridges from post-glacial isostatic rebound are interspersed with marine clays, often covered by peat. Mineral soils are typically Brunisols and Luvisols, with Gleysols and Cryosols on moist, poorly drained sites. Peatlands dominated by Organic Cryosols are common and often extensive in poorly drained areas; peat depths can be >1 m.

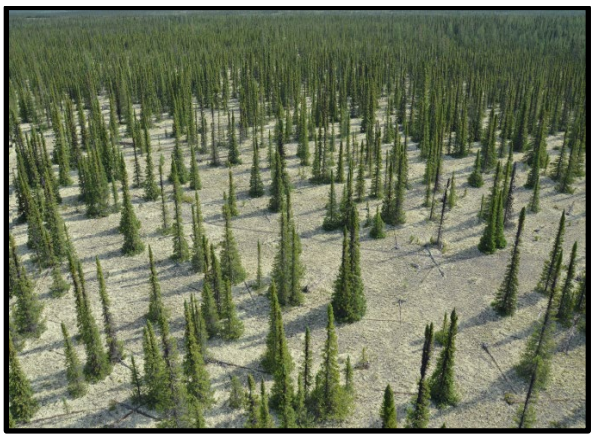
Permafrost is a characteristic of the subarctic, occurring in organic and fine- to medium-textured mineral soils; continuous permafrost is common in western portions of the zone. Permafrost creates variable patterns within the surface mineral and organic substrates. In many places, surficial expression is strongly modified by permafrost features such as sorted and non-sorted circles and stripes, hummocks, mounds, peat plateaux, pingos and palsas. Depth to

permafrost affects the temperature of the active soil layer and thus, the effective growing season for vegetation.

Notes

Except in Ontario and parts of Manitoba and Quebec where it borders the coasts of Hudson Bay and James Bay, the northern boundary of the *Subarctic Woodland-Tundra* zone is the *Low Arctic Shrub Tundra*. To the south, it adjoins the *Northern Boreal Woodland*.

Northern Boreal Woodland



General Description

The *Northern Boreal Woodland* zone covers an area of approximately 1,230,000 km² in a band of varying width that extends for over 4700 km from the Alaska border to the Labrador coast. This zone represents the northern extent of a largely treed landscape, with trees generally becoming smaller and more widely spaced northward. The northern boreal climate has very long winters and short summers. Landcover on upland sites is dominated by woodlands, but extensive peatlands (often with active permafrost features) and numerous water bodies occupy much of the overall landscape.

Vegetation

Upland vegetation is typified by woodlands comprising short, narrow-crowned trees and open understories with continuous lichen ground cover. Vegetative layering often creates dense patches of trees in a generally open woodland mosaic. Groves of closed forest occur on warm aspects and moist, wind-sheltered sites (e.g., river valleys). Woodland canopies mostly comprise evergreen coniferous species, although some cold-deciduous broad-leaved and deciduous coniferous species are present. Understory structure is typically patchy, depending on site and canopy conditions, and is usually dominated by cold-deciduous broad-leaved shrubs, conifer regeneration and lichens or bryophytes. A light-coloured carpet of lichens between widely spaced trees is a striking visual characteristic of these northern woodlands.

Frequent stand-replacing fires create a diverse landscape mosaic; individual woodland stands are seldom over 100 years old. The cold environment and short growing season result in slow vegetation growth and disturbances are evident on the landscape for decades. Fires are not actively suppressed across much of the area and young stands are common. Anthropogenic disturbance is uncommon, except near settlements.

The dominant tree species are black spruce (*Picea mariana*) and white spruce (*P. glauca*). Black spruce is the main species on the Shield, and on raised peat formations, while white spruce is more often prevalent in the western portion of the zone. Paper birch (*Betula papyrifera*) and/or Alaska paper birch (*B. neoalaskana*) are common associates. Balsam poplar (*Populus balsamifera*) occurs on nutrient-rich, often moist, sites. Tamarack (*Larix laricina*) occurs throughout the zone, but is most common in the east. In the east-central portion of the zone, jack pine (*Pinus banksiana*) recolonizes sites following wildfire. In eastern areas, balsam fir (*Abies balsamea*) is sometimes found on fire-protected sites. In the Caribou Hills and Cameron Mountains of northern Alberta and southern NWT, hybrid Murraybanks' pine (*Pinus* x*murraybanksiana*) occurs. Alluvial forests dominated by white spruce and/or balsam poplar occur on stable floodplains throughout the zone.

The understory shrub layer can be well-developed under an open canopy. Common understory species throughout the zone include

shrub birches (mainly arctic dwarf birch [*Betula nana*] and glandular birch [*B. glandulosa*]), green alder (*Alnus viridis*), black crowberry (*Empetrum nigrum*), common Labrador tea (*Rhododendron groenlandicum*), bog bilberry (*Vaccinium uliginosum*), dwarf bilberry (*V. cespitosum*), mountain cranberry (*V. vitis-idaea*) and fireweed (*Chamaenerion angustifolium*). In west-central areas, willows (e.g., grey-leaved willow [*Salix glauca*]), northern Labrador tea (*R. tomentosum*) and common bearberry (*Arctostaphylos uva-ursi*) are often present. In the east, early lowbush blueberry (*V. angustifolium*), creeping snowberry (*Gaultheria hispidula*) and bunchberry (*Cornus canadensis*) are common. In Yukon and western NWT, Lapland rosebay (*R. lapponicum*), red bearberry (*Arctous rubra*), entire-leaved mountain avens (*Dryas integrifolia*), Alaska mountain avens (*D. alaskansis*) and alpine hedysarum (*Hedysarum americanum*) are prominent understory species. Lichen species diversity is high, but the most common mat-forming species are reindeer lichens (*Cladina* spp.), especially in eastern Canada, and foam lichens (*Stereocaulon* spp.). Feathermosses, usually red-stemmed feathermoss (*Pleurozium schreberi*) or stairstep moss (*Hylocomium splendens*), can dominate ground cover when tree canopies are closed. On raised peat formations, peat mosses (*Sphagnum* spp.) are present in the ground layer.

Wetlands are common and often extensive. Fens and bogs are the predominant wetland classes, while marshes occur at the shallow margins of water bodies. With low relief and impermeable frozen soils, many plains have intricate “string” and “net” bog – fen peatland complexes on the landscape; this is especially the case on the Hudson Bay Lowland. Permafrost dynamics often result in peat formations that are raised above the water table, permitting bog islands to develop within a wetter fen matrix.

Shallow marshes, wetter fens and wet meadows are dominated by sedges (e.g., water sedge [*Carex aquatilis*], northern beaked sedge [*C. utriculata*], woolly-fruit sedge [*C. lasiocarpa*], creeping sedge *C. chordorrhiza*]), tufted clubrush (*Trichophorum cespitosum*), water horsetail (*Equisetum fluviatile*), tussock cottongrass (*Eriophorum vaginatum)*, pendant grass (*Arctophila fulva*), bluejoint reedgrass (*Calamagrostis canadensis*) or northern reedgrass (*C. stricta* ssp. *inexpansa*).

Where water tables fluctuate and some root zone drying occurs during the growing season, fens include shrub birches (e.g., arctic dwarf birch, bog birch [*Betula pumila*]), willows (e.g., bog willow [*Salix pedicellaris*]), shrubby cinquefoil (*Dasiphora fruticosa*), sweet gale (*Myrica gale*) and stunted tamarack. On these sites, brown mosses such as ribbed bog moss (*Aulacomnium palustre*), golden fuzzy fen moss (*Tomentypnum nitens*) and hook mosses (*Drepanocladus* spp.) usually dominate between *Sphagnum* hummocks.

Bogs and nutrient-poor fens are usually dominated by low or dwarf shrub species such as common Labrador tea, leatherleaf (*Chamaedaphne calyculata*), mountain cranberry, small cranberry (*Vaccinium oxycoccos*), cloudberry (*Rubus chamaemorus*), pale bog laurel (*Kalmia polifolia*), black crowberry, bog bilberry and, in eastern Canada, early lowbush blueberry. On sites with slightly richer nutrient status, shrub birches (e.g., glandular birch, arctic dwarf birch, bog birch), willows (e.g., tea-leaved willow [*Salix planifolia*], diamond-leaved willow [*S. pulchra*]) and tussock cottongrass are often abundant. Black spruce and tamarack are the main tree species, occurring in stunted form on the poorest sites. Peat mosses dominate the moss layer, with red-stemmed feathermoss, stairstep moss or lichens (especially reindeer lichens) on the drier tops of hummocks. Permafrost is often present in peatlands.

Treed swamps are usually dominated by tamarack, black spruce and/or white spruce. Shrub swamps and annually active floodplains typically include grey alder (*Alnus incana*), green alder, willows (e.g. Barclay’s willow [*Salix barclayi*], tea-leaved willow, satiny willow

[*S. pellita*], coyote willow [*S. exigua*]), shrub birches (e.g., arctic dwarf birch, bog birch, water birch [*Betula occidentalis*]) and bluejoint reedgrass.

Upland shrublands are common on raised peat formations, dry shallow mineral soils, exposed bedrock and following fire. On most sites with some winter snow cover, vegetation is usually dominated by shrub birches (especially glandular birch or arctic dwarf birch) and bog bilberry. Shrub height varies with wind exposure and average snow depth. On sites with acidic substrates (e.g., Shield-derived till), Labrador teas (common and northern), black crowberry, mountain cranberry and, in the east, early lowbush blueberry characterize the vegetation. Especially in western Canada, entire-leaved mountain avens is ubiquitous on substrates with higher pH, often occurring with dwarf willows (e.g., net-veined willow [*Salix reticulata*]). In these areas, four-angled mountain heather (*Cassiope tetragona*) is found on sites with late-melting snowbeds. On exposed rock surfaces or snow-scoured sites (e.g., bedrock, boulders, peat hummocks), lichens characterize the vegetation. Species include those found in the woodlands as well as rocktripe lichens (*Umbilicaria* spp.), map lichens (*Rhizocarpon* spp.), clad lichens (*Cladonia* spp.), arctic kidney lichen (*Nephroma arcticum*), snow lichens (*Flavocetraria* spp.) and whiteworm lichens (*Thamnolia* spp.).

Climate

The northern boreal climate of the *Northern Boreal Woodland* zone is generally characterized by very long, cold winters and short, cool to moderately warm summers. Continental effects prevail in central Quebec and most of the western portion of the zone, but maritime influences become pronounced in the vicinity of Hudson Bay and James Bay, and in Labrador. Mean annual temperatures vary from approximately -10°C in Inuvik, NWT to -4°C in Labrador and the southern Hudson Bay Lowland. Growing degree days above 5°C average approximately 600 across the zone. Mean annual precipitation generally follows a west to east gradient, increasing from <300 mm in the west to approximately 800 mm in Labrador.

Physiography, Geology, Topography and Soils

In western Canada, this zone occurs in portions of the Cordilleran, Arctic Coastal Plain and Interior Plains physiographic regions. The majority of the zone lies on the Precambrian Shield (Kazan, Hudson, James, Laurentian, Davis regions).

In Yukon and western NWT, the zone occurs on a series of low elevation plains and plateaux underlain by Paleozoic, Mesozoic and late Proterozoic sedimentary rocks. The topography is generally rolling or undulating with low relief, although there are some low elevation ridge and hill systems. In the Mackenzie and Franklin Mountains, the North Ogilvie region and the Old Crow Range, this zone occurs below 800 – 1200 mASL; in the Richardson Mountains, it occurs below approximately 600 mASL. This zone also occupies the majority of the Mackenzie Delta.

On the Precambrian Shield in eastern NWT, Nunavut, Saskatchewan, Manitoba, Ontario, Quebec and Labrador, elevations are generally <600 mASL, except in parts of central Quebec and western Labrador where a series of higher plateaux have elevations up to 1100 mASL. Here, areas approximately >800 mASL are in the *Eastern Alpine Tundra* zone. Most of the Shield landscapes are characterized by broad expanses of rolling terrain containing numerous wetlands and lakes, with local relief rarely exceeding 100 m. Shield geology consists of Precambrian sedimentary and crystalline rocks. On the Hudson Bay Lowland, Paleozoic carbonate-rich strata overlie the Precambrian rocks creating a level plain with low relief and extensive wetlands.

The majority of the zone was affected by late Pleistocene glaciation, with the exception of northern Yukon, which remained unglaciated during this period (Beringia). In most glaciated areas, surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. In the unglaciated areas of

northern Yukon, surficial materials consist of colluvium from weathering of ancient bedrock, or glaciofluvial and glaciolacustrine deposits created by water released from glaciers outside the zone. The Mackenzie Delta comprises recent and ancient alluvial and fluvial-marine sediments. On the Shield and raised plateaux of the Interior Plains, shallow till veneers often overlie bedrock on upland sites, while deeper deposits fill landscape depressions. On the Hudson Bay Lowland, raised sandy beach ridges from post-glacial isostatic rebound are interspersed with marine clays and silts, often covered by peat. Mineral soils are typically Brunisols and Luvisols, with Gleysols and Cryosols on moist, poorly drained sites. Peatlands dominated by Organic Cryosols are common and often extensive in poorly drained areas; peat depths can be >2 m.

Permafrost is common in peatlands throughout the zone, and continuous permafrost occurs in fine-textured soils at more northerly latitudes in western areas. Active permafrost features include earth hummocks, cryoturbated surface soil horizons, palsas, peat plateaux and ice wedge polygons. Depth to permafrost affects the temperature of the active substrate layer and thus, the effective growing season for vegetation. Elevated permafrost features sometimes raise peat surfaces above the surrounding water table.

Notes

To the north, the *Northern Boreal Woodland* zone mostly transitions into the *Subarctic Woodland-Tundra,* except in northern Yukon, where it borders directly on the *Low Arctic Shrub Tundra* zone, and a small section in Quebec where it extends to the coast of Hudson Bay. In Ontario and Quebec, it is divided by James Bay, the islands of which are included in the zone. In Labrador, Quebec and northeastern Ontario, the zone is bounded to the south by the *Eastern Boreal Forest.* In northwestern Ontario, Manitoba, Saskatchewan and east-central NWT, its southern boundary is with the *West-Central Boreal Forest*. In Yukon and western NWT, the zone lies to the north of, or at lower elevations to, the *Subarctic Alpine Tundra*. In northern Alberta, this zone occurs at the highest elevations of the Cameron Hills and Caribou Mountains, surrounded by the *West-Central Boreal Forest*.

Northwestern Boreal Forest

General Description

The *Northwestern Boreal Forest* zone covers an area of approximately 280,000 km² in Yukon, northern BC and southwestern NWT. It includes all forested areas in Yukon west of approximately Swift River, but only higher elevation forests and woodlands in northern BC, southeastern Yukon and southwestern NWT. The continental boreal climate has long winters and short summers. Landcover is dominated by forests and woodlands, but numerous lakes, rivers and wetlands contribute to a complex landscape mosaic.

Vegetation

Closed forests are typical on upland sites at lower elevations, however open forests and woodlands occur on dry sites and in colder environments. Treed stands become more open and patchy with increased elevation (or in valleys where cold air ponding is significant), often occurring as tree islands or widely-spaced trees in a shrubland matrix. At the highest elevations or on sites most exposed to wind, trees develop characteristic krummholtz growth forms in response to physical damage by extreme cold and blowing ice crystals. Forest canopies can be dominated by evergreen coniferous, cold-deciduous broad-leaved, or a mixture of conifer and broad-leaved species. Understory structure varies from dense to sparse, and is usually dominated by cold-deciduous broad-leaved shrubs, conifer regeneration and mosses. A continuous feathermoss ground cover is characteristic of these forests, especially under conifer canopies; lichen cover is often high on dry sites and under open canopies.

Frequent stand-replacing fires create a diverse landscape mosaic comprising forest stands of varying age and composition. Individual stands are seldom over 150 years old, and are typically even-aged with a simple structure. In the prolonged absence of fire, a multi-storied, multi-aged stand structure can develop over time. Anthropogenic disturbance is uncommon, except near settlements.

Dominant tree species include white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta* var. *latifolia*), subalpine fir (*Abies lasiocarpa*) and black spruce (*Picea mariana*). Higher elevation woodlands are dominated by white spruce and/or subalpine fir, sometimes with Yukon lodgepole pine (*Pinus contorta* var. *yukonensis*). Trembling aspen or balsam poplar (*Populus balsamifera*) occasionally occur at high elevations on steep warm aspects. Alluvial forests dominated by white spruce and/or balsam poplar occur on stable floodplains. Peatland forests dominated mostly by black spruce occur in wet basins and on cold upland slopes.

Understories vary from dense, species-rich shrub and herb conditions to a continuous feathermoss ground cover with only a few erect vascular plants. Common vascular species include willows (*Salix* spp.), shrub birches (primarily arctic dwarf birch [*Betula nana*] and glandular birch [*B. glandulosa*]), black

crowberry (*Empetrum nigrum*), common Labrador tea (*Rhododendron groenlandicum*), fireweed (*Chamaenerion angustifolium*), mountain cranberry (*Vaccinium vitis-idaea*), twinflower (*Linnaea borealis*), arctic lupine (*Lupinus arcticus*), northern rough fescue (*Festuca altaica*) and common bearberry (*Arctostaphylos uva-ursi*). Reindeer lichens (*Cladina* spp.) and stairstep moss (*Hylocomium splendens*) are prevalent in the ground layer. Greater abundance of shrub birches, willows, black crowberry and bog bilberry (*V. uliginosum*) occurs at higher elevations, especially in the understory of open woodland stands and in shrubland patches.

Wetlands are common and often extensive in poorly drained locations. Fens and bogs are the predominant wetland classes, with peat accumulation occurring on both lowland and cold upland sites. Peatlands often contain permafrost.

In addition to stunted black spruce, bogs and nutrient-poor fens typically include arctic dwarf birch, glandular birch, black crowberry, common Labrador tea, mountain cranberry, bog bilberry, small cranberry (*V. oxycoccos*) and cloudberry (*Rubus chamaemorus*). Peat mosses (*Sphagnum* spp.) dominate the moss layer, with stairstep moss, red-stemmed feathermoss (*Pleurozium schreberi*) or lichens on the drier tops of hummocks.

Marshes and nutrient-rich fens occur at the shallow margins of water bodies and in areas of permanently elevated water tables. Shallow marshes, wetter fens and wet meadows usually include sedges (e.g. water sedge [*Carex aquatilis*], spruce muskeg sedge [*C. bigelowii* ssp. *lugens*], northern beaked sedge [*C. utriculata*]), spikerushes (e.g., needle spikerush [*Eleocharis acicularis*], common spikerush [*E. palustris*]), tussock cottongrass (*Eriophorum vaginatum*), water horsetail (*Equisetum fluviatile*), bluejoint reedgrass (*Calamagrostis canadensis*) or northern reedgrass (*C. stricta* ssp. *inexpansa*). Brown mosses such as ribbed bog moss (*Aulacomnium palustre*), golden fuzzy fen moss (*Tomentypnum nitens*) and hook mosses (*Drepanocladus* spp.) occur between *Sphagnum* hummocks.

Treed swamps are usually dominated by white and/or black spruce, with black spruce prevalent on nutrient-limited sites. Shrub swamps, fens and annually active floodplains include mountain alder (*Alnus incana* ssp. *tenuifolia*), willows (e.g. Barclay's willow [*S. barclayi*], grey-leaved willow [*S. glauca*], tea-leaved willow [*S. planifolia*], Alaska willow [*S. alaxensis*]), arctic dwarf birch and glandular birch.

Upland grasslands and shrublands are relatively common on the landscape, especially at higher elevations and on very dry or shallow sites. Upland shrub communities are usually dominated by shrub birches but can also be willow dominated, especially in areas with deeper snowpacks. Common juniper (*Juniperus communis*) and common bearberry occur on dry rocky sites. Grasslands occur on warm aspects; they are characterized by prairie sagebrush (*Artemisia frigida*), northern rough fescue, glaucous bluegrass (*Poa glauca*) and purple reedgrass (*Calamagrostis purpurascens*). At higher elevations, subalpine grasslands and meadows are common, including mountain monkshood (*Aconitum delphiniifolium*) and mountain sagewort (*Artemisia norvegica* ssp. *saxatilis*).

Climate

The *Northwestern Boreal Forest* zone occurs within the subhumid continental boreal climate of western Canada, characterized by long, cold winters and short, cool summers. Some areas are climatically more humid and some slightly less continental, depending on orographic effects and prevailing westerly air flows. Mean annual temperatures vary from -1°C to -6°C. The growing season is short, ranging between 450 and 1000 growing degree days above 5°C. Mean annual precipitation varies from approximately 300 to 800 mm, depending upon latitude, longitude and elevation (>1000 mm is received at some higher elevations in northwestern BC).

Over half of the annual precipitation falls as snow.

Physiography, Geology, Topography and Soils

This zone occurs in north-central portions of the Cordilleran physiographic region. In Yukon and BC, it includes the Pelly, Omineca, Cassiar and northern Rocky Mountains, plus the southern windward slopes and valleys of the Ogilvie, Selwyn and Wernecke Mountains. It also occurs on the Stikine and Yukon Plateaux of northwestern BC and central Yukon, and the Liard Lowland and the Liard and Hyland Plateaux of southeastern Yukon, southwestern NWT and northeastern BC. In western Yukon, this zone includes all areas that support upland forests and woodlands at elevations below approximately 750 – 1450 mASL. In northern BC, southeastern Yukon and southwestern NWT, it includes forested areas above 800 – 1200 mASL.

The geology of the Cordillera within the zone is mostly faulted and folded Paleozoic, Mesozoic or Tertiary sedimentary, often carbonate-rich, rocks. The Coast and Omineca Mountains consist predominantly of crystalline igneous and metamorphic rocks. The terrain is a complex mixture of high mountains (up to 2500 mASL) with intervening plateaux, hill systems, valleys, trenches and basins.

Except for some small areas in western Yukon and southwestern NWT, the zone was affected by late Pleistocene glaciation, and surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. In mountainous areas, the main parent material is glacial till, usually occurring as blankets and shallow veneers overlying bedrock; alluvial and glaciofluvial materials occur on valley bottoms. At higher elevations and on steep slopes, colluvial materials predominate. In areas with lower relief, deeper till and glaciolacustrine or glaciofluvial deposits occur over more extensive areas. Mineral soils are typically Brunisols and Luvisols, with Gleysols occurring on moist, poorly drained sites. Peatlands dominated by Organic soils are common and often extensive in poorly drained areas; peat depths are usually <3 m. Cryosols are found where discontinuous permafrost occurs, mostly in peatlands and on steep cool aspects with thick moss mats.

Notes

In northern BC, southeastern Yukon and southwestern NWT, the *Northwestern Boreal Forest* zone adjoins the *West-Central Boreal Forest*. At equivalent elevations in southern and western BC, it borders the *Cordilleran Montane Forest*. At higher elevations, near and above treeline, the *Western Boreal Alpine Tundra* occurs. To the west, this zone continues into the US.

West-Central Boreal Forest

General Description

The *West-Central Boreal Forest* zone covers an area of approximately 1,820,000 km² in western and central Canada. It occupies the low elevation boreal and Rocky Mountains foothills areas from northern BC and southeastern Yukon to northwestern Ontario. The continental boreal climate has long winters and short summers. Landcover is dominated by forests, but numerous lakes, rivers and wetlands contribute to a complex landscape mosaic.

Vegetation

Closed forests dominate most upland sites, although open forests and woodlands are commonly associated with very dry sites. Forest canopies can be dominated by evergreen coniferous, cold-deciduous broad-leaved, or a mixture of conifer and broad-leaved species. Understory structure varies from dense to sparse, and is usually dominated by cold-deciduous broad-leaved shrubs, conifer regeneration, perennial herbs and mosses. A continuous feathermoss ground layer is characteristic of these forests, especially under conifer canopies.

Stand-replacing fires and insect outbreaks are the most widespread forms of natural disturbance, creating a diverse landscape mosaic comprising forest stands of varying age and composition. Because of frequent fires, individual stands are seldom over 150 years old and are typically even-aged with a simple structure. In the prolonged absence of fire, a multi-storied, multi-aged stand structure can develop over time. Forest harvesting, other industrial activities (e.g., oil and gas exploration), agricultural conversion and settlement clearance are also significant disturbance factors in some areas.

Dominant tree species include trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), black spruce (*Picea mariana*), lodgepole pine (*Pinus contorta* var. *latifolia*) and jack pine (*Pinus banksiana*). Balsam poplar (*Populus balsamifera*) occurs on nutrient-rich, usually moist, sites. Paper birch (*Betula papyrifera*) is an early seral species that becomes more common eastward in the zone. In fire-sheltered locations, subalpine fir (*Abies lasiocarpa*) or balsam fir (*A. balsamea*) occur with white spruce in late seral stands. In general terms, jack pine and balsam fir occur east of the Rocky Mountains foothills and northwestern Alberta, while lodgepole pine and subalpine fir occur to the west; hybrids occur in areas where the species ranges overlap. Alluvial forests dominated by white spruce, paper birch, trembling aspen and/or balsam poplar occur on stable floodplains.

Understories vary from dense, species-rich shrub and herb conditions to a continuous feathermoss ground cover with only a few erect vascular plants. Common vascular species include prickly rose (*Rosa acicularis*), squashberry (*Viburnum edule*), common Labrador tea (*Rhododendron groenlandicum*), fireweed (*Chamaenerion angustifolium*), tall bluebells (*Mertensia paniculata*), downy lymegrass (*Leymus innovatus*), bluejoint

reedgrass (*Calamagrostis canadensis*) and mountain cranberry (*Vaccinium vitis-idaea*). Red-stemmed feathermoss (*Pleurozium schreberi*) and stairstep moss (*Hylocomium splendens*) are the most prevalent feathermosses. Beaked hazelnut (*Corylus cornuta*) is an important shrub species in the eastern part of the zone.

Wetlands are common and often extensive in poorly drained locations. Swamps, marshes and fens are the predominant wetland classes; true bogs are less common, especially on the Interior Plains.

Treed swamps are typically dominated by black spruce and/or tamarack (*Larix laricina*), with black spruce prevalent on nutrient-limited sites. Shrub swamps and annually active floodplains typically include grey alder (*Alnus incana*), willows (e.g. Bebb's willow [*Salix bebbiana*], tea-leaved willow [*S. planifolia*]), bluejoint reedgrass and field horsetail (*Equisetum arvense*).

Where water tables fluctuate and some root zone drying occurs during the growing season, fens include shrub birches (mainly arctic dwarf birch [*Betula nana*] and bog birch [*B. pumila*]), willows (e.g., bog willow [*Salix pedicellaris*]) and stunted tamarack. On these sites, brown mosses such as ribbed bog moss (*Aulacomnium palustre*), golden fuzzy fen moss (*Tomentypnum nitens*) and hook mosses (*Drepanocladus* spp.) are usually dominant between *Sphagnum* hummocks.

Shallow marshes, wetter fens and wet meadows are often dominated by water sedge (*Carex aquatilis*) and northern beaked sedge (*C. utriculata*), sometimes in association with common spikerush (*Eleocharis palustris*), bluejoint reedgrass or northern reedgrass (*Calamagrostis stricta* ssp. *inexpansa*). In southern parts of the zone, broad-leaved cattail (*Typha latifolia*) and hard-stemmed bulrush (*Schoenoplectus acutus*) marshes occur on the shallow margins of water bodies.

In addition to stunted black spruce and tamarack, bogs and nutrient-poor fens typically include common Labrador tea, mountain cranberry, small cranberry (*Vaccinium oxycoccos*), cloudberry (*Rubus chamaemorus*), pale bog laurel (*Kalmia polifolia*), three-leaved false Solomon's seal (*Maianthemum trifolium*) or, in the west, field horsetail. Peat mosses (*Sphagnum* spp.) dominate the moss layer, with red-stemmed feathermoss, stairstep moss or lichens on the drier tops of hummocks.

Upland grasslands and shrublands are rare on the landscape, other than immediately following forest removal and on very dry or shallow sites.

Climate

The *West-Central Boreal Forest* zone occurs within the subhumid continental boreal climate of west-central Canada, characterized by long, cold winters and short, cool to moderately warm summers. Continental effects are moderated in the Cordilleran portion of the range, including the Rocky Mountains foothills of Alberta and the boreal regions of northern BC, southeastern Yukon and southwestern NWT, where higher elevations and orographic effects produce cooler summers, warmer winters and more precipitation than is characteristic of areas to the east.

Mean annual temperatures vary from -3°C to -5°C along the northern edge of the zone to >2° C in the southern Alberta foothills. The growing season is typically short, averaging less than 1000 growing degree days above 5°C (GDD), although southern portions of the range can reach 1600 GDD. In the Cordilleran areas of Yukon, NWT, BC and Alberta, mean annual precipitation varies from approximately 300 to 600 mm, depending upon latitude, longitude and elevation. East of the foothills, mean annual precipitation generally increases eastward, reaching 750 mm at the eastern limit of the zone in northwestern Ontario. In all parts of the zone, over half of the annual precipitation falls as rain. Summer drought is a regular occurrence and well-drained sites often experience a growing season moisture deficit.

Physiography, Geology, Topography and Soils

This zone occupies portions of the Cordilleran and Interior Plains physiographic regions of western Canada, as well as portions of the Kazan, Hudson and James regions of the western Precambrian Shield. In the Cordilleran region, the zone occurs below approximately 1200 mASL in the Omineca, Cassiar and northern Rocky Mountains of BC, and on the Stikine and Yukon Plateaux of northwestern BC. It is found below approximately 950 mASL in the Selwyn and Mackenzie Mountains, the Liard Lowland and the Liard and Hyland Plateaux of southeastern Yukon, southwestern NWT and northeastern BC. In the Rocky Mountains foothills of Alberta, north of the Bow River, the zone occurs below about 1400 mASL. In the Interior Plains region, the Alberta Plateau and associated Fort Nelson and Peace River Lowlands are included, as well as the forested portions of the Alberta, Saskatchewan and Manitoba Plains. On the Precambrian Shield, the zone occurs on the Athabasca Plain and the southern Kazan Uplands of northern Alberta, Saskatchewan and Manitoba, as well as in the Severn Uplands and Hudson Bay Lowland of eastern Manitoba and northwestern Ontario. East of the Rocky Mountains, elevations rarely exceed 800 mASL.

The geology of the Cordillera within the zone is mostly faulted and folded Paleozoic, Mesozoic or Tertiary sedimentary, often carbonate-rich, rocks. The terrain is a complex mixture of high mountains (up to 3900 mASL) with intervening plateaux, hill systems, valleys, trenches and basins. The Interior Plains physiographic region is underlain by level to gently tilted Paleozoic, Mesozoic or Tertiary sedimentary bedrock. The topography is mostly an undulating plain, although there are several low elevation hill systems. The Kazan and Severn Uplands exhibit characteristic Shield landscapes, with broad expanses of rolling terrain containing numerous wetlands and lakes; local relief rarely exceeds 100 m. Shield geology consists of Precambrian sedimentary and crystalline rocks. On the Hudson Bay Lowland, Paleozoic carbonate-rich strata overlie the Precambrian rocks creating a level plain with low relief and extensive wetlands.

With the exception of a small area in southwestern NWT, the entire zone was affected by late Pleistocene glaciation, and surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. Typically, in the mountains and foothills, glacial till overlies bedrock while alluvial and glaciofluvial materials occur on valley bottoms. In areas with lower relief underlain by gently tilted to level sedimentary rocks (especially in the Interior Plains), deeper till and glaciolacustrine or glaciofluvial deposits occur over more extensive areas. In Shield areas, shallow till veneers often overlie bedrock on upland sites, while deeper deposits fill landscape depressions. Mineral soils are typically Brunisols and Luvisols, with Gleysols occurring on moist, poorly drained sites. Peatlands dominated by Organic soils are common and often extensive in poorly drained areas; peat depths can be >3 m. Discontinuous permafrost occurs sporadically at the northern edge of the zone.

Notes

The *West-Central Boreal Forest* zone is bounded to the north by the *Northern Boreal Woodland* and, to the east, by the *Eastern Boreal Forest*. Its southern boundary across most of its area is with the *Great Plains Parkland*, although small sections adjoin the *Rocky Mountains Foothills Parkland* in southwestern Alberta and the *Cordilleran Subboreal Forest* in central BC. To the west, and at higher elevations in northern BC and parts of Yukon, it borders the *Northwestern Boreal Forest*. At higher elevations in Alberta, some parts of northcentral BC and south of approximately the Halfway River in eastern BC, the adjoining zone is the *Cordilleran Montane Forest*. In northern Alberta, two high elevation occurrences of the *Northern Boreal Woodland* in the Cameron Hills and Caribou Mountains are surrounded by this zone.

Eastern Boreal Forest

General Description

The *Eastern Boreal Forest* zone covers an area of approximately 1,160,000 km² in eastern Canada. It extends from southeastern Manitoba to insular Newfoundland, and includes the islands in the Gulf of St. Lawrence and the highest elevations of the Gaspé Peninsula and Cape Breton Island. The boreal climate of the eastern part of the zone is significantly influenced by maritime effects generated by the Atlantic Ocean, creating a distinct humidity gradient from west to east. Landcover is dominated by forests, but numerous lakes, rivers and wetlands contribute to a complex landscape mosaic.

Vegetation

Closed forests dominate most upland sites, although open forests and woodlands are commonly associated with very dry sites or repeated severe disturbances. Forest canopies can be dominated by evergreen coniferous, cold-deciduous broad-leaved, or a mixture of conifer and broad-leaved species. Understory structure varies from dense to sparse, and is usually dominated by cold-deciduous broad-leaved shrubs, conifer regeneration, perennial herbs and bryophytes. A continuous feathermoss ground layer is characteristic of these forests, especially under conifer canopies.

Stand-replacing fires and insect outbreaks are the most widespread forms of natural disturbance, creating a diverse landscape mosaic comprising forest stands of varying age and composition. Following fire, individual stands are typically even-aged with a simple structure. The fire regime reflects the climatic humidity gradient, with longer fire cycles in the more humid eastern portion of the zone. In these areas, insect outbreaks typically play a greater role in forest dynamics, creating a multi-aged, multi-storied stand structure. Forest harvesting, other industrial activities (e.g., mining), agricultural conversion and settlement clearance are also significant disturbance factors in some areas.

Dominant tree species include balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*) and jack pine (*Pinus banksiana*). Species dominance patterns vary from west to east. Generally, black spruce, jack pine and trembling aspen are more prevalent in Manitoba, Ontario and western Quebec, where fire cycles are shorter, while black spruce, balsam fir and paper birch dominate in the eastern portion of the zone. Balsam poplar (*Populus balsamifera*) occurs on moist, nutrient-rich sites. Alluvial forests dominated by balsam poplar, eastern white cedar (*Thuja occidentalis*), paper birch, white spruce and, in Ontario, black ash (*Fraxinus nigra*) occur on stable floodplains.

Understories vary from dense, species-rich shrub and herb conditions to a continuous feathermoss or lichen ground cover with only a few erect vascular plants. Common vascular species include common Labrador tea (*Rhododendron groenlandicum*), velvet-leaved blueberry (*Vaccinium myrtilloides*), early lowbush blueberry (*V. angustifolium*), mountain

ashes (*Sorbus* spp.), mountain maple (*Acer spicatum*), creeping snowberry (*Gaultheria hispidula*), bunchberry (*Cornus canadensis*), yellow clintonia (*Clintonia borealis*), northern starflower (*Lysimachia borealis*) and wild sarsaparilla (*Aralia nudicaulis*). Red-stemmed feathermoss (*Pleurozium schreberi*) is the dominant moss. In the eastern part of the zone, sheep laurel (*Kalmia angustifolia*) is a prominent shrub species on nutrient-poor sites.

Wetlands are common and often extensive in poorly drained locations and in areas with a very humid climate. On level terrain and in maritime-influenced areas of eastern Quebec and Newfoundland, peat accumulation also occurs on upland sites. Bogs and nutrient-poor fens and swamps are the predominant wetland classes.

Bogs, poor fens and poor swamps include common Labrador tea*,* leatherleaf (*Chamaedaphne calyculata*), velvet-leaved and early lowbush blueberries, cranberries (*Vaccinium oxycoccos*, *V. microcarpon*, *V. macrocarpon*), pale bog laurel (*Kalmia polifolia*), cloudberry (*Rubus chamaemorus*) and glaucous-leaved bog rosemary (*Andromeda polifolia* var. *latifolia*). Black spruce and tamarack (*Larix laricina*) are the main tree species, occurring in stunted form on the poorest sites. Peat mosses (*Sphagnum* spp.) dominate the moss layer, with red-stemmed feathermoss and lichens on the drier tops of hummocks.

Treed swamps with moderate to rich nutrient status are dominated by balsam poplar, black ash, eastern white cedar, white birch and/or white spruce. Shrub swamps and annually active floodplains include speckled alder (*Alnus incana* ssp. *rugosa*)*,* mountain holly (*Ilex mucronata*) and a variety of willow species (e.g. Bebb's willow [*Salix bebbiana*], satiny willow [*S. pellita*], tea-leaved willow [*S. planifolia*]). Broad-leaved cattail (*Typha latifolia*) and hard-stemmed bulrush (*Schoenoplectus acutus*) marshes occur on the shallow margins of water bodies. Shallow marshes, wetter fens and wet meadows are dominated by sedges (e.g., water sedge [*Carex aquatilis*], mud sedge (*C. limosa*]), common spikerush (*Eleocharis palustris*), water horsetail (*Equisetum fluviatile*), bluejoint reedgrass (*Calamagrostis canadensis*) or northern reedgrass (*C. stricta* ssp. *inexpansa*).

Where water tables fluctuate and some root zone drying occurs during the growing season, fens include bog birch (*Betula pumila*), willows (e.g., bog willow [*Salix pedicellaris*]) and stunted tamarack. On these sites, brown mosses such as ribbed bog moss (*Aulacomnium palustre*), golden fuzzy fen moss (*Tomentypnum nitens*) and hook mosses (*Drepanocladus* spp.) are usually dominant between *Sphagnum* hummocks.

Upland grasslands and shrublands are rare on the landscape, other than immediately following forest removal and on very dry or shallow sites. In the eastern part of the zone, shrublands dominated by sheep laurel may develop on formerly forested sites when tree regeneration fails.

Climate

The *Eastern Boreal Forest* zone occurs within the mostly humid and continental, boreal climate of eastern Canada, characterized by long, cold winters and short, cool to moderately warm summers. Maritime influences become pronounced in the eastern part of the zone, and some coastal areas of Newfoundland, Nova Scotia and the Quebec North Shore have hypermaritime climates with persistent fog and cloud. These areas experience cooler summers, milder winters and greater year-round precipitation. In otherwise temperate parts of Quebec and the Maritime provinces, boreal climates occur at higher elevations.

Mean annual temperatures vary from approximately 0.7°C in more continental parts of the zone to >3.5°C in areas near the Atlantic Ocean. Temperature extremes are moderated in maritime locations. The growing season averages about 1300 growing degree days above 5°C (GDD), with the longest growing season (approximately 1600 GDD) in southeastern Manitoba and northwestern Ontario. Mean annual precipitation generally follows a strong west to east gradient,

increasing from approximately 600 mm near the Manitoba border, to 825 mm in northeastern Ontario and western Quebec, to 980 mm in central and eastern Quebec and Labrador, to >1800 mm in parts of Cape Breton Island and insular Newfoundland. Rainfall significantly exceeds snowfall, except at high elevations in the eastern portion of the zone where much of the overall annual precipitation falls as snow.

Physiography, Geology, Topography and Soils

This zone occurs primarily in the James and Laurentian physiographic regions of the east-central Precambrian Shield, and also occupies the southeastern portion of the Hudson region. South of the Shield, in the Appalachian physiographic region, the zone occurs on insular Newfoundland as well as at higher elevations of the Notre Dame Mountains and Chaleur Uplands of the Gaspé Peninsula, and of the Cape Breton Island highlands. Boreal conditions occur at elevations approximately >400 mASL in Gaspésie and, on Cape Breton Island, approximately >350 mASL. In the St. Lawrence Lowlands physiographic province, this zone includes Anticosti Island, the Magdalen Islands and other islands of the Gulf of St. Lawrence.

Most of the Shield landscapes in Ontario and western Quebec are characterized by rolling terrain containing numerous wetlands and lakes, with elevations largely below 500 mASL and local relief rarely exceeding 100 m. However, in the Laurentian physiographic region of Quebec and Labrador, the topography is considerably more rugged and dissected, with elevations up to 1000 mASL. Here, areas approximately >900 mASL (>600 mASL for the Mealy Mountains) are in the *Eastern Alpine Tundra* zone. The geology consists of Precambrian sedimentary and crystalline rocks. On the Hudson Bay Lowland, Paleozoic carbonate-rich strata overlie the Precambrian rocks creating a level plain with low relief and extensive wetlands.

The Appalachian physiographic region is more diverse, with many subdivisions. Highland and mountainous areas on the Gaspé Peninsula, Cape Breton Island and western Newfoundland are generally rugged, often deeply dissected plateaux with steep slopes, developed in Precambrian or Paleozoic rocks. Subalpine transition to treeline begins at approximately 1000 – 1150 mASL in the Chic-Choc and McGerrigle Mountains of Gaspésie; in western Newfoundland, the subalpine begins at about 500 – 650 mASL. The central and northern parts of insular Newfoundland consist of low elevation, generally rolling terrain with low relief.

The entire zone was affected by late Pleistocene glaciation, and surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. The predominant parent material is glacial till, often occurring as shallow veneers overlying bedrock on upland sites while deeper deposits fill landscape depressions. On the Shield, coarse-textured glaciofluvial materials (e.g., eskers) are common. An extensive area of fine-textured glaciolacustrine sediments occurs in the Clay Belt of northeastern Ontario and western Quebec, while glaciomarine deposits underlie the Hudson Bay Lowland. Mineral soils are typically Podzols, Brunisols and Luvisols, with Gleysols occurring on moist, poorly drained sites. Peatlands dominated by Organic soils are common and often extensive in poorly drained areas; peat depths can be >4 m. Discontinuous permafrost occurs sporadically at the northern edge of the zone.

Notes

The *Eastern Boreal Forest* zone is mostly bounded to the north by the *Northern Boreal Woodland*, except in northwestern Ontario and southeastern Manitoba where it borders the *West-Central Boreal Forest*. Over the majority of its extent, the southern boundary is with the *Eastern Temperate Mixed Forest*, except on insular Newfoundland where it adjoins the *Atlantic Maritime Heathland* to the south. On the Quebec North Shore and in Newfoundland, the eastern boundaries are the Gulf of St. Lawrence and the Atlantic Ocean, respectively; in Labrador, the eastern boundary is mostly

with the *Atlantic Maritime Heathland*. In some parts of Quebec, Labrador and insular Newfoundland, the *Eastern Alpine Tundra* occurs at higher elevations, near and above treeline.

Atlantic Maritime Heathland

General Description

The *Atlantic Maritime Heathland* zone consists of two disjunct geographic subunits in insular Newfoundland and eastern Labrador, where vegetation similar to that in arctic-alpine environments develops at low latitudes and low elevations. Altogether, the zone covers an area of approximately 50,000 km². The northern subunit includes low elevation coastal areas at the northern tip of Newfoundland and on the eastern coast of Labrador. The larger southern subunit includes most of the southern and eastern parts of insular Newfoundland, extending up to 100 km inland from the south coast. Strong winds, fog and low summer temperatures characterize the maritime boreal climate. Landcover is a mosaic of shrublands, krummholtz, peatlands and low tundra-like vegetation. Discontinuous permafrost occurs sporadically.

Vegetation

Vegetation is distributed according to micro-environmental conditions; cover can be sparse in harsh environments, grading to continuous on favourable sites. Near the coast, upland vegetation is characterized by low and dwarf shrubs. Trees are either absent from coastal areas or occur as patches of krummholtz on sites where snowbeds establish. Inland or in sheltered coastal valleys, stunted coniferous forests can be very dense. Bedrock and surficial geology, as well as permafrost action, affect vegetation distribution and species composition, especially along the coastlines of the Strait of Belle Isle.

On dry to moist acidic mineral substrates with wind exposure and minimal winter snow cover, vegetation is dominated by pink and black crowberries (*Empetrum eamesii; E. nigrum*), together with Lapland diapensia (*Diapensia lapponica*), alpine azalea (*Kalmia procumbens*), moss campion (*Silene acaulis*), alpine bearberry (*Arctous alpina*), mountain cranberry (*Vaccinium vitis-idaea*) and alpine bilberry (*V. uliginosum*). Prostrate occurrences of common Labrador tea (*Rhododendron groenlandicum*), glandular birch (*Betula glandulosa*), black spruce (*Picea mariana*) and cloudberry (*Rubus chamaemorus*) intertwine in the crowberry mat. Various lichen species form small patches on these sites, including reindeer lichens (*Cladina* spp.), Easter foam lichen (*Stereocaulon paschale*), crinkled snow lichen (*Flavocetraria nivalis*), globe ball lichen (*Sphaerophorus globosus*), true Iceland lichen (*Cetraria islandica*), green witch's hair lichen (*Alectoria ochroleuca*) and grey witch's hair lichen (*Gowardia nigricans*). Bryophytes are generally uncommon in these harsh conditions, however on hypermaritime extremities of the Burin and Avalon Peninsulas, dense carpets of hoary rock moss (*Racomitrium lanuginosum*) occur.

Along the coastlines of the Strait of Belle Isle, especially on the Newfoundland side, the combination of cold climate and calcareous parent materials favours a unique assemblage of species for this latitude and elevation. Species include entire-leaved mountain avens (*Dryas integrifolia*), Lapland rosebay (*Rhododendron lapponicum*), purple mountain

saxifrage (*Saxifraga oppositifolia*), yellow mountain saxifrage (*S. aizoides*), Laestadius' mountain saxifrage (*S. paniculata* ssp. *laestadii*) and red-tipped lousewort (*Pedicularis flammea*). Snowbed communities are dominated by American cow parsnip (*Heracleum maximum*), purple-stemmed angelica (*Angelica atropurpurea*) and Canada burnet (*Sanguisorba canadensis*). Soapberry (*Shepherdia canadensis*), net-veined willow (*Salix reticulata*), beautiful willow (*S. glauca* var. *cordifolia*), hairy willow (*S. vestita*), Lake Huron tansy (*Tanacetum bipinnatum* ssp. *huronense),* dwarf scouring-rush (*Equisetum scirpoides*), long-stalked starwort (*Stellaria longipes*) and Rand's eyebright (*Euphrasia randii*) occur in small patches.

In sheltered coastal valleys and inland, stunted forests develop. In the northern subunit, the dominant tree species is black spruce (*Picea mariana*); in the southern subunit, balsam fir (*Abies balsamea*) dominates. Tamarack (*Larix laricina*), white spruce (*P. glauca*) and paper birch (*Betula papyrifera*) are occasional canopy associates. The understory includes early lowbush blueberry (*Vaccinium angustifolium*)*,* common Labrador tea, black crowberry, northern comandra (*Geocaulon lividum*)*,* cloudberry*,* goldthread (*Coptis trifolia*)*,* wild lily-of-the-valley (*Maianthemum canadense*), bunchberry (*Cornus canadensis*), northern starflower (*Lysimachia borealis*)*,* creeping snowberry (*Gaultheria hispidula*) and twinflower (*Linnaea borealis*). A continuous feathermoss ground layer is dominated by red-stemmed feathermoss (*Pleurozium schreberi*) and, in the southern subunit, stairstep moss (*Hylocomium splendens*). In the southern subunit, due to the high frequency of fog, forests are characterized by an abundance of pendulous epiphytic lichens, including Methuselah's beard lichen (*Usnea longissima*)*,* burred horsehair lichen (*Bryoria furcellata*) and common witch's hair lichen (*Alectoria sarmentosa*).

In the southern subunit, where disturbance has removed forests and tree regeneration has failed, dense low shrub heaths dominated by sheep laurel (*Kalmia angustifolia*) cover extensive areas. Rhodora (*Rhododendron canadense*), common Labrador tea, early lowbush blueberry and, in moist depressions, mountain holly (*Ilex mucronata*) and wild raisin (*Viburnum nudum* var. *cassinoides*) are common associates. Red-stemmed feathermoss, stairstep moss and large patches of reindeer lichens dominate the ground layer.

Abundant precipitation in this low-relief landscape promotes the development of extensive peatlands in both the northern and southern subunits. Shallow fens dominate inland portions of the zone on the northern tip of Newfoundland. Shrubby cinquefoil (*Dasiphora fruticosa*)*,* bog birch (*Betula pumila*)*,* Newfoundland dwarf birch (*B. michauxii*)*,* sweet gale (*Myrica gale*) and creeping juniper (*Juniperus horizontalis*) are the main shrub species. Forbs include alpine meadow-rue (*Thalictrum alpinum*), Canada burnet, balsam groundsel (*Packera paupercula*) and New York aster (*Symphyotrichum novi-belgii*). The primary peat-forming species are graminoids, including livid sedge (*Carex livida*)*,* water sedge (*C. aquatilis*), alpine clubrush (*Trichophorum alpinum*) and tufted clubrush (*T. cespitosum*).

In the southern subunit, peatlands are primarily slope and blanket bogs, dominated by sedges and ericaceous shrubs. Sedges include tufted clubrush*,* tussock cottongrass (*Eriophorum vaginatum*) and meagre sedge (*Carex exilis*). The dominant shrubs are sheep laurel, common Labrador tea*,* leatherleaf (*Chamaedaphne calyculata*)*,* glaucous-leaved bog rosemary (*Andromeda polifolia* var. *latifolia*) and early lowbush blueberry. Near the coast, black huckleberry (*Gaylussacia baccata*) and bog huckleberry (*G. bigeloviana*) sometimes occur on bog hummocks. Peat accumulations are derived primarily from *Sphagnum* mosses. Brown and red peat mosses (*Sphagnum fuscum*; *S. rubellum*) are the most common hummock-forming mosses; red-stemmed feathermoss and lichens occupy the drier tops of hummocks.

Climate

The *Atlantic Maritime Heathland* zone occurs at low elevations within the boreal climate of Newfoundland and Labrador in areas exposed to extreme maritime conditions. Fog frequency is high, creating an overall humid climate, lowering summer temperatures and effectively reducing the length of the growing season. Persistent strong winds, regularly with sustained velocities >100 km/hr, stunt or eliminate tree growth on all but the most sheltered sites. Snow, which provides protection for vegetation from extreme winter cold and abrasion by wind-driven ice particles, is significantly redistributed from exposed locations. In the near-coastal environment, trees can only persist as krummholtz in isolated patches where micro-topography favours snow accumulation.

In the northern subunit, summers are cool and winters are cold. Fog occurs less frequently than in the south (approximately 25% of days in the June to August period). Mean July temperature is about 12°C. Sea ice carried by the Labrador Current persists in adjacent coastal waters until mid-June, reducing growing degree days above 5°C (GDD) to between 500 and 600. Mean annual precipitation is approximately 900 – 950 mm; most winter precipitation falls as snow.

In the southern subunit, summers are cool and winter temperatures fluctuate around 0°C. Fog occurs on approximately 70% of days in the June to August period. Mean July temperature is about 14°C. GDD for the southern subunit, where sea ice is rare, vary between 1000 and 1200. Mean annual precipitation is approximately 1200 – 1700 mm; less than 40% of winter precipitation falls as snow.

Physiography, Geology, Topography and Soils

Most of the northern subunit of this zone occurs in the St. Lawrence Lowlands physiographic province, although its northernmost extent on the Labrador coast lies on the Mecatina and George Plateaux of the Precambrian Shield. Elevations are generally <250 mASL. The southern subunit occurs in the Appalachian physiographic region. It occupies the Avalon Peninsula, the Burin Peninsula, most of the Bonavista Peninsula, and all but the western portion of south-central Newfoundland.

In the St. Lawrence Lowlands, on both sides of the Strait of Belle Isle, calcareous Paleozoic limestones, dolostones and shales are the dominant bedrock formations underlying the northern subunit. The terrain is a combination of undulating coastal plain and low hills dissected by broad valleys and fjords. For the portion of the northern subunit on the Shield, the geology is Precambrian igneous and metamorphic rocks. The southern subunit is underlain by acidic Precambrian or Paleozoic igneous and sedimentary rocks. The terrain is generally rolling, although near the coast fjords with steep cliffs dissect the coastline and elevation rises to 300 mASL.

The entire zone was affected by late Pleistocene glaciation. The predominant surficial materials are stony glacial till and peat. On upland sites, till often occurs as shallow veneers overlying bedrock. Soils are calcareous in the coastal lowlands of the northern subunit, and limestone pavement with pockets of frost-shattered boulders and gravel is a common feature. Mineral soils are typically Podzols and Regosols, with Gleysols occurring on moist, poorly drained sites. Peatlands dominated by Organic soils are common in poorly drained areas, but peat depths are generally <2 m. Especially in the southern subunit, the cool humid environment is conducive to paludification, resulting in extensive peatlands on both lowland and upland topographic positions.

Discontinuous permafrost, with Cryosolic soils, occurs in some locations. Sorted soil polygons on the northern tip of Newfoundland are likely the southernmost sea level occurrences of these permafrost features in North America.

Notes

The *Atlantic Maritime Heathland* zone occurs between sea level at the Atlantic or Strait of Belle Isle coast and the adjacent *Eastern Boreal Forest*.

Pacific Cool Temperate Forest

Three **Level 2** descriptions in this section:

- **Pacific Maritime Rainforest**
- **Pacific Dry Forest**
- **Pacific Montane Forest**

Pacific Maritime Rainforest

General Description

The *Pacific Maritime Rainforest* zone covers almost 110,000 km² at low to mid-elevations along the southern and central BC coast, as well as on Vancouver Island and Haida Gwaii. This zone represents the central portion of North American Pacific coastal rainforests, extending from Alaska to northern California. The maritime temperate climate is cool and wet. Landcover is dominated by evergreen coniferous forests.

Vegetation

Upland vegetation is dominated by temperate rainforests characterized by closed, multi-layered canopies composed of tall, long-lived evergreen coniferous trees in stands that may persist for centuries. Cold-deciduous broad-leaved tree species are sometimes present following disturbance. Understory structure varies from dense to sparse, and is usually dominated by cold-deciduous and evergreen broad-leaved shrubs, conifer regeneration and ferns. The moss layer is typically well developed on the forest floor.

Windthrow, slope failures, pathogens and insect infestations are the most widespread forms of natural disturbance throughout the zone. Forest harvesting, roadbuilding, agricultural conversion, urban development, and industrial and recreational activities are also significant disturbance factors in some areas. In general, stand-replacing fire plays a relatively minor role in the disturbance regime. However, fire becomes an increasingly important contributor to forest dynamics where climatic conditions are drier, primarily in the more southern and eastern portions of the zone. Otherwise, gap replacement of single or small groups of trees is the common regeneration process. Overall, stand structure is typically multi-storied and multi-aged, but it can be single-storied and even-aged after stand-replacing disturbance.

Western hemlock (*Tsuga heterophylla*) is the characteristic tree species. Western red cedar (*Thuja plicata*) is the most common canopy associate, except at the northern edge of the zone where it occurs less frequently. Other common trees include Pacific silver fir (*Abies amabilis*), coast Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*), Sitka spruce (*Picea sitchensis*), yellow-cypress (*Callitropsis nootkatensis*), grand fir (*Abies grandis*), red alder (*Alnus rubra*) and big-leaved maple (*Acer macrophyllum*). Shore pine (*Pinus contorta* var. *contorta*) is dominant on some very dry sites, as well as in treed coastal bogs. Western white pine (*Pinus monticola*) and mountain hemlock (*Tsuga mertensiana*) occur occasionally. Alluvial forests dominated by western hemlock, western red cedar, Sitka spruce, red alder and/or black cottonwood (*Populus trichocarpa*) occur on stable floodplains.

Common upland understory shrubs include oval-leaved blueberry (*Vaccinium ovalifolium*), red huckleberry (*V. parvifolium*), salal (*Gaultheria shallon*), false azalea (*Menziesia ferruginea*) and in drier climates, Cascade barberry (*Berberis nervosa*). Deer fern (*Blechnum spicant)* is the most widespread

herb, but three-leaved foamflower (*Tiarella trifoliata*) and western sword fern (*Polystichum munitum*) are also common. Lanky moss (*Rhytidiadelphus loreus*), stairstep moss (*Hylocomium splendens*) and Oregon beaked moss (*Kindbergia oregana*) predominate in the moss layer.

Wetlands occur frequently in poorly drained locations and along the Pacific coastline. Swamps, fens, bogs, marshes and estuarine wetlands are all represented.

Coastal treed swamps usually include red alder, western red cedar, western hemlock, big-leaved maple and/or yellow-cypress in the tree stratum, with yellow skunk cabbage (*Lysichiton americanus*), salmonberry (*Rubus spectabilis*) and ferns in the understory.

Extensive wetland complexes occur in outer coastal areas. These complexes typically include both treed and non-treed bogs, dominated by shore pine, yellow-cypress, common juniper (*Juniperus communis*), common Labrador tea (*Rhododendron groenlandicum*), black crowberry (*Empetrum nigrum*), tufted clubrush (*Trichophorum cespitosum*), narrow-leaved cottongrass (*Eriophorum angustifolium*) and/or peat mosses (*Sphagnum* spp.).

Shallow marshes and wetter fens usually are dominated by Sitka sedge (*Carex aquatilis* var. *dives*), woolly-fruit sedge (*C. lasiocarpa*), three-way sedge (*Dulichium arundinaceum*), sweet gale (*Myrica gale*) or white beakrush (*Rhynchospora alba*). Shrub swamps and annually active floodplains are dominated by Sitka willow (*Salix sitchensis*), shining willow (*S. lucida*), mountain alder (*Alnus incana* ssp. *tenuifolia*) or Douglas' meadowsweet (*Spiraea douglasii*).

Coastal estuaries and intertidal zones have marshes and wet meadows dominated by Lyngbye's sedge (*Carex lyngbyei*), Pacific silverweed (*Potentilla anserina* ssp. *pacifica*), Beringian hairgrass (*Deschampsia cespitosa* ssp. *beringensis*), seaside plantain (*Plantago maritima*), Virginia glasswort (*Salicornia depressa*), saltgrass (*Distichlis spicata*), sea milkwort (*Lysimachia maritima*) or sea ditchgrass (*Ruppia maritima*). Sparsely vegetated rocky shorelines and beaches/dunes occur in coastal areas.

Upland grasslands and shrublands are rare on the landscape, other than immediately following forest removal and on shallow bedrock sites.

Climate

Moderate temperatures and high precipitation characterize the maritime temperate climate of the *Pacific Maritime Rainforest* zone. In general, cool summers, mild rainy winters and high annual precipitation are typical. Local climatic variation influences vegetation patterns. Areas with lower precipitation have an increased frequency of fire. In hypermaritime areas along the immediate coast, frequent fog and low clouds during warmer months produce a uniformly wet and mild climate, with fog drip often contributing significant additional site moisture. Inland, the climate is still relatively mild but typically with lower overall precipitation and greater temperature extremes.

Mean annual precipitation is generally high, averaging >3000 mm (varying between approximately 1500 and 5300 mm). The majority of total precipitation falls as rain; snow is only a minor proportion, occurring mostly in northern, montane and submaritime areas. Rain shadow effects from the Queen Charlotte Ranges, the Vancouver Island Ranges, the Olympic Mountains and, in some places, the Coast Mountains create the largest variability in precipitation patterns across the zone, accounting for the lower values in the continuum. Mean annual temperatures vary from approximately 3°C to 10°C, depending mostly on latitude and elevation. Growing degree days above 5°C average between approximately 1000 and 2200 throughout the zone. Frozen soils are uncommon in winter, which is important for the survival of many of the coastal plant species.

Physiography, Geology, Topography and Soils

This zone occurs in the westernmost Cordillera, occupying the windward portions of the Coast Mountains in BC, including the Pacific Ranges, the Kitimat Ranges and some lower valleys in the Boundary Ranges. It also occurs in the insular mountains of Vancouver Island and Haida Gwaii, as well as their adjoining coastal lowlands. Minor portions of the zone occur in the Cascade Mountains of southwestern BC and the St. Elias Mountains of northwestern BC. The zone occurs at sea level over most of its area and extends up to about 900 mASL in southern BC and to 450 mASL in northern BC on windward slopes. On leeward slopes in the eastern part of the zone, the upper elevation can reach 1000 mASL.

The Coast, Cascade and St. Elias Mountains consist primarily of crystalline igneous and metamorphic rocks. The Vancouver Island and Queen Charlotte Ranges, as well as the coastal lowlands, comprise mostly folded and faulted volcanic and sedimentary Tertiary rocks. The terrain is a complex mixture of high mountains (some >4000 mASL), valleys, coastal lowlands and rugged coastlines.

All of the zone has been glaciated numerous times and the most prevalent surficial material is glacial till. Colluvium is also common on steep mountain slopes, often with bedrock exposures. Several large rivers terminate at the Pacific Ocean, creating riparian and estuarine benches, beaches and deltas of alluvial materials. Although geologically young, the soils are generally well developed. Organic matter tends to accumulate in the wet, cool climate. Soils are mostly Podzols, with some Folisols; Gleysols occur on moist, poorly drained sites. Peatlands dominated by Organic soils are extensive in some areas with permanently high water tables.

Notes

At low elevations, the *Pacific Maritime Rainforest* zone usually extends to sea level, except in the southern Georgia Depression where it adjoins the *Pacific Dry Forest*. At higher elevations, it is bounded by the *Pacific Montane Forest*. To the south and north, it continues into the US.

Pacific Dry Forest

General Description

The *Pacific Dry Forest* zone occurs at low elevations in the Georgia Depression of the southern BC coast, where it covers an area of 2,500 km². Rain shadow effects of the Olympic and Vancouver Island mountain ranges create a cool Mediterranean climate with relatively drier conditions than in nearby areas of the BC coast. Much of the area has been converted to agriculture and urban infrastructure, including the cities of Victoria, Duncan and Nanaimo, but the contemporary landscape still includes considerable cover by evergreen forests and woodlands.

Vegetation

Natural upland vegetation includes forests as well as woodlands. Typically, forests have closed, multi-layered canopies characterized by tall long-lived, evergreen coniferous trees. Stand structure becomes more open on drier sites and natural woodlands can occur. Dry site forests and woodlands often include sclerophyllous evergreen and/or cold-deciduous broad-leaved tree species. Forest canopy composition is usually of multiple conifer species, but conifer – broad-leaved mixes and pure broad-leaved compositions can occur. Understory structure varies from dense to sparse, and is usually dominated by cold-deciduous and evergreen broad-leaved shrubs, perennial herbs and conifer regeneration. The moss layer is typically well developed under conifer canopies.

Forest stands have the potential to be hundreds of years old, but few old forests remain on the landscape. Historically, stand-replacing fire was the main natural disturbance factor but most forests were harvested many years ago, and anthropogenic disturbances now predominate. Invasive non-native plant species exert a strong influence on vegetation composition and structure in much of the zone.

Coast Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) is the characteristic tree species, however other diagnostic trees include Pacific arbutus (*Arbutus menziesii*) and Garry oak (*Quercus garryana*). Western red cedar (*Thuja plicata*) and grand fir (*Abies grandis*) often co-occur with Douglas-fir on circum-mesic to moist sites. Red alder (*Alnus rubra*) and big-leaved maple (*Acer macrophyllum*) are common seral components of forests and are particularly abundant on moist sites. Shore pine (*Pinus contorta* var. *contorta*) occurs occasionally on some dry sites, as well as in bogs, where it can be dominant. Alluvial forests are dominated by red alder and/or black cottonwood (*Populus trichocarpa*).

The understory of conifer forests is typically dominated by evergreen broad-leaved shrubs, conifer regeneration and a well-developed moss layer. Common shrubs include ocean-spray (*Holodiscus discolor*), Cascade barberry (*Berberis nervosa*) and salal (*Gaultheria shallon*). Moist forests usually have a high cover of western sword fern (*Polystichum munitum*) and can also include salmonberry (*Rubus spectabilis*), Indian plum (*Oemleria cerasiformis*), bracken fern (*Pteridium*

aquilinum), vanilla-leaf (*Achlys triphylla*) and three-leaved foamflower (*Tiarella trifoliata*). The main moss species are Oregon beaked moss (*Kindbergia oregana*) and stairstep moss (*Hylocomium splendens*). Garry oak forests and woodlands have a rich understory dominated by camas (*Camassia* spp.) and other flowering herbs in the spring, and a variety of grasses later in the growing season.

Wetlands are uncommon on the contemporary landscape; most have been altered or converted by agriculture, urbanisation or shoreline development. Shallow marshes, shrub swamps and wetter fens usually are dominated by Sitka sedge (*Carex aquatilis* var. *dives*), sweet gale (*Myrica gale*), Douglas' meadowsweet (*Spiraea douglasii*) or broad-leaved cattail (*Typha latifolia*).

Coastal estuaries and intertidal zones have marshes and wet meadows dominated by Lyngbye's sedge (*Carex lyngbyei*), Beringian hairgrass (*Deschampsia cespitosa* ssp. *beringensis*), Virginia glasswort (*Salicornia depressa*), saltgrass (*Distichlis spicata*), arctic rush (*Juncus arcticus*) or sea ditchgrass (*Ruppia maritima*). Sparsely vegetated rocky shorelines and beaches/dunes occur in coastal areas.

Climate

The *Pacific Dry Forest* zone occurs at low elevations of coastal southern BC in the lee of the Olympic Mountains and the Vancouver Island Ranges. Rain shadow effects create relatively drier conditions within the generally maritime temperate climate of coastal BC, resulting in a localized cool Mediterranean climate with moderately warm dry summers and mild wet winters.

Mean annual precipitation mostly varies between 650 and 1250 mm, significantly lower than that received by the surrounding *Pacific Maritime Rainforest* zone. The majority of total precipitation falls in autumn and winter months as rain; snow is only a minor proportion. Mean annual temperatures are between approximately 8°C and 11°C, the lower values in wetter climatic areas. Growing degree days above 5°C average approximately 2200 throughout the zone. Frozen soils do not occur in winter, which is important for the survival of many of the coastal plant species.

Physiography, Geology, Topography and Soils

This zone occurs in the southern Georgia Depression, a lowland area lying between the Vancouver Island Ranges and the Pacific Ranges of the Coast Mountains. Elevations are mostly between sea level and approximately 150 mASL. The geology of the Georgia Depression is mostly folded and faulted volcanic and sedimentary rocks.

The area has been glaciated numerous times and the most prevalent surficial material is glacial till, although marine clay is also common due to post-glacial isostatic rebound. An extensive area of alluvial outwash occurs on the lower Fraser River valley, although it is now mostly agricultural land. In dissected hilly terrain, colluvium is also common, often with bedrock exposures. Mineral soils are mostly Brunisols, but in areas of higher precipitation Podzols can develop.

Notes

The *Pacific Dry Forest* zone occurs between sea level at the Pacific coast and the surrounding *Pacific Maritime Rainforest*. The southern boundary is the international border; similar ecological conditions occur in the adjacent US.

Pacific Montane Forest

General Description

The *Pacific Montane Forest* zone occurs at high elevations, below treeline, in the coastal and insular mountain systems of BC. It covers an area of approximately 40,000 km² in the windward Coast Mountains, and on Vancouver Island and Haida Gwaii. This zone represents the central portion of North American Pacific coastal high montane and subalpine forests, extending from Alaska to Baja, Mexico. The maritime temperate climate is cool and wet. Landcover is dominated by evergreen coniferous forests and woodlands.

Vegetation

Closed forests are typical on most upland sites at lower and mid-elevations, transitioning to short-statured open woodlands in a parkland landscape at subalpine elevations. Canopies mostly comprise a mixture of evergreen coniferous tree species. A deep, heavy, long-lying snowpack is characteristic of the environment, creating distinct growth patterns and stand structures in these forests and woodlands. On steep slopes, at higher elevations and where late-melting snow occurs, treed stands become more open and patchy, often occurring as tree islands or ribbons in a matrix of grasslands, meadows, heaths or shrublands. At treeline, microsites determine tree distribution and the forest/woodland patches are found where snow melts earliest, while areas with the latest-lying snow contain sedge, heath or meadow vegetation. At higher elevations, deep long-lying snowpacks often create “elfinwood” stands of stunted, scrubby trees; where tree stems emerge above the snow they develop characteristic krummholtz growth forms in response to physical damage by blowing ice crystals. Understory structure varies from dense to sparse, and is typically dominated by ericaceous low and dwarf shrubs as well as conifer regeneration. Most closed forests have a well-developed bryophyte layer on the forest floor.

Broad-scale disturbances (especially wildfire) are rare in these forests and woodlands; windthrow, avalanches and landslides are the main stand-replacing mechanisms. Otherwise, gap replacement of single or small groups of trees is the common regeneration process. Overall, stands tend to be old and uneven-aged; taller stands can be structurally diverse and multi-storied. Forest harvesting is a disturbance factor in some lower elevation areas but, overall, anthropogenic modification of the landscape is minor.

Mountain hemlock (*Tsuga mertensiana*) is the characteristic tree species. Other common trees include Pacific silver fir (*Abies amabilis*), yellow-cypress (*Callitropsis nootkatensis*) and western hemlock (*T. heterophylla*). On Haida Gwaii, Sitka spruce (*Picea sitchensis*) is often codominant in these forests. Treed wetlands are dominated by the same tree species, with yellow skunk cabbage (*Lysichiton americanus*) a characteristic of the understory.

Common vascular understory species include oval-leaved blueberry (*Vaccinium ovalifolium*), mountain huckleberry (*V. membranaceum*), false azalea (*Menziesia ferruginea*), red huckleberry (*V. parvifolium*), copperbush

(*Elliottia pyroliflora*), five-leaved dwarf bramble (*Rubus pedatus*), twistedstalks (*Streptopus* spp.), deer fern (*Blechnum spicant*), green false hellebore (*Veratrum viride*), three-leaved foamflower (*Tiarella trifoliata*), fern-leaved goldthread (*Coptis aspleniifolia*) and deer cabbage (*Nephrophyllidium crista-galli*). Pipecleaner moss (*Rhytidiopsis robusta*), broom mosses (*Dicranum* spp.) and lanky moss (*Rhytidiadelphus loreus*) are the most common forest bryophytes. At higher elevations, various heath species are common, including pink mountain heather (*Phyllodoce empetriformis*), black crowberry (*Empetrum nigrum*) and white mountain heather (*Cassiope mertensiana*).

At the highest elevations of this zone, subalpine heaths and meadows are interspersed with clumps of trees in a parkland mosaic. Heath communities, mostly comprising moss heathers (*Cassiope* spp.) and mountain heathers (*Phyllodoce* spp.) with a variety of bryophytes (e.g., alpine haircap moss [*Polytrichastrum alpinum*]), usually occur near treeline in areas with late-lying snowbeds. On wet microsites in late-snowmelt areas, snow rustwort (*Marsupella brevisimma*) dominates. Subalpine meadows develop in seepage areas and along stream edges near treeline; they are characterized by a large diversity of often showy forbs including Sitka valerian (*Valeriana sitchensis*), American cow parsnip (*Heracleum maximum*) and green false hellebore. Avalanche tracks, often dominated by Sitka alder (*Alnus viridis* ssp. *sinuata*), are common features in steep terrain.

Poorly drained sites in the subalpine often develop shallow peat deposits with bog and nutrient-poor fen vegetation, typically containing narrow-leaved cottongrass (*Eriophorum angustifolium*) and peat mosses (*Sphagnum* spp.).

Climate

High precipitation and relatively moderate temperatures characterize the high elevation maritime temperate climate of the *Pacific Montane Forest* zone. In general, short cool summers, rainy autumns, and long, cool snowy winters are typical. However, local climates vary from hypermaritime on Haida Gwaii and the outer mainland coast, to maritime on Vancouver Island and most of the windward Coast Mountains, to a more continental submaritime climate in the easternmost portions of the zone.

Mean annual precipitation is high, usually exceeding 4000 mm (varying between approximately 2000 and 7000 mm). Between 20% and 70% of total precipitation falls as snow, depending on location; a deep and late-melting snowpack is characteristic of the zone. Maximum snowpack depth in late winter varies from as little as 50 cm at lower elevations of hypermaritime areas to >300 cm in wet subalpine areas. The snowpack insulates soils from freezing, which is important for the survival of the major tree species. However, heavy snow buries smaller vegetation, including regenerating trees, which must be resilient to being bent, crushed and frozen as well as being adapted to the short growing season created by late-melting snow. Mean annual temperatures vary from approximately 0°C to 5°C and the growing season is short, averaging <1000 growing degree days above 5°C.

Physiography, Geology, Topography and Soils

This zone occurs in the westernmost Cordillera, where it occupies mid- to high elevations in the windward portions of the Coast Mountains in BC, including the Pacific Ranges, the Kitimat Ranges and the Boundary Ranges. It also occurs in the insular mountains of Vancouver Island and Haida Gwaii. Minor portions of the zone occur in the Cascade Mountains of southwestern BC and the St. Elias Mountains of northwestern BC. Near the coast, the lower elevation of the zone varies between approximately 600 mASL and 1000 mASL, depending upon latitude and typical snowpack (about 500 mASL on Haida Gwaii).

Upper elevations are near 1600 mASL in the south and 1000 mASL in the north (about 850 mASL on Haida Gwaii). In inland areas, due to

lower amounts of snow, elevation thresholds are higher (e.g., in the south, the lower elevation of the zone is 1200 mASL). The zone can occur as low as 400 mASL in valleys with pronounced cold air ponding.

The Coast, Cascade and St. Elias Mountains consist primarily of crystalline igneous and metamorphic rocks. The Vancouver Island and Queen Charlotte Ranges comprise mostly folded and faulted volcanic and sedimentary Tertiary rocks. The terrain is a complex of high mountains (some >4000 mASL) and valleys.

All of the zone has been glaciated numerous times and the most prevalent surficial material is glacial till. Colluvium is also common on steep mountain slopes, often with bedrock exposures. Although geologically young, the soils are generally well developed. Organic matter tends to accumulate in the wet, cool climate. Soils are mostly Podzols, with some Folisols; Gleysols occur on moist, poorly drained sites. Shallow peatlands dominated by Organic soils develop in areas with permanently high water tables.

Notes

At lower elevations, the *Pacific Montane Forest* zone is bounded by the *Pacific Maritime Rainforest*. The *Pacific Alpine Tundra* occurs at higher elevations, above treeline. Montane conditions on the eastern slopes of the mainland coastal mountains are included in the *Cordilleran Montane Forest*. To the south and northwest, this zone continues into the US.

Cordilleran Cool Temperate Forest

Four **Level 2** descriptions in this section:

- **Cordilleran Subboreal Forest**
- **Cordilleran Montane Forest**
- **Cordilleran Rainforest**
- **Cordilleran Dry Forest**

Cordilleran Subboreal Forest

General Description

The *Cordilleran Subboreal Forest* zone covers an area of approximately 140,000 km², primarily on the intermontane plateaux of central BC. Orographic effects of the Coast, Cariboo and Rocky Mountains create a temperate climate that varies from subhumid to humid. Landcover is dominated by evergreen coniferous forests, but several major rivers and large lakes dissect the landscape.

Vegetation

Closed forests dominate most upland sites, although open forests and woodlands are commonly associated with very dry sites or very dry local climates. Forest canopies are typically dominated by evergreen coniferous species. Cold-deciduous broad-leaved species often intermingle with, and occasionally dominate, the conifers. Understory structure varies from dense to sparse, and is usually dominated by cold-deciduous broad-leaved shrubs, conifer regeneration and perennial herbs. The moss layer is typically well developed, especially under conifer canopies.

Stand-replacing fires and insect outbreaks are the most widespread forms of natural disturbance, creating a diverse landscape mosaic comprising forest stands of varying age and composition. Post-fire stands are typically even-aged with a simple structure. In the prolonged absence of fire, a multi-storied, multi-aged stand structure can develop over time. Forest harvesting is a significant disturbance factor in many areas, but agriculture and other anthropogenic modifications of the landscape are relatively minor overall and mostly confined to some river valleys.

The dominant tree species are interior spruce (*Picea engelmannii x glauca*) and lodgepole pine (*Pinus contorta* var. *latifolia*). Subalpine fir (*Abies lasiocarpa*) occurs in fire-sheltered locations throughout the zone, but is most common in more humid (typically snowy) areas where fire cycles are longer. Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) occurs in warmer locations, with old trees often persisting in stands for hundreds of years. Black spruce (*Picea mariana*) is sometimes present, primarily on nutrient-limited sites with cold soils. Trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) commonly occur following disturbance and often dominate near settlements and in agricultural areas. Alluvial forests dominated by interior spruce and/or black cottonwood (*Populus trichocarpa*) occur on stable floodplains.

Understories vary from dense, species-rich shrub and herb conditions to a continuous feathermoss ground cover with only a few erect vascular plants. Common vascular species include prickly rose (*Rosa acicularis*), shiny-leaved meadowsweet (*Spiraea lucida*), bracted honeysuckle (*Lonicera involucrata*), mountain huckleberry (*Vaccinium membranaceum*), squashberry (*Viburnum edule*), bristly black currant (*Ribes lacustre*), soapberry (*Shepherdia canadensis*), bunchberry (*Cornus canadensis*),

twinflower (*Linnaea borealis*), one-sided wintergreen (*Orthilia secunda*), fireweed (*Chamaenerion angustifolium*) and arnicas (*Arnica* spp.). The most common moss species are red-stemmed feathermoss (*Pleurozium schreberi*), knight's plume moss (*Ptilium crista-castrensis*) and stairstep moss (*Hylocomium splendens*). On dry sites, especially under open canopies, ground lichens are prevalent.

Wetlands are relatively common on the landscape in poorly drained locations, but are rarely extensive. Swamps, marshes and fens are the predominant wetland classes.

Treed wetlands are mostly dominated by spruces. Shrub swamps, annually active floodplains and hummocky fens include arctic dwarf birch (*Betula nana*), mountain alder (*Alnus incana* ssp. *tenuifolia*), willows (e.g., Bebb's willow [*Salix bebbiana*], Drummond's willow [*S. drummondiana*]), bluejoint reedgrass (*Calamagrostis canadensis*) and field horsetail (*Equisetum arvense*).

Stunted black spruce is typically present in nutrient-poor fens along with arctic dwarf birch, common Labrador tea (*Rhododendron groenlandicum*), water sedge (*Carex aquatilis*), ribbed bog moss (*Aulacomnium palustre*), golden fuzzy fen moss (*Tomentypnum nitens*) and abundant peat mosses (*Sphagnum* spp.).

Shallow marshes and wetter fens usually are dominated by sedges (often water sedge or northern beaked sedge [*C. utriculata*]), common spikerush (*Eleocharis palustris*), water horsetail (*Equisetum fluviatile*) or broad-leaved cattail (*Typha latifolia*).

Upland grasslands and shrublands are rare on the landscape, other than immediately following forest removal and on some warm, dry sites in river valleys.

Climate

The *Cordilleran Subboreal Forest* zone occupies the intermontane plateau areas of central BC in the lee of the Coast Mountains, where rain shadow effects on Pacific air masses create relatively dry to subhumid conditions within the continental temperate climate of interior BC. Temperatures are generally more moderate than those of the *West-Central Boreal Forest* zone to the north. Some areas are climatically more humid and some slightly less continental, depending on orographic effects and prevailing westerly air flows. Overall, summers are relatively short but warm, and winters are cool and snowy.

Mean annual temperatures vary from approximately 2°C to 5°C. The growing season varies between approximately 1000 and >1300 growing degree days above 5°C. Mean annual precipitation is highly variable throughout the zone, from about 600 mm to almost 2000 mm, depending on local orographic effects. Up to half of the annual precipitation falls as snow. Drier areas receive summer precipitation of 250 – 350 mm and most well-drained sites experience a slight soil moisture deficit. In the moister portions of the zone, few sites experience a growing season soil moisture deficit.

Physiography, Geology, Topography and Soils

This zone occurs within the southern Interior System of the Cordilleran physiographic region, between the Coast Mountains to the west and the Rocky Mountains and Columbia Mountains in eastern BC. This area is dominated by the northern Interior Plateau, Fraser Basin and the northern Columbia (Shuswap) Highlands and is characterized by a series of plateaux and lowlands. The zone also fingers into valleys of the surrounding mountain ranges, particularly the Rocky Mountains, Cariboo Mountains, southern Omineca Mountains and northern Shuswap Highlands, and occurs in the central portion of the Rocky Mountain Trench. There are also some disjunct occurrences in the Stikine and Taku River valleys on the Stikine Plateau in northwestern BC. Depending on the location, elevations range from as low as 450 mASL in some valley bottoms to about 1500 mASL (i.e., mid-elevations in mountainous terrain).

The Coast and Omineca Mountains consist predominantly of crystalline igneous and

metamorphic rocks, while the Rocky and Columbia Mountains comprise faulted and folded Paleozoic, Mesozoic or Tertiary sedimentary, often carbonate-rich, rocks. The plateaux of central BC are mostly underlain by geologically recent lava deposits. The gently rolling terrain is incised by several large river valleys.

The entire zone was affected by late Pleistocene glaciation. The predominant surficial material is glacial till derived from basaltic bedrock, thus reasonably rich in cations. Also found on the plateaux are eskers of coarse-textured glaciofluvial materials and bedrock knobs with shallow soils. In mountain valleys, alluvial and glaciofluvial deposits occur on the valley bottoms, and thin till and colluvial materials on steeper slopes. Several areas were inundated by large lakes at the time of glacial retreat and are now overlain by fine-textured glaciolacustrine materials. Mineral soils are mostly Luvisols and Brunisols, although Podzols develop in wetter climates. Gleysols occur on moist, poorly drained sites.

Notes

At lower elevations, the *Cordilleran Subboreal Forest* zone borders the *West-Central Boreal Forest* to the north, the *Cordilleran Rainforest* in wetter climates to the northwest and east, and the *Cordilleran Dry Forest* to the south. At higher elevations, the adjoining zone is the *Cordilleran Montane Forest*.

Cordilleran Montane Forest

General Description

The *Cordilleran Montane Forest* zone occurs at mid- to high elevations, below treeline, primarily in the mountain systems of south-central BC and western Alberta. Altogether, it covers an area of approximately 220,000 km² in the Rocky Mountains, Columbia Mountains, the southern Omineca and Skeena Mountains, and the eastern (leeward) side of the Cascade and southern Coast Mountains. A small expression of this zone also occurs at the highest elevations of the Cypress Hills in southern Alberta and Saskatchewan. This zone represents the northern portion of temperate high montane and subalpine forests found throughout the Rocky Mountains and Intermountain West region of North America, extending south to Texas. Orographic influences create highly variable climatic conditions. Landcover is dominated by evergreen coniferous forests and woodlands.

Vegetation

Closed forests are typical on most upland sites at lower and mid-elevations, transitioning to short-statured open woodlands in a parkland landscape at subalpine elevations. Canopies mostly comprise evergreen coniferous tree species, although some cold-deciduous broad-leaved species are found in mid-elevation forests. Treed stands become more open and patchy on steep slopes and with increased elevation, often occurring as tree islands or ribbons in a matrix of grasslands, meadows or shrublands at treeline. At the highest elevations or on sites most exposed to wind, trees develop characteristic krummholtz growth forms in response to physical damage by extreme cold and blowing ice crystals. Understory structure varies from dense to sparse, and is usually dominated by cold-deciduous or evergreen broad-leaved shrubs, conifer regeneration and perennial herbs. Most forests and woodlands have a well-developed bryophyte and/or lichen layer on the forest floor.

These forests and woodlands are subject to regular stand replacement or significant modification by wildfire, avalanches, windthrow and insect outbreaks. Stand structure is simple and even-aged after stand-replacing fire, but generally becomes multi-storied and multi-aged as succession proceeds. Fire cycles are shorter and insect outbreaks more frequent in the climatically drier areas of the zone. At high elevations, woodland and parkland stands burn less frequently due to cooler temperatures, later-melting snowpack, greater precipitation, lower incidence of dry lightning, and more open or patchy tree distribution. In the subalpine, the cold humid environment and short growing season hamper regeneration of trees, so stand development usually takes longer than on comparable sites at lower elevations. Forest harvesting is a significant disturbance factor in many lower and mid-elevation areas, but agriculture and other anthropogenic modifications of the landscape are relatively minor overall.

Dominant tree species throughout the zone are subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta* var. *latifolia*) and interior spruce

(*Picea engelmannii x glauca*). White spruce (*Picea glauca*) occurs at lower elevations (i.e., approximately <1100 mASL) in the Rocky Mountains foothills in Alberta and in the Cypress Hills. Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) and trembling aspen (*Populus tremuloides*) are common in mid-elevation forests, especially on warm aspects. Limber pine (*Pinus flexilis*) is characteristic of dry, exposed mid-elevation sites in Alberta.

Understories vary from dense, species-rich shrub and herb conditions to a continuous bryophyte or lichen ground cover with only a few erect vascular plants. Common vascular species include mountain huckleberry (*Vaccinium membranaceum*), white-flowered rhododendron (*Rhododendron albiflorum*), grouseberry (*V. scoparium*), false azalea (*Menziesia ferruginea*), arnicas (*Arnica cordifolia, A. latifolia*), five-leaved dwarf bramble (*Rubus pedatus*), three-leaved foamflower (*Tiarella trifoliata*), Sitka valerian (*Valeriana sitchensis*) , single-flowered clintonia (*Clintonia uniflora*), oak fern (*Gymnocarpium dryopteris*) and green false hellebore (*Veratrum viride*). Bryophytes include red-stemmed feathermoss (*Pleurozium schreberi*), broom mosses (*Dicranum* spp.), ragged mosses (*Brachythecium* spp.) and leafy liverworts (*Barbilophozia* spp.). On dry sites, especially under open canopies, ground lichens (especially clad [*Cladonia* spp.], reindeer [*Cladina* spp.] and pelt [*Peltigera* spp.] lichens) are prevalent.

Subalpine heaths and meadows are common at the highest elevations of this zone, interspersed with clumps of stunted trees. Heath communities, mostly comprising white mountain heather (*Cassiope mertensiana*) and pink mountain heather (*Phyllodoce empetriformis*) with a variety of bryophytes (e.g., leafy liverworts [*Barbilophozia* spp.]), usually occur near treeline in areas with late-lying snowbeds. Subalpine meadows occur on moist sites, often with mobile soils through processes like soil creep, ravelling or bioturbation, that encourage herb growth and limit shrub, tree and heath establishment. They are characterized by a large diversity of often showy forbs, including Sitka valerian, arrow-leaved ragwort (*Senecio triangularis*), wandering fleabane (*Erigeron peregrinus*), paintbrushes (*Castilleja* spp.) and green false hellebore.

In the climatically drier parts of the zone, grasslands occur at all elevations on south-facing slopes. They are typically dominated by fescues, especially mountain rough fescue (*Festuca campestris*), Idaho fescue (*F. idahoensis*) and green fescue (*F. viridula*). Avalanche tracks, often dominated by Sitka alder (*Alnus viridis ssp. sinuata*), are common features in steep terrain.

Treed wetlands are dominated by subalpine fir and/or spruces. Fens dominated by sedges (often water sedge [*Carex aquatilis*]), narrow-leaved cottongrass (*Eriophorum angustifolium*) or willows (e.g., Barclay's willow [*Salix barclayi*]) are common in poorly drained locations at higher elevations. Shrub-carrs/ swamps, characterized by arctic dwarf birch (*Betula nana*) or willows (e.g., grey-leaved willow [*S. glauca*], short-capsuled willow [*S. brachycarpa*] or Barclay's willow) occur on imperfectly to poorly drained slopes and in cold valleys.

Climate

Latitudinal and orographic influences significantly modify the continental temperate climate across the *Cordilleran Montane Forest* zone, generating highly variable regional to local climates. Overall, cold, snowy winters and moderately short, cool summers are typical. Slope and aspect control site-scale patterns of insolation, snow deposition and melting; southerly and westerly slopes are warm aspects where snowmelt occurs earlier in the spring, and northerly and easterly slopes are cool aspects where snowmelt is later and wind deposition of snow is often greater.

Mean annual temperatures vary from approximately -1°C to +4.5°C; warmer temperatures are associated with mid-elevation locations and colder temperatures

with subalpine areas near treeline. At higher elevations, frost is possible in any month and occurs most frequently in locations with cold air drainage or ponding, such as closed topographic depressions. The growing season is short, averaging less than 800 growing degree days above 5°C (GDD), although mid-elevation locations can average >1000 GDD. Climatically drier areas receive as little as 400 mm of total precipitation annually, whereas areas within wetter subregional climates can receive >2000 mm. The mid-elevation areas of Alberta and southern BC typically receive the lowest total precipitation (400 – 650 mm) and the lowest snowfall (approximately 150 – 450 cm). High elevation areas receive more snow, often constituting the majority of total annual precipitation, varying from approximately 330 to >1500 cm. Snow depth varies locally, with some sites nearly snow-free because of high winds, while snow accumulation is deeper on lee slopes and in forest openings; in some areas, late-melting snowbeds provide the majority of growing season moisture.

Physiography, Geology, Topography and Soils

This zone primarily occurs in the southern portion of the Cordilleran physiographic region, including most mountain ranges and high plateaux of interior BC, the Rocky Mountains, and the Rocky Mountains foothills of western Alberta. The zone occupies mid- to high elevations in the Skeena, Omineca and Rocky Mountains south of approximately latitude 57° 30'; along the eastern side of the Coast Mountains as far north as the Yukon border; and in the Columbia and Cascade Mountains, Columbia Highlands and Interior Plateau of south-central BC. In Alberta, the Rocky Mountains foothills south of approximately the Bow River are included in this zone, as are the highest elevations of the Cypress Hills in southeastern Alberta and southwestern Saskatchewan. Depending on the location, the lower elevation of the zone can be as low as 950 – 1000 mASL; upper elevations can be as high as 2500 mASL.

The Coast and Omineca Mountains consist predominantly of crystalline igneous and metamorphic rocks, while the rest of the Interior and Eastern Systems of the Cordillera, as well as the Cypress Hills, comprise faulted and folded Paleozoic, Mesozoic or Tertiary sedimentary, often carbonate-rich, rocks. The terrain is a complex mixture of high mountains (up to 3900 mASL) with intervening plateaux, hill systems, valleys, trenches and basins.

Except for the highest parts of the Cypress Hills, the zone was affected by late Pleistocene glaciation. The main surficial material is glacial till, often occurring as a thin veneer overlying bedrock. At higher elevations and on steep slopes, colluvial materials predominate. Volcanic ash often forms a thin upper soil layer in southern portions of the zone. Variable topography produces rapid and frequent changes in site-scale aspect, moisture and nutrient status. Mineral soils are typically Podzols, Brunisols and Luvisols; Gleysols develop on moist, poorly drained sites.

Notes

Montane conditions to the north of the *Cordilleran Montane Forest* zone are included in the *Northwestern Boreal Forest* and, to the west, in the *Pacific Montane Forest*. The *Western Boreal Alpine Tundra* and *Cordilleran Alpine Tundra* occur at higher elevations, above treeline. At lower elevations on the east side of the Rockies, and in a few areas of northwestern BC, the *West-Central Boreal Forest* is adjoining. In central and southern BC, the *Cordilleran Rainforest*, *Cordilleran Dry Forest* and *Cordilleran Subboreal Forest* zones constitute the lower elevation boundaries. To the south, this zone continues into the US.

Cordilleran Rainforest

General Description

The *Cordilleran Rainforest* zone covers an area of over 55,000 km² in northwestern and southeastern BC. It is found where relatively high precipitation occurs east of the coastal mountains, creating an "interior wet belt". This zone represents the northern portion of "interior" moist conifer forests that also occur at low to mid-elevations in eastern Washington, northern Idaho and western Montana. Landcover is dominated by evergreen coniferous forests.

Vegetation

Upland vegetation is dominated by evergreen coniferous forests characterized by tall, long-lived trees in stands that may persist for centuries. Cold-deciduous broad-leaved tree species are sometimes present following disturbance. Understory structure varies from dense to sparse and is usually dominated by cold-deciduous broad-leaved shrubs, conifer regeneration and perennial herbs. The moss layer is typically well developed, especially under conifer canopies.

Stand-replacing fires occur less frequently than in other forests of the BC interior; gap dynamics driven by pathogens, insects and windthrow are the prevailing stand regeneration processes. Overall, stand structure is typically multi-storied and multi-aged, but it can be single-storied and even-aged after stand-replacing disturbance. Forest harvesting is a significant disturbance factor throughout the zone. Crop cultivation and other anthropogenic modifications of the landscape are relatively minor and mostly confined to a few river valleys in the southern part of the zone. In some river valleys, large hydroelectric reservoirs have flooded otherwise forested terrestrial lands.

Western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*) are the characteristic tree species, often dominating uneven-aged stands. Subalpine fir (*Abies lasiocarpa*) and hybrids of white spruce (*Picea glauca*) (i.e., interior spruce [*Picea engelmannii x glauca*] throughout the zone and Lutz spruce [*Picea* x*lutzii*] in the northwestern portion of the zone) are common associates, while younger stands may contain lodgepole pine (*Pinus contorta* var. *latifolia*). Trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) are often present but only dominate in some early seral stands. Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) occurs over all but the northernmost portions of the zone. Alluvial forests dominated by spruces and/or black cottonwood (*Populus trichocarpa*) occur on stable floodplains.

Understories vary from dense, species-rich shrub and herb conditions to a continuous feathermoss ground cover with only a few erect vascular plants. Common understory species include mountain huckleberry (*Vaccinium membranaceum*), falsebox (*Paxistima myrsinites*), western thimbleberry (*Rubus parviflorus*), devil's club (*Oplopanax horridus*), oval-leaved blueberry (*V. ovalifolium*), Rocky Mountain maple (*Acer glabrum*), saskatoon

(*Amelanchier alnifolia*), single-flowered clintonia (*Clintonia uniflora*), bunchberry (*Cornus canadensis*), three-leaved foamflower (*Tiarella trifoliata*), twisted-stalks (*Streptopus* spp.), five-leaved dwarf bramble (*Rubus pedatus*), common pipsissewa (*Chimaphila umbellata*), wild sarsaparilla (*Aralia nudicaulis*) and twinflower (*Linnaea borealis*). Ferns often constitute an important component of the herb layer, especially common oak fern (*Gymnocarpium dryopteris)* and common lady fern (*Athyrium filix-femina*). Frequently occurring mosses are red-stemmed feathermoss (*Pleurozium schreberi*), knight's plume moss (*Ptilium crista-castrensis*), stairstep moss (*Hylocomium splendens*), pipecleaner moss (*Rhytidiopsis robusta*) and electrified cat's-tail moss (*Rhytidiadelphus triquetrus*).

Wetlands are relatively common on the landscape, but are rarely extensive. Swamps and fens are scattered in small poorly drained basins, but shoreline marshes are relatively common along the shallow margins of water bodies.

Treed wetlands are dominated by western red cedar, western hemlock, subalpine fir and/or spruces. Shrub swamps, annually active floodplains and hummocky fens typically include arctic dwarf birch (*Betula nana*), mountain alder (*Alnus incana* ssp. *tenuifolia*), willows (e.g., Sitka willow [*Salix sitchensis*]), yellow skunk cabbage (*Lysichiton americanus*), Douglas' meadowsweet (*Spiraea douglasii*) and common horsetail (*Equisetum arvense*). Stunted black spruce (*Picea mariana*) and lodgepole pine are often present in nutrient-poor fens.

Shallow marshes and wetter fens usually are dominated by sedges (especially water sedge [*Carex aquatilis*], Sitka sedge [*C. aquatilis* var. *dives*], northern beaked sedge [*C. utriculata*]), common spikerush (*Eleocharis palustris*), water horsetail (*Equisetum fluviatile*) or broad-leaved cattail (*Typha latifolia*).

Upland grasslands and shrublands are rare on the landscape, other than immediately following forest removal and on shallow bedrock sites.

Climate

The *Cordilleran Rainforest* zone occurs at low to mid-elevations in interior BC wherever incursions of mild moist Pacific air provide relatively high precipitation, creating "wet belts" within the continental temperate climate of interior BC. In the northwestern portion of the zone, these air masses penetrate the Coast Mountains through the large valleys of the Nass, Skeena and Stikine Rivers. In southeastern BC, areas of high orographic precipitation result when westerly air flows rise over the Columbia and Rocky Mountains. In general, summers are warm, winters are cool and annual precipitation is high.

Mean annual precipitation varies from approximately 700 to 1700 mm. Up to 50% of annual precipitation is snow, but rain can also occur during winter months. Snowmelt adds significantly to soil moisture. Mean annual temperatures vary from approximately 3.5°C to 9°C, depending on latitude and elevation. The growing season averages between approximately 1200 and 2200 growing degree days above 5°C, depending mostly on latitude and elevation. Deep snowpacks and moderate winter temperatures prevent soils from freezing, which is important for the survival of western hemlock and western red cedar.

Physiography, Geology, Topography and Soils

This zone occurs in southern and central portions of the Interior System of the Cordilleran physiographic region, and on the western side of the southern Rocky Mountains. In southeastern BC, it is found in valleys and on lower slopes of the Columbia Highlands, the Columbia Mountains, the Rocky Mountains and in much of the adjacent Rocky Mountain Trench, from elevations as low as 400 mASL up to 1550 mASL. In northwestern BC, the zone occurs mostly in the Nass Basin and Skeena Mountains between 100 mASL and 1100 mASL.

The northwestern portion of the zone primarily comprises faulted and folded sedimentary rocks. The southeastern portion comprises mostly faulted and folded Paleozoic, Mesozoic or Tertiary sedimentary and metamorphic,

often carbonate-rich, rocks. The terrain is a complex mixture of high mountains (up to 3000 mASL) with intervening plateaux, hill systems, valleys, trenches and basins.

The entire zone was affected by late Pleistocene glaciation. Glacial till covers most of the area, but valley bottoms also include glaciofluvial and recent alluvial materials. Colluvial deposits are found on steeper slopes and at higher elevations. Volcanic ash often forms a thin upper soil layer in the southeastern portion of the zone. Mineral soils are typically Podzols, Luvisols and Brunisols; Gleysols develop on moist, poorly drained sites.

Notes

At low elevations in most locations, the *Cordilleran Rainforest* zone adjoins the *Cordilleran Subboreal Forest*; in some parts of southern BC, it borders the *Cordilleran Dry Forest*. At higher elevations, it is bounded by the *Cordilleran Montane Forest* and, in parts of the northwest, the *Pacific Montane Forest.* To the south, it continues into the US.

Cordilleran Dry Forest

General Description

The *Cordilleran Dry Forest* zone covers an area of approximately 48,000 km² in south-central BC, including valley, lower montane and plateau terrain. This zone represents the northern extent of dry temperate conifer forest and parkland that is widespread at low to mid-elevations in the northwestern US. Rain shadow effects of the Coast Mountains create a dry temperate climate. Landcover is dominated by evergreen coniferous forests and woodlands, sometimes in a parkland landscape.

Vegetation

Upland vegetation is dominated by structurally diverse forests and woodlands, typically comprising evergreen coniferous tree species. Cold-deciduous broad-leaved species are occasionally intermixed with the conifers on mesic or moist sites, or in early seral stands. In the warmest and driest areas, the climate is moist enough to support tree growth only under certain conditions, and the natural vegetation is often a parkland mosaic comprising patches of grassland or shrub-steppe and groves of forest and woodland. In cooler and moister areas, forest cover can be continuous. Open woodland stands are most common at the lowest elevations in the driest climates, as well as on edaphically dry sites in moister climates. Stand structure can be simple or multi-storied, and age structure can be even-aged or multi-aged. Understory structure varies from dense to sparse, and is typically dominated by shrubs and/or graminoids. Shrubs can be cold-deciduous broad-leaved, evergreen needle-leaved or evergreen microphyllous species; graminoids are primarily bunchgrasses and rhizomatous grasses.

These ecosystems are adapted to frequent low- to moderate-intensity surface fires that maintain relatively open stands of fire-resistant plant species and restrict the size of forest patches in parkland landscapes. With fire suppression, treed stands become denser, forest groves encroach into grasslands and shrub-steppe, and high intensity stand-replacing fires are more prevalent. Many of these stands are used for livestock grazing, which often alters the understory structure and species composition. Forest harvesting is a significant disturbance factor in many areas. Crop cultivation and other anthropogenic modifications of the landscape are relatively minor overall and mostly confined to a few river valleys in the southern part of the zone.

Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) is the characteristic tree species. In the warmest areas, ponderosa pine (*Pinus ponderosa*) occupies the driest locations that support tree growth, often forming open woodland stands, and Douglas-fir is found on slightly moister and cooler sites. At low to mid-elevations in southern parts of the zone, these two species often form mixed stands. At higher elevations and in northern parts of the zone, lodgepole pine (*Pinus contorta* var. *latifolia*) often occurs with Douglas-fir. Trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) are commonly found following disturbance, especially on moist sites. Alluvial forests dominated by black cottonwood (*Populus trichocarpa*) occur on some stable floodplains.

Understory species composition is variable, depending on site conditions and degree of canopy closure. Typical shrubs include saskatoon (*Amelanchier alnifolia*), snowberries (*Symphoricarpos albus; S. occidentalis*), holly-leaved barberry (*Berberis aquifolium*), shiny-leaved meadowsweet (*Spiraea lucida*), wild roses (*Rosa* spp.), soapberry (*Shepherdia canadensis*) and common juniper (*Juniperus communis*). Grasses are often important in the understory, including pine reedgrass (*Calamagrostis rubescens*), bluebunch wheatgrass (*Pseudoroegneria spicata*), mountain rough fescue (*Festuca campestris*), Idaho fescue (*F. idahoensis*) and prairie junegrass (*Koeleria macrantha*). Other common understory species include common yarrow (*Achillea millefolium*), wild strawberry (*Fragaria virginiana*), common bearberry (*Arctostaphylos uva-ursi*), arrow-leaved balsamroot (*Balsamorhiza sagittata*), heart-leaved arnica (*Arnica cordifolia*) and northern bedstraw (*Galium boreale*). Red-stemmed feathermoss (*Pleurozium schreberi*) is the most commonly occurring moss. Stands with a history of heavy grazing have reduced cover of native bunchgrasses, and often an abundance of non-native species such as Kentucky bluegrass (*Poa pratensis*), common timothy (*Phleum pratense*), downy brome (*Bromus tectorum*) and knapweeds (*Centaurea* spp.).

In the drier parts of the zone, grassland and shrub-steppe communities are often extensive within the parkland. They are characterized by bluebunch wheatgrass, mountain rough fescue, Idaho fescue and big sagebrush (*Artemisia tridentata* var. *tridentata*).

Wetlands occur in poorly drained locations, mostly along watercourses. Swamps, marshes and fens are the predominant wetland classes. Treed wetlands are uncommon.

Shrub swamps dominated by tall willows (especially Bebb's willow [*Salix bebbiana*], Drummond's willow [*S. drummondiana*] and MacCalla's willow [*S. maccalliana*]) or water birch (*Betula occidentalis*) often line small watercourses and shorelines of water bodies where water tables remain near the surface throughout the year.

Marshes occur on the shallow margins of water bodies and typically are dominated by sedges (especially water sedge [*Carex aquatilis*] or northern beaked sedge [*C. utriculata*]), hard-stemmed bulrush (*Schoenoplectus acutus*) or broad-leaved cattail (*Typha latifolia*).

Sedge-dominated fens often include a shrub component of arctic dwarf birch (*Betula nana*) or willows. Saline wet meadows dominated by saltgrass (*Distichlis spicata*), alkali cordgrass (*Spartina gracilis*), Nuttall's alkaligrass (*Puccinellia nuttalliana*) or clustered field sedge (*Carex praegracilis*) occur on seasonally flooded sites where evaporation concentrates salts.

Climate

The *Cordilleran Dry Forest* zone occurs at low to mid-elevations in southern BC in the lee of the Coast, Cascade and Columbia Mountains, where rain shadow effects on Pacific air masses create relatively dry conditions within the continental temperate climate of interior BC. In general, summers are warm and winters are cool; annual precipitation is typically low.

The primary climatic determinant of vegetation patterns is moisture. Mean annual precipitation varies between approximately 400 and 800 mm, with higher amounts (>1000 mm) near the Coast Mountains. Summer precipitation is 200 – 300 mm throughout the zone. In some locations, up to half of the precipitation falls as snow. Winter snowpacks typically melt in early spring, especially at lower elevations, leaving sites prone to summer drought and subject to growing season moisture deficits. Mean annual temperatures vary from approximately 3.5°C to 9°C, the warmest areas occurring at low elevations where forests/woodlands are dominated by ponderosa pine. The growing season averages between approximately 1100 and 2200 growing degree days above 5°C.

Physiography, Geology, Topography and Soils

This zone occurs within the southern Interior System of the Cordilleran physiographic region in BC. It dominates the southern portion of the Interior Plateau and fingers into lower elevations of valleys in the Columbia Highlands, Columbia Mountains, and the eastern Cascade and Coast Mountains. This zone also occurs in the southern Rocky Mountain Trench and adjacent valleys. Depending on the location, elevations range from as low as 150 mASL in some valley bottoms to about 1400 mASL in mountainous terrain.

The Coast and Cascade Mountains consist predominantly of crystalline igneous and metamorphic rocks, while the Interior Plateau is mostly underlain by geologically recent lava deposits. The Columbia and Rocky Mountains comprise mostly faulted and folded Paleozoic, Mesozoic or Tertiary sedimentary, often carbonate-rich, rocks. The terrain is a complex mixture of high mountains (up to 3900 mASL) with intervening plateaux, hill systems, valleys, trenches and basins.

The entire zone was affected by late Pleistocene glaciation. The predominant surficial material is glacial till derived from basaltic bedrock, thus reasonably rich in cations. In the valleys, alluvial and glaciofluvial deposits occur, along with thin till and colluvial materials on steeper slopes. Volcanic ash often forms a thin upper soil layer. Mineral soils are typically Luvisols and Brunisols, with Chernozems in the warmest driest areas.

Notes

At low elevations, the *Cordilleran Dry Forest* zone is mostly bounded by the *Cordilleran Subboreal Forest*, although in some locations of southern BC it adjoins the *Cordilleran Rainforest*. At higher elevations, with the exception of a few occurrences in the Coast Mountains, it is bounded by the *Cordilleran Montane Forest*. To the south, it continues into the US. At the lowest elevations of the deeper river valleys in south-central BC, the *Intermontane Shrub-Steppe* zone occurs, surrounded by this zone.

Eastern Cool Temperate Forest

Three **Level 2** descriptions in this section:

- **Eastern Temperate Mixed Forest**
- **Eastern Temperate Deciduous Forest**
- **Acadian Temperate Forest**

Eastern Temperate Mixed Forest

General Description

The *Eastern Temperate Mixed Forest* zone covers an area of approximately 360,000 km² in a band of varying width that extends from southeastern Manitoba to the Gaspé Peninsula. This zone marks the northern extent of the humid temperate climate in eastern North America, and the transition between broad-leaved temperate forests and conifer-dominated boreal forests. Landcover is dominated by forests and numerous water bodies, but agriculture, settlement infrastructure and industrial activities are significant contributors to the contemporary landscape mosaic.

Vegetation

Closed forests dominate most upland sites, although open forests and woodlands are sometimes associated with very dry sites. Forest canopies are primarily a mixture of cold-deciduous broad-leaved and evergreen coniferous species, although patches of pure broad-leaved or conifer canopies are relatively common. Tall conifers (especially eastern white pine [*Pinus strobus*] and white spruce [*Picea glauca*]) often occur as emergents above a broad-leaved canopy. Understory structure varies from dense to sparse; cold-deciduous broad-leaved shrubs, perennial herbs and tree regeneration are the most common understory growth forms.

Anthropogenic disturbance, including forest harvesting, roadbuilding, agricultural conversion, urban development, and industrial and recreational activities, is a dominant factor in contemporary forest dynamics. Windthrow, ice loading and insect infestations are the most widespread modes of natural disturbance. Browsing by white-tailed deer (*Odocoileus virginianus*) can alter stand composition and structure, especially in southern portions of the zone. Stand-replacing fire is a factor in the westernmost portion of the zone where the climate is drier. Forests are characteristically uneven-aged, multi-storied mixedwoods containing several species in the tree stratum. However, even-aged, single storied stands can develop after stand-replacing disturbance.

The main tree species throughout the zone include balsam fir (*Abies balsamea*), paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), trembling aspen (*Populus tremuloides*) and white spruce. East of the Great Lakes, sugar maple (*Acer saccharum*), red maple and yellow birch (*B. alleghaniensis*) often dominate canopies. West of Lake Superior, trembling aspen is the primary broad-leaved species. Eastern white cedar (*Thuja occidentalis*) is a common companion species throughout the zone. Eastern white pine, red pine (*Pinus resinosa*) and northern red oak (*Quercus rubra*) are common canopy associates in the Great Lakes and western Quebec portions of the zone; red spruce (*Picea rubens*) is an important canopy constituent in the east. East of the Great Lakes, American beech (*Fagus grandifolia*) and eastern hemlock (*Tsuga canadensis*) occur occasionally in southern parts of the zone. Alluvial forests dominated by black ash

(*Fraxinus nigra*), eastern white cedar, balsam poplar (*Populus balsamifera*), balsam fir, red maple, paper birch and/or yellow birch occur on stable floodplains.

In addition to regenerating balsam fir, common understory species throughout the zone include mountain maple (*Acer spicatum*), beaked hazelnut (*Corylus cornuta*), Canada fly-honeysuckle (*Lonicera canadensis*), northern bush-honeysuckle (*Diervilla lonicera*), bunchberry (*Cornus canadensis*), wild lily-of-the-valley (*Maianthemum canadense*), northern starflower (*Lysimachia borealis*), yellow clintonia (*Clintonia borealis*), wild sarsaparilla (*Aralia nudicaulis*) and rose twisted-stalk (*Streptopus lanceolatus*). Vernal ephemeral forbs like spring beauty (*Claytonia* spp.) and trout lily (*Erythronium americanum*) are characteristic of maple-dominated stands east of the Great Lakes. Bryophytes are most common on tree boles, rocks and dead wood, only forming substantial ground cover under conifer canopies; the most common moss species is red-stemmed feathermoss (*Pleurozium schreberi*). On dry sites, especially under open canopies, ground lichens (especially clad lichens [*Cladonia* spp.] and reindeer lichens [*Cladina* spp.]) are prevalent.

Wetlands are common and occasionally extensive in poorly drained locations. All wetland classes (swamps, marshes, fens and bogs) occur, although bogs are relatively infrequent.

Treed swamps with moderate to rich nutrient status are dominated by black ash, eastern white cedar, balsam poplar, balsam fir, red maple, paper birch and/or yellow birch; black spruce (*Picea mariana*) and tamarack (*Larix laricina*) are prevalent on nutrient-limited sites.

Shrub swamps, annually active floodplains and hummocky fens include speckled alder (*Alnus incana* ssp. *rugosa*), mountain holly (*Ilex mucronata*), common winterberry (*I. verticillata*), sweet gale (*Myrica gale*), white meadowsweet (*Spiraea alba*), black chokeberry (*Aronia melanocarpa*), red-osier dogwood (*Cornus sericea*) and a variety of willows (e.g., sandbar willow [*Salix interior*], tea-leaved willow [*S.planifolia*]) and graminoids (e.g., tall mannagrass [*Glyceria grandis*]). Marshes dominated by cattails (*Typha* spp.), American reed (*Phragmites australis* ssp. *americanus*) or bulrushes (*Schoenoplectus* spp.) occur on the shallow margins of water bodies. Shallow marshes, wetter fens and wet meadows are dominated by sedges (e.g., water sedge [*Carex aquatilis*], woolly-fruit sedge [*C. lasiocarpa*], tussock sedge [*C. stricta*]), water horsetail (*Equisetum fluviatile*), bluejoint reedgrass (*Calamagrostis canadensis*) or mannagrasses (*Glyceria* spp.).

Where water tables fluctuate and some root zone drying occurs during the growing season, fens include bog birch (*Betula pumila*), willows (e.g., bog willow [*Salix pedicellaris*]) and stunted tamarack. On these sites, brown mosses such as ribbed bog moss (*Aulacomnium palustre*), golden fuzzy fen moss (*Tomentypnum nitens*) and hook mosses (*Drepanocladus* spp.) usually dominate between peat moss (*Sphagnum* spp.) hummocks.

Bogs and nutrient-poor fens include stunted black spruce and tamarack, as well as common Labrador tea (*Rhododendron groenlandicum*), leatherleaf (*Chamaedaphne calyculata*), velvet-leaved blueberry (*Vaccinium myrtilloides*), early lowbush blueberry (*V. angustifolium*), cranberries (*Vaccinium oxycoccos*, *V. microcarpon*, *V. macrocarpon*), pale bog laurel (*Kalmia polifolia*), glaucous-leaved bog rosemary (*Andromeda polifolia* var. *latifolia*) and few-seeded sedge (*Carex oligosperma*). Peat mosses dominate the moss layer.

Upland grasslands and shrublands are rare on the landscape, other than immediately following forest removal, on abandoned fields, or on very dry or shallow sites. Along Great Lakes shorelines, beaches and sand dunes are populated by species like sand cherry (*Prunus pumila*), American beachgrass (*Ammophila breviligulata*) and beach pea (*Lathyrus japonicus*).

Climate

The *Eastern Temperate Mixed Forest* zone occurs within the continental cool temperate climate of eastern Canada. Temperature extremes are more moderate than are those of the adjacent *Eastern Boreal Forest* zone. The climate is increasingly humid eastwards, varying from subhumid at the western edge of the zone to humid in eastern Ontario and western Quebec to very humid with maritime influences in eastern Quebec. On the Gaspé Peninsula, this zone occurs at low elevations below the *Eastern Boreal Forest* and *Acadian Temperate Forest* zones. Overall, winters are cold and snowy, and summers are warm and moist.

Mean annual temperatures vary from approximately 1°C along the northern and western edges of the zone (and at higher elevations of the Notre Dame Mountains in Gaspésie) to >5°C at the southern extent of the zone in east-central Ontario and the Quebec Eastern Townships. The growing season averages between approximately 1300 and 1700 growing degree days above 5°C, with the longest period occurring at low elevations in southern Quebec. Mean annual precipitation follows a strong west to east gradient, increasing from approximately 600 mm near the Manitoba border to >1100 mm in some areas of eastern Ontario and Quebec. Rainfall significantly exceeds snowfall.

Physiography, Geology, Topography and Soils

This zone occurs primarily in the southern James and Laurentian physiographic regions of the east-central Precambrian Shield. South of the Shield, in the Appalachian physiographic region, it occurs in the Eastern Quebec Uplands, the Sutton Mountains, the Megantic Hills and at all but the highest elevations in the Notre Dame Mountains and Chaleur Uplands of the Gaspé Peninsula. In the St. Lawrence Lowlands physiographic province, this zone occurs east of approximately Granby, Quebec.

Most of the Shield landscapes in Ontario and western Quebec are characterized by rolling terrain containing numerous wetlands and lakes, with elevations largely below 500 mASL and local relief rarely exceeding 100 m. However, in the Abitibi Uplands of eastern Ontario and the Laurentian Highlands of Quebec the topography is considerably more rugged and dissected, with elevations up to 800 mASL. The geology consists of Precambrian sedimentary and crystalline rocks.

The dominant features of the highland and mountainous areas in the Appalachian portion of the zone are the Notre Dame Mountains and the Eastern Quebec Uplands, derived from Paleozoic mountain-forming events. On the Gaspé Peninsula, this zone occurs below approximately 400 mASL. Southwest of the Gaspé Peninsula, the zone occurs at elevations up to approximately 900 mASL in the Sutton Mountains and Megantic Hills.

The entire zone was affected by late Pleistocene glaciation and surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. The predominant parent material is glacial till, often occurring as shallow veneers overlying bedrock on upland sites while deeper deposits fill landscape depressions. Coarse-textured glaciofluvial materials (e.g., outwash plains) are relatively common on the Shield, and fine-textured glaciolacustrine and glaciomarine sediments are notable in northwestern Ontario and in the St. Lawrence River Valley in Quebec. Mineral soils are typically Podzols, Brunisols and Luvisols, with Gleysols occurring on moist, poorly drained sites. Deeper peat deposits containing Organic soils occur where water tables remain near the surface throughout the year.

Notes

The *Eastern Temperate Mixed Forest* zone borders the *Eastern Boreal Forest* to the north and at higher elevations on the Gaspé Peninsula. At low elevations on the Gaspé Peninsula, it is bounded by the Gulf of St. Lawrence and the St. Lawrence River, as well as the *Acadian Temperate Forest*. In eastern Ontario and southern Quebec, this zone borders the *Eastern Temperate Deciduous Forest* to the south. To the west, it adjoins the *Great Plains Parkland* in southern Manitoba, while in north-

central Ontario, it is divided by Lake Superior. West of Lake Superior and in southeastern Quebec, the zone continues to the south and east into the US.

Eastern Temperate Deciduous Forest

General Description

The *Eastern Temperate Deciduous Forest* zone occupies the southernmost portions of Ontario and Quebec, covering an area of approximately 100,000 km². This zone represents the northern extent of broad-leaved temperate forests that are widespread in the eastern US. The temperate climate is humid and continental. Over half of Canada's population lives in this zone, including the metropolitan areas of Toronto and Montreal. Much of the area has been converted to agriculture and urban infrastructure, but the contemporary landscape still includes moderate cover by forest patches.

Vegetation

Natural upland vegetation for this zone is typified by closed forests with multi-layered canopies characterized by temperate, cold-deciduous broad-leaved trees. Woodlands occur on very dry and very moist sites. Tree species diversity can be high within stands, including many species that are long-lived. Composition is usually of multiple broad-leaved species, but conifer – broad-leaved mixes and pure conifer stands can occur, especially on nutrient-limited sites and toward the northern limit of the zone. Understory structure varies from dense to sparse and is usually dominated by cold-deciduous broad-leaved shrubs, perennial herbs and broad-leaved tree regeneration. Bryophytes are typically confined to dead wood, rocks and tree boles.

Forest stands have the potential to be hundreds of years old, but few old forests remain on the landscape. Stand structure is typically multi-storied and uneven-aged, but can be single-storied after stand-replacing disturbance. Anthropogenic disturbance is the dominant factor in contemporary forest dynamics. Windthrow, ice loading and insect outbreaks are the most widespread forms of natural disturbance; wildfire is not a factor. Browsing by white-tailed deer (*Odocoileus virginianus*) can alter stand composition and structure.

The overwhelmingly dominant tree species in contemporary forests is sugar maple (*Acer saccharum*). Red maple (*A. rubrum*), white ash (*Fraxinus americana*), basswood (*Tilia americana*), American beech (*Fagus grandifolia*), hop-hornbeam (*Ostrya virginiana*), black cherry (*Prunus serotina*) and red oak (*Quercus rubra*) are common canopy associates. Eastern hemlock (*Tsuga canadensis*), eastern white pine (*Pinus strobus*), white elm (*Ulmus americana*) and large-toothed aspen (*Populus grandidentata*) occur occasionally. Balsam fir (*Abies balsamea*), yellow birch (*Betula alleghaniensis*), paper birch (*B. papyrifera*), eastern white cedar (*Thuja occidentalis*), white spruce (*Picea glauca*) and trembling aspen (*Populus tremuloides*) are more common in the northern portion of the zone. Hickories (*Carya* spp.), red ash (*Fraxinus pennsylvanica*), white oak (*Quercus alba*) and blue-beech (*Carpinus caroliniana*) are more common in the southern portion. Some trees of deciduous broad-leaved forests in the eastern US, such as eastern flowering dogwood (*Cornus florida*), common hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), sassafras (*Sassafras albidum*), black oak (*Quercus velutina*) and tulip

tree (*Liriodendron tulipifera*) reach their northern range limits in southernmost Ontario and are occasionally present in contemporary forests of this zone; many of these species are rare and at risk of extirpation in Canada. Alluvial forests dominated by black ash (*Fraxinus nigra*), red ash, white ash, balsam poplar (*Populus balsamifera*), eastern white cedar, red maple, sugar maple, silver maple (*Acer saccharinum*), white elm and/or Manitoba maple (*A. negundo*) occur on stable floodplains.

Forest understories are typically dominated by regenerating broad-leaved tree species, led by sugar maple. Shrub species include maple-leaved viburnum (*Viburnum acerifolium*), alternate-leaved dogwood (*Cornus alternifolia*), eastern prickly gooseberry (*Ribes cynosbati*), northern spicebush (*Lindera benzoin*) and, in the northern portion of the zone, striped maple (*Acer pensylvanicum*), mountain maple (*A. spicatum*), hobblebush (*V. lantanoides*), beaked hazelnut (*Corylus cornuta*) and Canada fly-honeysuckle (*Lonicera canadensis*). Typical herb/dwarf shrub species include trilliums (especially white trillium [*Trillium grandiflorum*], red trillium [*T. erectum*], painted trillium [*T. undulatum*]), hairy Solomon's seal (*Polygonatum pubescens*), large false Solomon's seal (*Maianthemum racemosum*), Jack-in-the-pulpit (*Arisaema triphyllum*), herbaceous carrionflower (*Smilax herbacea*), bristly greenbrier (*S. tamnoides*), May-apple (*Podophyllum peltatum*), heart-leaved foamflower (*Tiarella cordifolia*) and blue cohosh (*Caulophyllum thalictroides*). Vernal ephemeral forbs like spring beauties (*Claytonia* spp.), trout lily (*Erythronium americanum*), toothworts (*Cardamine* spp.), Dutchman's breeches (*Dicentra cucullaria*) and squirrel-corn (*D. canadensis*) are characteristic of these densely shaded understories.

Wetlands are common on the landscape, but rarely extensive. Most have been altered or converted by agriculture, urbanisation or shoreline development. Swamps, marshes and fens are the predominant wetland classes; bogs are uncommon.

Treed swamps with moderate to rich nutrient status are dominated by black ash, red ash, eastern white cedar and/or red maple; silver maple, white elm and Manitoba maple are common associates. Several wetland oak species reach their northern range limits in southern parts of the zone, including pin oak (*Quercus palustris*), Shumard oak (*Q. shumardii*) and swamp white oak (*Q. bicolor*). Black spruce (*Picea mariana*) and tamarack (*Larix laricina*) are the prevalent trees on nutrient-limited sites.

Shrub swamps, annually active floodplains and hummocky fens include speckled alder (*Alnus incana* ssp. *rugosa*), mountain holly (*Ilex mucronata*), common winterberry (*I. verticillata*), sweet gale (*Myrica gale*), black chokeberry (*Aronia melanocarpa*), red-osier dogwood (*Cornus sericea*) and a variety of willows (e.g., sandbar willow [*Salix interior*], tea-leaved willow [*S. planifolia*]) and graminoids (e.g., tall mannagrass [*Glyceria grandis*]). Eastern skunk cabbage (*Symplocarpus foetidus*) is a common constituent of nutrient-rich swamps.

Marshes dominated by cattails (*Typha* spp.), American reed (*Phragmites australis* ssp. *americanus*), bulrushes (*Schoenoplectus* spp.) or burreeds (*Sparganium* spp.) occur on the shallow margins of water bodies. Shallow marshes, wetter fens and wet meadows are dominated by sedges (e.g., water sedge [*Carex aquatilis*], woolly-fruit sedge [*C. lasiocarpa*], tussock sedge [*C. stricta*], eastern narrow-leaved sedge [*C. amphibola*], grey sedge [*C. grisea*]), water horsetail (*Equisetum fluviatile*), bluejoint reedgrass (*Calamagrostis canadensis*) or mannagrasses (*Glyceria* spp.).

Where water tables fluctuate and some root zone drying occurs during the growing season, fens include bog birch (*Betula pumila*), willows (e.g., bog willow [*Salix pedicellaris*]) and stunted tamarack or eastern white cedar. On these sites, brown mosses such as ribbed bog moss (*Aulacomnium palustre*), golden fuzzy fen moss (*Tomentypnum nitens*) and hook mosses (*Drepanocladus* spp.) usually dominate between peat moss (*Sphagnum* spp.) hummocks.

Upland grasslands and shrublands are common occurrences on the landscape, mostly following anthropogenic disturbance or agricultural abandonment, but also on very dry or shallow sites, and in coastal areas.

Along Great Lakes shorelines, beaches and sand dunes are populated by species like American beachgrass (*Ammophila breviligulata*), American sea rocket (*Cakile edentula*), Great Lakes sandreed (*Sporobolus rigidus* var. *magnus*) and tall wormwood (*Artemisia campestris* ssp*. caudata*).

On shallow limestone bedrock, alvar communities include junipers (*Juniperus* spp.), dropseed grasses (e.g. prairie dropseed [*Sporobolus heterolepis*]), little bluestem (*Schizachyrium scoparium*) and tufted hairgrass (*Deschampsia cespitosa* ssp. *cespitosa*). Remnants of tallgrass prairie occur in localised pockets, including species such as big bluestem (*Andropogon gerardi*) and blazing-stars (*Liatris* spp.). Along the Niagara Escarpment, cliff and talus communities include some of the oldest (>1000 years) trees in Canada, stunted cliff-face eastern white cedars, as well as numerous calciphiles like purple-stemmed cliffbrake (*Pellaea atropurpurea*), walking fern (*Asplenium rhizophyllum*) and white-flowered leafcup (*Polymnia canadensis*).

Climate

The *Eastern Temperate Deciduous Forest* zone occurs within the humid, continental cool temperate climate of eastern Canada, generally characterized by cool winters and warm to hot summers. Temperatures are moderated by three of the Great Lakes (Lakes Huron, Erie and Ontario), which surround the western portion of the zone.

Mean annual temperatures vary from approximately 5°C at the northernmost edge of the zone to >9°C at the southernmost point. Growing degree days above 5°C average between approximately 1850 and 2500, with the longest growing season occurring at Windsor in southwestern Ontario. Mean annual precipitation averages >900 mm throughout the zone. Rainfall significantly exceeds snowfall.

Physiography, Geology, Topography and Soils

This zone occurs in the West and Central divisions of the St. Lawrence Lowlands physiographic province. With the exception of the Niagara Escarpment, which traverses the west-central part of the zone, the terrain is essentially a level, undulating plain with low relief. The geology consists of calcareous Paleozoic rocks, except in southeastern Ontario where acidic Precambrian bedrock occurs on the Frontenac Axis.

The entire zone was affected by late Pleistocene glaciation, and surficial landscape expression is dominated by glacial features, such as moraines and drumlins; generally, till deposits overlie bedrock. Significant areas are covered by glaciolacustrine materials from a series of pro-glacial lakes that predated the contemporary Great Lakes. Mineral soils are typically Luvisols or Brunisols, with Gleysols and some shallow peat deposits on moist, poorly drained sites.

Notes

The *Eastern Temperate Deciduous Forest* zone borders the *Eastern Temperate Mixed Forest* to the north and east. To the west and south, it is bounded by Lakes Huron, Erie and Ontario, and continues southward into the US.

Acadian Temperate Forest

General Description

The *Acadian Temperate Forest* zone covers an area of approximately 140,000 km², including the Maritime provinces and a small portion of Quebec adjacent to the New Brunswick border. The Atlantic Ocean generates a pronounced maritime influence on the cool temperate climate. The contemporary landscape is a mosaic of forests, agriculture, industrial and settlement infrastructure, and numerous water bodies.

Vegetation

Closed forests dominate most upland sites, although open forests and woodlands are sometimes associated with very dry sites. Forest canopies can be dominated by evergreen coniferous, cold-deciduous broad-leaved, or a mixture of conifer and broad-leaved species. Understory structure varies from dense to sparse and is generally rich in cold-deciduous broad-leaved shrubs, perennial herbs, tree regeneration and bryophytes.

Anthropogenic disturbance, including forest harvesting, roadbuilding, agricultural conversion, urban development and industrial and recreational activities, is the dominant factor in contemporary forest dynamics. Windthrow, ice loading and insect infestations are the most widespread forms of natural disturbance; wildfire is generally not a factor. Forest stand structure is typically multi-storied and uneven-aged, but can be single-storied after stand-replacing disturbance.

The main tree species include balsam fir (*Abies balsamea*), red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), yellow birch (*B. alleghaniensis*), red spruce (*Picea rubens*), sugar maple (*Acer saccharum*) and white spruce (*P. glauca*). Black spruce (*P. mariana*) often dominates stands on nutrient-limited sites. Eastern white cedar (*Thuja occidentalis*) is a common companion species in Quebec and New Brunswick. Eastern white pine (*Pinus strobus*), eastern hemlock (*Tsuga canadensis*), red oak (*Quercus rubra*) and American beech (*Fagus grandifolia*) are occasional canopy dominants or associates in the southern part of the zone and at lower elevations in the north. White ash (*Fraxinus americana*), butternut (*Juglans cinerea*) and basswood (*Tilia americana*) are prominent in parts of west-central New Brunswick.

On larger rivers in New Brunswick, alluvial forests dominated by silver maple (*Acer saccharinum*), red ash (*F. pennsylvanica*) and/or white elm (*Ulmus americana*) occur on stable floodplains, occasionally with bur oak (*Quercus macrocarpa*) on drier microsites. Elsewhere in the zone, sugar maple, white ash, red maple, eastern white cedar, white spruce, yellow birch, and/or ironwood (*Ostrya virginiana*) occupy floodplains on smaller rivers. Black ash (*Fraxinus nigra*) and balsam poplar (*Populus balsamifera*) are common floodplain dominants in cooler portions of the zone.

In addition to regenerating trees, common understory species include striped maple (*Acer pensylvanicum*), velvet-leaved blueberry (*Vaccinium myrtilloides*), Canada fly-honeysuckle (*Lonicera canadensis*), wild lily-of-valley (*Maianthemum canadense*), northern

starflower (*Lysimachia borealis*), yellow clintonia (*Clintonia borealis*), bunchberry (*Cornus canadensis*), wild sarsaparilla (*Aralia nudicaulis*), common wood-sorrel (*Oxalis montana*), rose twisted-stalk (*Streptopus lanceolatus*), sedges (e.g., drooping woodland sedge [*Carex arctata*], New England sedge [*C. novae-angliae*], fibrous-root sedge [*C. communis*]) and wood ferns (e.g., evergreen wood fern [*Dryopteris intermedia*], spinulose wood fern [*D. carthusiana*], mountain wood fern [*D. campyloptera*]). Bryophytes and epiphytic lichens can be abundant, especially in older stands and in areas with a very humid climate. The most common bryophyte species include red-stemmed feathermoss (*Pleurozium schreberi),* stairstep moss (*Hylocomium splendens*) and three-lobed whipwort (*Bazzania trilobata*).

Wetlands are common and occasionally extensive in poorly drained locations. All wetland classes (swamps, marshes, fens and bogs) occur, including both freshwater and saltwater/brackish marshes and fens.

Treed swamps with moderate to rich nutrient status are typically dominated by eastern white cedar, white and/or black ash, tamarack (*Larix laricina*), red maple, balsam fir, yellow birch and/or, less often, red spruce and eastern hemlock; black spruce is particularly characteristic on nutrient-limited sites.

Shrub swamps are characterized by speckled alder (*Alnus incana* ssp. *rugosa*)*,* mountain holly (*Ilex mucronata*), common winterberry (*I. verticillata*), sweet gale (*Myrica gale*), wild raisin (*Viburnum nudum* ssp. *cassinoides*), white meadowsweet (*Spiraea alba* var. *latifolia*) and a variety of willows (e.g., balsam willow [*Salix pyrifolia*]*,* shining willow [*S. lucida*]), sedges (e.g., retrorse sedge [*Carex retrorsa*], bog sedge [*C. magellanica* ssp*. irrigua*], sallow sedge [*C. lurida*]) and forbs (e.g., common St. John's wort [*Hypericum fraseri*] and rough goldenrod [*Solidago rugosa*]).

Deeper marshes dominated by cattails (*Typha* spp.), bulrushes (*Schoenoplectus* spp.), common spikerush (*Eleocharis palustris*), American sweetflag (*Acorus americanus*) and/or rushes (e.g., Canada rush [*Juncus canadensis*], bayonet rush [*J. militaris*], soft rush [*J. effusus*]) occur on the shallow margins of water bodies. Shallow marshes, wetter fens and wet meadows are characterized by sedges (e.g., water sedge [*Carex aquatilis*], lake sedge [*C. lacustris*], woolly-fruit sedge [*C. lasiocarpa*], tussock sedge [*C. stricta*], smooth twig-rush [*Cladium mariscoides*]), cottongrasses (*Eriophorum* spp.), bog buckbean (*Menyanthes trifoliata*), mannagrasses (*Glyceria* ssp.), bluejoint reedgrass (*Calamagrostis canadensis*), reed canarygrass (*Phalaris arundinacea*) and/or prairie cordgrass (*Sporobolus michauxianus*). Salt marshes are mostly dominated by dropseed grasses (*Sporobolus* spp.).

Nutrient-rich open fens are localized to areas of calcareous bedrock. On these sites, alder-leaved buckthorn (*Rhamnus alnifolia*), shrubby cinquefoil (*Dasiphora fruticosa*), green-keeled cottongrass (*Eriophorum viridicarinatum*), spike muhly (*Muhlenbergia glomerata*), yellow sedge (*Carex flava*), Kalm's lobelia (*Lobelia kalmii*), alpine bulrush (*Trichophorum alpinum*), hardstem bulrush (*Schoenoplectus acutus*) and several rare orchids (e.g., showy lady slipper [*Cypripedium reginae*], bog candle [*Platanthera dilatata*], northern green orchid [*P. aquilonis*]) are notable. Fens may include shrubs such as sweet gale, leatherleaf (*Chamaedaphne calyculata*), bog willow (*Salix pedicellaris*), as well as stunted red maple, tamarack and other tree species. Brown mosses such as ribbed bog moss (*Aulacomnium palustre*), golden fuzzy fen moss (*Tomentypnum nitens*) and hook mosses (*Drepanocladus* spp.) usually dominate between peat moss (*Sphagnum* spp.) hummocks.

Bogs and nutrient-poor fens include stunted black spruce and tamarack, as well as common Labrador tea *(Rhododendron groenlandicum),* leatherleaf, velvet-leaved blueberry, early lowbush blueberry (*Vaccinium angustifolium*), cranberries (*Vaccinium oxycoccos, V. macrocarpon*), pale bog laurel (*Kalmia polifolia*), glaucous-leaved bog rosemary (*Andromeda*

polifolia var. *latifolia*), few-seeded sedge (*Carex oligosperma*), Billing's sedge (*C. billingsii*), coastal sedge (*C. exilis*) and tufted clubrush (*Trichophorum cespitosum*). Peat mosses dominate the moss layer.

Moist to wet heaths occur on mineral soil with thick humus deposits. They are characterized by rhodora (*Rhododendron canadense*), black huckleberry (*Gaylussacia baccata*), bog huckleberry (*G. bigeloviana*), common Labrador tea, early low-bush blueberry, sheep laurel *(Kalmia angustifolia),* smooth black sedge (*Carex nigra*), large cranberry (*Vaccinium macrocarpon*) and cinnamon fern (*Osmundastrum cinnamomeum*).

Dunes and sand beaches are particularly well developed on Prince Edward Island, the Northumberland coasts of New Brunswick and Nova Scotia, and on Sable Island. Dune species include American beachgrass (*Ammophila breviligulata*), sea lymegrass (*Leymus mollis*), seabeach sedge (*Carex silicea*), beach pea (*Lathyrus japonicus*), woolly beach-heather (*Hudsonia tomentosa*) and northern bayberry (*Morella pensylvanica*). Common sand beach species include American sea rocket (*Cakile edentula*), seabeach sandwort (*Honckenya peploides*) and rough cockleburr (*Xanthium strumarium*); oysterleaf (*Mertensia maritima*), saltbushes (*Atriplex* spp.) and Scotch lovage (*Ligusticum scoticum*) are more common on gravel and cobble beaches.

Temperate and boreal heathlands are relatively conspicuous on larger dunes on Prince Edward and Sable Islands, across the Cape Breton plateau, and within the western interior, and along the Atlantic coast, of Nova Scotia. They are usually dominated by huckleberries, black crowberry (*Empetrum nigrum*), mountain cranberry (*Vaccinium vitis-idaea*), pink crowberry (*E. eamesii*), broom crowberry (*Corema conradii*), common juniper or sometimes sheep laurel. Most coastal grasslands have been disturbed by domestic grazing and past settlement, but red fescue (*Festuca rubra*), American beachgrass and, in wet areas, smooth black sedge form natural stands in some locations.

Climate

The *Acadian Temperate Forest* zone occupies the easternmost extent of the humid continental, cool temperate climate of Canada. In general, winters are cool and summers are warm. The zone is surrounded by the Atlantic Ocean on three sides, creating a distinct oceanic gradient from more continental areas in Quebec and northern New Brunswick to the hypermaritime Atlantic coast of Nova Scotia. Increasing proximity to the ocean results in significant effects on insolation, fog, total precipitation, and seasonal temperature averages and extremes.

Mean annual temperatures vary from approximately 3.5°C in northern New Brunswick to 7°C in the Annapolis Valley, Nova Scotia. Growing degree days above 5°C average between approximately 1300 and 1800. Mean annual precipitation varies from 1000 mm in west-central New Brunswick to >1650 mm along the outer Atlantic coast of Nova Scotia. Rainfall significantly exceeds snowfall.

Physiography, Geology, Topography and Soils

This zone occurs in the eastern mainland portion of the Appalachian physiographic region. It occupies most of the Chaleur Uplands, the New Brunswick and Atlantic Highlands, the Maritime Plain, the Annapolis Lowland, all but the highest Cape Breton elevations of the Nova Scotia Highlands, and a small part of the lower elevations of the Notre Dame Mountains in Quebec. On the Gaspé Peninsula, the zone occurs approximately at elevations <400 mASL and on Cape Breton Island below about 350 mASL. In northern New Brunswick, it occurs at elevations up to approximately 800 mASL.

Higher elevations are most notable in northern New Brunswick and the Gaspé Peninsula, as well as on Cape Breton Island. In northern New Brunswick and Quebec, the geology includes Paleozoic igneous and older sedimentary bedrock formations, while the highlands of Cape Breton are mostly igneous and

metamorphic. Lowlands are associated with river valleys eroded into upland bedrock or extensive areas of gentle relief underlain by softer Paleozoic or Mesozoic sedimentary rocks. A general topographic gradient tilts toward the Atlantic Ocean with elevations ranging from just over 800 mASL in northern New Brunswick to sea level. Much of the zone is below 200 mASL and, while relief is generally not pronounced, topographic changes can be abrupt. The terrain varies from gently rolling plains with little relief to rugged, often deeply dissected, plateaux with steep slopes.

The entire zone was affected by late Pleistocene glaciation and surficial landscape expression is dominated by glacial features and bedrock-controlled terrain. The predominant parent material is glacial till, often occurring as shallow veneers overlying bedrock on upland sites while deeper deposits fill landscape depressions. Glaciofluvial, alluvial, marine and aeolian deposits occur in river valleys and coastal areas. Mineral soils are typically Podzols and Luvisols, with Gleysols occurring on moist, poorly drained sites. Folisols develop in very humid areas along the Atlantic Coast and on the Cape Breton Highlands. Deeper peat deposits containing Organic soils occur where water tables remain near the surface throughout the year.

Notes

At low elevations, the *Acadian Temperate Forest* zone is mostly bounded by the Atlantic Ocean, including the Gulf of St. Lawrence and the Bay of Fundy. To the northwest, it adjoins the *Eastern Temperate Mixed Forest.* At higher elevations in Quebec and on Cape Breton Island, it borders the *Eastern Boreal Forest*. To the south and west, it continues into the US.

Grassland, Parkland and Steppe

Seven **Level 2** descriptions in this section:

- **Rocky Mountains Foothills Parkland**
- **Great Plains Parkland**
- **Intermontane Shrub-Steppe**
- **Rocky Mountains Foothills Fescue Grassland**
- **Great Plains Fescue Grassland**
- **Great Plains Mixedgrass Grassland**
- **Central Tallgrass Grassland**

Rocky Mountains Foothills Parkland

General Description

The *Rocky Mountains Foothills Parkland* zone covers an area of approximately 3,900 km² in the southern Rocky Mountains foothills of Alberta, at elevations between approximately 1000 mASL and 1400 mASL. It occurs as two disjunct subunits on the eastern edge of the foothills, the larger extending from just north of Calgary to the north end of the Porcupine Hills, and a smaller southern subunit extending to the international border near Waterton. This zone marks the transition between temperate grasslands and Rocky Mountains montane forests; here, the climate supports tree growth on cooler, moister sites. The majority of the contemporary landscape has been converted to crop cultivation and livestock grazing.

Vegetation

Natural landscape structure is a parkland mosaic of grassland patches with groves of forests, woodlands and shrublands. In this rolling terrain, grassland vegetation occurs on southerly aspects and ridges (i.e., warmer, drier sites), while forests, woodlands and shrublands occur on northerly aspects and in topographic depressions (i.e., cooler, moister sites). Grasslands are dominated by bunchgrasses, while forest and shrub communities comprise primarily cold-deciduous broad-leaved species. Vegetation patterns reflect relatively small changes in local topography and fine-scale aspect and drainage. Agricultural activities have altered the structure and species composition of most of these communities, including the introduction of non-native species.

Trembling aspen (*Populus tremuloides*) is the overwhelmingly dominant tree species, although white spruce (*Picea glauca*) and, on moist sites, balsam poplar (*Populus balsamifera*) are occasional canopy associates. Alluvial forests dominated by balsam poplar, plains cottonwood (*Populus deltoides* ssp. *monilifera*) and/or trembling aspen occur on stable floodplains.

Understories include saskatoon (*Amelanchier alnifolia*), snowberries (*Symphoricarpos albus, S. occidentalis*), prickly rose (*Rosa acicularis*), silverberry (*Elaeagnus commutata*), white meadowsweet (*Spiraea lucida*) and a variety of grass and forb species.

Mountain rough fescue (*Festuca campestris*), Idaho fescue (*F. idahoensis*) and Parry oatgrass (*Danthonia parryi*) are the primary dominant species of grassland communities.

Shrub communities establish on sites with moister soils, often the result of seepage. Stands dominated by prickly rose, snowberries, saskatoon and silverberry occur on sites that are transitional between grassland and forest. Dense groves of Bebb's willow (*Salix bebbiana*) with a tall herb understory are characteristic of the northern subunit.

Wetlands occur in poorly drained locations and near water bodies, but are rarely extensive. Shrub communities dominated by willows (e.g., Bebb's willow, meadow willow [*S. petiolaris*], tea-leaved willow [*S. planifolia*], coyote willow [*S. exigua*], yellow willow [*S. lutea*]), silverberry or water birch (*Betula occidentalis*) develop on active alluvial terraces or line small

watercourses and shorelines of water bodies where water tables remain near the surface throughout the year.

Shallow marshes and wet meadows occur on the wettest sites, including species such as wheat sedge (*Carex atherodes*), northern beaked sedge (*C. utriculata*) and water sedge (*C. aquatilis*). Deeper marshes dominated by hard-stemmed bulrush (*Schoenoplectus acutus*) occur on the shallow margins of water bodies.

Climate

The *Rocky Mountains Foothills Parkland* zone occurs at low to mid-elevations within the subhumid continental temperate climate of the southern Alberta foothills. This zone reflects an ecoclimatic transition between grasslands, at lower elevations to the east, and montane forests at higher elevations to the west. Cooler temperatures and increased precipitation relative to the adjoining *Rocky Mountains Foothills Fescue Grassland* are sufficient to support tree growth on cooler, moister sites while grasslands occupy the warmer drier parts of the landscape.

Elevational effects and winter Chinook winds modify the climate. In general, summers are warm and winters are cool. Mean annual temperature is approximately 3°C. The growing season averages approximately 1150 growing degree days above 5°C. Mean annual precipitation is approximately 500 mm, with the majority falling as rain in summer months.

Physiography, Geology, Topography and Soils

This zone occurs in the southern portion of the Rocky Mountains Foothills physiographic region in Alberta. Elevations range between approximately 1000 mASL and 1400 mASL.

Mesozoic sandstones, mudstones and shales are the dominant bedrock formations. The terrain is generally rolling, with small hummocky hills and upland slopes incised by small to large watercourses.

The entire zone was affected by late Pleistocene glaciation. The predominant surficial material is weakly calcareous glacial till. Glaciolacustrine sediments are especially prominent in lower valley positions. Soils are primarily deep Chernozems.

Notes

At higher elevations, the *Rocky Mountains Foothills Parkland* zone adjoins the *Cordilleran Montane Forest*. At lower elevations, it mostly borders the *Rocky Mountains Foothills Fescue Grassland.* To the north, at equivalent elevations, it meets the *West-Central Boreal Forest* and, at lower elevations to the northeast, the *Great Plains Parkland*. The southern boundary is the international border; similar ecological conditions occur in the adjacent US.

Great Plains Parkland

General Description

The *Great Plains Parkland* zone covers an area of approximately 250,000 km² along the northern edge of the Canadian Prairies. It extends for over 1300 km in a broad band, up to 200 km wide, from near Edmonton to the international border southeast of Winnipeg. This zone marks the transition between temperate grasslands and boreal forests. The subhumid temperate climate supports tree growth on cooler, moister sites. The majority of the contemporary landscape has been converted to crop cultivation and livestock grazing.

Vegetation

Natural landscape structure is a parkland mosaic of grassland patches with groves of forests, woodlands and shrublands. On level terrain, grassland and treed patches may be interspersed with no obvious site differences. On rolling terrain, forests and woodlands tend to occur on northerly aspects and in topographic depressions (i.e., cooler, moister sites), while grassland vegetation occurs on southerly aspects and ridges (i.e., warmer, drier sites). At the southern edge of the zone, forest and woodland stands are more restricted to landscape depressions, often forming rings around wetlands. The treed component of landcover gradually expands northward; at the northern edge of the zone forests and woodlands occupy most topographic positions while grasslands are restricted to steep south aspects. Agricultural activities have altered the structure and species composition of most of these communities, including the introduction of non-native species.

Shrubs and trees are primarily cold-deciduous broad-leaved species. Most forest/woodland occurrences are pure stands of trembling aspen (*Populus tremuloides*), occasionally accompanied on moist lower slopes by balsam poplar (*P. balsamifera*), Manitoba maple (*Acer negundo*) or red ash (*Fraxinus pennsylvanica*). At the eastern end of the zone, bur oak (*Quercus macrocarpa*) also becomes important, especially on drier sites. Alluvial forests dominated by balsam poplar, trembling aspen, plains cottonwood (*P. deltoides* ssp. *monilifera*), Manitoba maple and, in the east, red ash, bur oak and/or white elm (*Ulmus americana*) occur on stable floodplains.

Understory vegetation includes a diverse suite of shrub and herb species adapted to partial shade. Common species include saskatoon (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), pin cherry (*P. pensylvanica*), hazelnuts (*Corylus* spp.), snowberries (*Symphoricarpos occidentalis*; *S. albus*), Canada gooseberry (*Ribes oxyacanthoides*), Woods' rose (*Rosa woodsii*), vetchlings (*Lathyrus* spp.), American vetch (*Vicia americana*), star-flowered false Solomon's seal (*Maianthemum stellatum*), wild lily-of-the-valley (*M. canadense*), meadow-rues (*Thalictrum* spp.), rough-fruited fairy bells (*Prosartes trachycarpa*), spreading dogbane (*Apocynum androsaemifolium*), Maryland sanicle (*Sanicula marilandica*), wild sarsaparilla (*Aralia nudicaulis*), slender wildrye (*Elymus*

trachycaulus), purple false melic (*Schizachne purpurascens*), rough-leaved mountain rice (*Oryzopsis asperifolia*), dry-spike sedge (*Carex siccata*) and Sprengel's sedge (*C. sprengelii*).

In Alberta and most of Saskatchewan, grassland communities are dominated by plains rough fescue (*Festuca hallii*), together with mixedgrass species, including needle-and-thread grass (*Hesperostipa comata*), northern porcupine grass (*H. curtiseta*), plains porcupine grass (*H. spartea*), thick-spike wildrye (*Elymus lanceolatus*), slender wildrye (*E. trachycaulus*), mat muhly (*Muhlenbergia richardsonis*), prairie junegrass (*Koeleria macrantha*) and western wheatgrass (*Pascopyrum smithii*). Blue grama (*Bouteloua gracilis*) is common on dry sites, and prairie sandreed (*Sporobolus rigidus* var. *rigidus*) and sand dropseed (*S. cryptandrus*) are common on sand dunes. In Manitoba, plains rough fescue is locally abundant; plains porcupine grass becomes increasingly important eastward, as well as various tallgrass species including big bluestem (*Andropogon gerardi*), prairie dropseed (*Sporobolus heterolepis*), yellow Indiangrass (*Sorghastrum nutans*), old switch panicgrass (*Panicum virgatum*) and little bluestem (*Schizachyrium scoparium*).

Forb/dwarf shrub species in grassland communities include three-flowered avens (*Geum triflorum*), prairie pasqueflower (*Pulsatilla nuttalliana*), prairie sagebrush (*Artemisia frigida*), prairie sage (*A. ludoviciana*), Lewis' wild blue flax (*Linum lewisii*), common yarrow (*Achillea millefolium*) and northern bedstraw (*Galium boreale*). On well-drained moist sites, shrub communities are often transitional to forest, including species such as prickly rose (*Rosa acicularis*), snowberries, saskatoon and silverberry (*Elaeagnus commutata*).

Wetlands and small water bodies are fairly common on the landscape, typically occurring in poorly drained topographic depressions. They often dry up during the summer and small alkali wetlands sometimes occur.

Deeper marshes dominated by broad-leaved cattail (*Typha latifolia*), hard-stemmed bulrush (*Schoenoplectus acutus*) and American reed (*Phragmites australis* ssp. *americanus*) occur on the shallow margins of water bodies. Non-saline shallow marshes and occasional fens are dominated by a variety of graminoids, including sedges (e.g., water sedge [*Carex aquatilis*], wheat sedge [*C. atherodes*], northern beaked sedge [*C. utriculata*]), grasses (e.g., prairie cordgrass [*Sporobolus michauxianus*], tall mannagrass [*Glyceria grandis*]) and common spikerush (*Eleocharis palustris*). Non-saline wet meadows are dominated by bluejoint reedgrass (*Calamagrostis canadensis*), slim-stemmed reedgrass (*C. stricta*), woolly sedge (*Carex pellita*), tufted hairgrass (*Deschampsia cespitosa*), fowl bluegrass (*Poa palustris*), willow (*Salix* spp.) shrubs and/or a wide variety of forbs. Saline wet meadows and shallow marshes dominated by saltgrass (*Distichlis spicata*), foxtail barley (*Hordeum jubatum*), Baltic rush (*Juncus balticus*), northern reedgrass (*Calamagrostis stricta* ssp. *inexpansa*) or Nuttall's alkaligrass (*Puccinellia nuttalliana*) occur on seasonally flooded sites where evaporation concentrates salts, especially in the western portion of the zone where the climate is drier.

Shrub swamps dominated by willows (e.g., Bebb's willow [*Salix bebbiana*], starved willow [*S. famelica*], meadow willow [*S. petiolaris*]) often line small watercourses and shorelines of water bodies where water tables remain near the surface throughout the year.

Climate

The *Great Plains Parkland* zone occurs within the subhumid continental temperate climate of Alberta, Saskatchewan and Manitoba. It reflects an ecoclimatic transition between temperate grasslands to the south and boreal forests to the north. Here, the climate is moist enough to support tree growth on cooler, moister sites while grasslands occupy the warmer drier parts of the landscape.

In general, winters are cold and summers are warm; mean annual temperature is approximately 2°C. In Alberta and western Saskatchewan, growing degree days (GDD) above 5˚ C vary between about 1300 and 1600, with annual precipitation between approximately 350 and 500 mm. In eastern Saskatchewan and Manitoba, the zone is generally warmer and wetter, with GDD averaging between 1550 and 1840, and annual precipitation between 400 and 540 mm.

Physiography, Geology, Topography and Soils

The *Great Plains Parkland* zone occupies portions of the Alberta, Saskatchewan and Manitoba Plains, subdivisions of the Interior Plains physiographic region. Elevations are <1000 mASL.

The zone is underlain mostly by level Mesozoic and Tertiary sedimentary bedrock. The terrain is generally an undulating plain, but local relief is provided by low bedrock hills, postglacial valley complexes, hummocky moraines and sand dunes.

The entire zone was affected by late Pleistocene glaciation. The predominant surficial material is weakly calcareous glacial till. Glaciolacustrine and glaciofluvial sediments are present in Alberta and Saskatchewan, mainly in lower and mid-valley positions, however virtually the entire Manitoba portion of the zone was inundated by glacial Lake Agassiz and is dominated by glaciolacustrine silts and clays, as well as sandy beach ridges and dunes. Soils are mainly deep Chernozems, with Gleysols occurring on moist, poorly drained sites.

Notes

To the north and west, the *Great Plains Parkland* zone is bounded by the *West-Central Boreal Forest*. In Saskatchewan it borders the *Great Plains Mixedgrass Grassland* to the south. In Alberta, the *Great Plains Fescue Grassland*, the *Rocky Mountains Foothills Fescue Grassland* and the *Rocky Mountains Foothills Parkland* lie to the south. In Manitoba, this zone adjoins the *Eastern Temperate Mixed Forest* and *Eastern Boreal Forest* to the east. Here, the southern boundary is the international border; similar ecological conditions occur in the adjacent US. The *Central Tallgrass Grassland* occurs in south-central Manitoba, surrounded by this zone.

Intermontane Shrub-Steppe

General Description

The *Intermontane Shrub-Steppe* zone covers an area of approximately 2500 km² at the lowest elevations of several major river valleys (e.g., the Fraser, Thompson and Okanagan drainages) in south-central BC. It occurs as several disjunct subunits surrounded by the *Cordilleran Dry Forest* zone at higher elevations. The *Intermontane Shrub-Steppe* zone represents the northern tip of sagebrush shrub-steppe that is widespread in the climatically dry and semi-arid western US. The continental temperate climate is one of the driest in Canada. The majority of the contemporary landscape has been converted to livestock grazing and irrigated crop cultivation.

Vegetation

Natural upland vegetation is dominated by widely spaced clumps of drought tolerant bunchgrasses and xerophytic shrubs, usually with a well-developed cryptogamic crust as the ground layer. Shrubs are typically cold-deciduous broad-leaved or evergreen microphyllous species. Vegetation patterns reflect relatively small changes in local topography and site-scale aspect and drainage. Scattered occurrences of trees are mostly confined to moist sites, cooler slope aspects or higher elevations. Agricultural activities have altered the structure and species composition of most of these communities, including the introduction of non-native species.

Bluebunch wheatgrass (*Pseudoroegneria spicata*) is the characteristic grass species, often occurring in association with big sagebrush (*Artemisia tridentata* var. *tridentata*). Other common species include needle-and-thread grass (*Hesperostipa comata*), mountain rough fescue (*Festuca campestris*), Idaho fescue (*F. idahoensis*), prairie junegrass (*Koeleria macrantha*), Sandberg's bluegrass (*Poa secunda* ssp. *secunda*), Great Basin lymegrass (*Leymus cinereus*), brittle prickly-pear cactus (*Opuntia fragilis*), antelope-brush (*Purshia tridentata*), large-fruited desert-parsley (*Lomatium macrocarpum*), low pussytoes (*Antennaria dimorpha*), slender hawksbeard (*Crepis atribarba*) and prairie spikemoss (*Selaginella densa*). The ground surface is often encrusted by cyanobacteria and numerous lichen species (especially clad [*Cladonia* spp.] and reindeer [*Cladina* spp.] lichens).

Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) and ponderosa pine (*Pinus ponderosa*) occur in small stands or as scattered individuals on cooler slopes or wherever subterranean moisture is available. Trembling aspen (*Populus tremuloides*) occurs on wetter sites, often associated with western snowberry (*Symphoricarpos occidentalis*) and a variety of forb species. Alluvial forests dominated by black cottonwood (*Populus trichocarpa*) occur on some stable floodplains.

Wetlands occur in poorly drained locations, but are rarely extensive. They often dry up during the summer and alkali wetlands are relatively common.

Broad-leaved cattail (*Typha latifolia*) and hard-stemmed bulrush (*Schoenoplectus acutus*)

marshes occur on the shallow margins of water bodies. Saline wet meadows dominated by saltgrass (*Distichlis spicata*) or clustered field sedge (*Carex praegracilis*) occur on seasonally flooded sites where evaporation concentrates salts.

Shrub communities dominated by willows (e.g., coyote willow [*Salix exigua*]) or water birch (*Betula occidentalis*) often line small watercourses and shorelines of waterbodies where water tables remain near the surface throughout the year.

Climate

The *Intermontane Shrub-Steppe* zone occurs at the lowest valley elevations in southern BC in the lee of the Coast and Cascade Mountains. Within the continental temperate climate of interior BC, rain shadow effects on Pacific air masses are most intense, and temperatures highest, in the deeper valleys.

In general, summers are warm to hot and winters are moderately cold; annual precipitation is low. Mean annual temperature is approximately 8°C. The growing season averages >2000 growing degree days above 5°C. Mean annual precipitation is typically <380 mm, with the wettest months being December and January. A growing season moisture deficit, exacerbated by warm summer temperatures, is the main factor restricting tree growth and promoting graminoid and shrub vegetation.

Physiography, Geology, Topography and Soils

This zone occurs at elevations between approximately 700 and 1000 mASL in the major river valleys of the southern Interior Plateau of BC. Specifically, portions of the middle Fraser, lower Chilcotin, lower Thompson, Nicola, Okanagan and Similkameen River valleys contain subunits of this zone. The Interior Plateau is mostly underlain by geologically recent lava deposits and soils are reasonably rich in cations.

The entire area was affected by late Pleistocene glaciation. The valleys where this zone occurs are relicts of post-glacial meltwater drainage and inundation. Predominant surficial materials are of alluvial, glaciofluvial and lacustrine origins. Soils are primarily deep Chernozems.

Notes

The *Intermontane Shrub-Steppe* zone is surrounded at higher elevations by the *Cordilleran Dry Forest*. To the south, it continues into the US.

Rocky Mountains Foothills Fescue Grassland

General Description

The *Rocky Mountains Foothills Fescue Grassland* zone covers an area of approximately 13,500 km² in the southern Rocky Mountains foothills of Alberta, at elevations between approximately 800 mASL and 1500 mASL. It extends from just north of Calgary to the international border south of Lethbridge. The continental temperate climate is modified by proximity to the Rocky Mountains. The majority of the contemporary landscape has been converted to crop cultivation and livestock grazing.

Vegetation

Natural upland vegetation comprises extensive grasslands south and east of the limit of tree growth in the western prairies and Rocky Mountains foothills. Shrub and tree-dominated communities only occur on moist sites and in topographic depressions. Grasses are mainly bunchgrasses; shrubs and trees are primarily cold-deciduous broad-leaved species. Agricultural activities have altered the structure and species composition of most native grasslands, including the introduction of non-native species.

Mountain rough fescue (*Festuca campestris*), Idaho fescue (*F. idahoensis*) and Parry oatgrass (*Danthonia parryi*) are the main dominant grasses, often in association with prairie junegrass (*Koeleria macrantha*), northern porcupine grass (*Hesperostipa curtiseta*) and western wheatgrass (*Pascopyrum smithii*).

Forb/dwarf shrub species include silvery lupine (*Lupinus argenteus*), sticky purple geranium (*Geranium viscosissimum*), three-flowered avens (*Geum triflorum*), prairie sagebrush (*Artemisia frigida*) and prairie golden bean (*Thermopsis rhombifolia*).

Shrub communities often establish on well-drained moist sites, including species such as prickly rose (*Rosa acicularis*), snowberries (*Symphoricarpos albus, S. occidentalis*), saskatoon (*Amelanchier alnifolia*) and silverberry (*Elaeagnus commutata*). Creeping juniper (*Juniperus horizontalis*) occurs on very dry sites. Shrubby cinquefoil (*Dasiphora fruticosa*) can be abundant where moderate to heavy grazing has occurred.

Alluvial forests dominated by balsam poplar (*Populus balsamifera*), trembling aspen (*P. tremuloides*) and/or plains cottonwood (*P. deltoides* ssp. *monilifera*) occur on stable floodplains. These stands often have shrub-rich understories.

Wetlands occur in poorly drained locations, but are rarely extensive. They are dominated by shrubs (e.g., Bebb's willow [*Salix bebbiana*]), sedges or tufted hair grass (*Deschampsia cespitosa*). Shallow marshes occur in the wettest parts of these sites, including species such as wheat sedge (*Carex atherodes*), northern beaked sedge (*C. utriculata*) and water sedge (*C. aquatilis*). Hard-stemmed bulrush (*Schoenoplectus acutus*) marshes occur on the shallow margins of water bodies.

Climate

The *Rocky Mountains Foothills Fescue Grassland* zone occurs at low to mid-elevations within the subhumid continental temperate climate of the southern Alberta foothills. Elevational effects

and winter Chinook winds modify the climate.

Summers are warm and winters are cool; mean annual temperature is approximately 4°C. The growing season averages approximately 1400 growing degree days above 5°C. Annual precipitation is low to moderate, but on average is relatively high for a Canadian grassland vegetation zone (only the *Central Tallgrass Grassland* zone is higher). Mean annual precipitation is between 400 and 590 mm, with the majority falling as rain in summer months.

Physiography, Geology, Topography and Soils

This zone occurs in the southwestern corner of the Alberta Plain, a subdivision of the Interior Plains physiographic region. Elevations range between approximately 800 mASL and 1500 mASL, with higher sections in the Porcupine Hills and on the Milk River Ridge.

Mesozoic and Tertiary sandstones, mudstones and shales are the dominant bedrock formations. The terrain is generally an undulating plain, but hill systems and bedrock ridges also occur.

With the unique exception of the highest levels of the Del Bonita Plateau, the entire zone was affected by late Pleistocene glaciation. The predominant surficial material is weakly calcareous glacial till, but glaciolacustrine and glaciofluvial sediments are prominent in lower and mid-valley positions. Soils are primarily deep Chernozems.

Notes

At higher elevations, the *Rocky Mountains Foothills Fescue Grassland* zone adjoins the *Rocky Mountains Foothills Parkland*, except in the Porcupine Hills where it is directly adjacent to the *Cordilleran Montane Forest*. To the north, it is bounded by the *Great Plains Parkland* and the *Great Plains Fescue Grassland*. To the east, it borders the *Great Plains Mixedgrass Grassland*. The southern boundary is the international border; similar ecological conditions occur in the adjacent US.

Great Plains Fescue Grassland

General Description

The *Great Plains Fescue Grassland* zone covers an area of over 16,000 km² at the northwestern edge of the Canadian Prairies, east of the Rocky Mountains foothills. The majority of this zone occurs in Alberta, extending from near Drumheller to just east of the Alberta – Saskatchewan border. The continental temperate climate is influenced by both its northern latitude and proximity to the Rocky Mountains. The majority of the contemporary landscape has been converted to crop cultivation and livestock grazing.

Vegetation

Natural upland vegetation is characterized by dense stands of vigorous mid-height (approximately 20-40 cm) bunchgrasses, strongly dominated by plains rough fescue (*Festuca hallii*). On well-drained hilltops and southerly aspects, stands are often co-dominated by plains rough fescue and northern porcupine grass (*Hesperostipa curtiseta*). Forbs and shrubs may be interspersed within stands, but the fescue tussocks can be so dense that few other species are present. The persistent, upright leaf litter of plains rough fescue adds to the density of stands. Shrub and tree-dominated communities only occur on moist sites and in topographic depressions. Shrubs and trees are primarily cold-deciduous broad-leaved species. Agricultural activities have altered the structure and species composition of most native grasslands, including the introduction of non-native species.

Stands of plains rough fescue prairie may occur in a variety of upland or valley settings but are increasingly restricted to warm southerly aspects at the northern edge of the zone, and to moist northerly aspects at the southern edge. Stands also occur on sandy soils, but these sites usually have higher proportional abundance of needle grasses (*Hesperostipa* spp.) and prairie junegrass (*Koeleria macrantha*).

Other common graminoid species include needle-and-thread grass (*Hesperostipa comata*), plains porcupine grass (*H. spartea*), thick-spike wildrye (*Elymus lanceolatus*), slender wildrye (*E. trachycaulus*), western wheatgrass (*Pascopyrum smithii*), Hooker's oatgrass (*Avenula hookeri*), mat muhly (*Muhlenbergia richardsonis*) and upland sedges such as blunt sedge (*Carex obtusata*), needle-leaved sedge (*C. duriuscula*) and long-stolon sedge (*C. inops* ssp. *heliophila*). Blue grama (*Bouteloua gracilis*) and prairie sandreed (*Sporobolus rigidus* var. *rigidus*) are common on dry sites (including sand dunes).

A variety of forbs and shrubs occur but may be restricted in abundance by dense grass thatch. Forb/dwarf shrub species include three-flowered avens (*Geum triflorum*), prairie pasqueflower (*Pulsatilla nuttalliana*), prairie sagebrush (*Artemisia frigida*), prairie sage (*A. ludoviciana*), Lewis' wild blue flax (*Linum lewisii*), common yarrow (*Achillea millefolium*) and northern bedstraw (*Galium boreale*). Grazing or fire can result in more open grass stands with a greater proportion of forb cover.

Shrub communities often establish on well-drained moist sites, including species such as prickly rose (*Rosa acicularis*), snowberries

(*Symphoricarpos albus, S. occidentalis*), saskatoon (*Amelanchier alnifolia*) and silverberry (*Elaeagnus commutata*).

Alluvial forests dominated by balsam poplar (*Populus balsamifera*) and/or trembling aspen (*P. tremuloides*) occur on stable floodplains. These stands often have shrub-rich understories.

Wetlands and small water bodies are fairly common on the landscape. They are mainly confined to poorly drained topographic depressions and often dry up during the summer; small alkali wetlands are common occurrences.

Deeper marshes dominated by broad-leaved cattail (*Typha latifolia*) and hard-stemmed bulrush (*Schoenoplectus acutus*) occur on the shallow margins of water bodies. Non-saline shallow marshes are dominated by a variety of graminoids, including sedges (e.g., wheat sedge [*Carex atherodes*], northern beaked sedge [*C. utriculata*]), grasses (e.g., common rivergrass [*Scolochloa festucacea*]) and common spikerush (*Eleocharis palustris*). Non-saline wet meadows are dominated by woolly sedge (*Carex pellita*), tufted hairgrass (*Deschampsia cespitosa*), fowl bluegrass (*Poa palustris*) or a wide variety of forbs. Saline wet meadows and shallow marshes dominated by saltgrass (*Distichlis spicata*), alkali cordgrass (*Spartina gracilis*), Nuttall's alkaligrass (*Puccinellia nuttalliana*) or northern reedgrass (*Calamagrostis stricta* ssp. *inexpansa*) occur on seasonally flooded sites where evaporation concentrates salts.

Shrub communities dominated by willows (e.g., Bebb's willow [*Salix bebbiana*]) or water birch (*Betula occidentalis*) often line small watercourses and shorelines of water bodies where water tables remain near the surface throughout the year.

Climate

The *Great Plains Fescue Grassland* zone occurs within the subhumid continental temperate climate of central Alberta and west-central Saskatchewan. It lies outside the primary area influenced by Chinook winter winds and, on average, is the coldest of the grassland vegetation zones in Canada.

Winters are cold and summers are warm; mean annual temperature is approximately 2.5˚ C. Growing degree days above 5˚ C average between about 1300 and 1600. Mean annual precipitation is between 350 and 500 mm, with the majority falling as rain in summer months; winter snowfall is generally low. Summer drought is a regular occurrence and a growing-season moisture deficit is the norm.

Physiography, Geology, Topography and Soils

This zone occupies portions of the Alberta and Saskatchewan Plains, subdivisions of the Interior Plains physiographic region. Elevations are generally <1000 mASL, although some western locations reach nearly 1100 mASL.

The zone is underlain by level Mesozoic and Tertiary sedimentary bedrock. The terrain is generally an undulating plain, but local relief is provided by low bedrock hills, postglacial valley complexes, hummocky moraines and sand dunes.

The entire zone was affected by late Pleistocene glaciation. The predominant surficial material is weakly calcareous glacial till. Glaciolacustrine and glaciofluvial sediments are prominent in lower and mid-valley positions. Dune complexes are also significant in some locations. Soils are primarily deep Chernozems, but Solonetzic soils with an impervious hardpan layer caused by excess sodium (Na+) occur in some locations.

Notes

To the north, the *Great Plains Fescue Grassland* zone borders the *Great Plains Parkland* and, to the south, the *Great Plains Mixedgrass Grassland*. On its western edge, it adjoins the *Rocky Mountains Foothills Fescue Grassland*.

Great Plains Mixedgrass Grassland

General Description

The *Great Plains Mixedgrass Grassland* zone covers an area of approximately 195,000 km² in southeastern Alberta and southern Saskatchewan. This zone represents the northern portion of North American mixedgrass prairie that extends south to Texas. The continental temperate climate is one of the driest in Canada. The majority of the contemporary landscape has been converted to crop cultivation and livestock grazing.

Vegetation

Natural mixedgrass prairie is characterized by a mixture of mid-height grasses (mid-grasses) and short grasses. In the *Great Plains Mixedgrass Grassland*, the mid-grass component generally dominates, but in climatically drier portions of the zone the short grass component becomes more prominent. Forbs and dwarf shrubs are scattered throughout the grassland. Shrub and tree-dominated communities only occur on moist sites and in topographic depressions. Shrubs and trees are primarily cold-deciduous broad-leaved species. Agricultural activities have altered the structure and species composition of most native grasslands, including the introduction of non-native species.

The dominant mid-grass species include needle-and-thread grass (*Hesperostipa comata*), northern porcupine grass (*H. curtiseta*), thick-spike wildrye (*Elymus lanceolatus*) and western wheatgrass (*Pascopyrum smithii*). Stands at the eastern end of the range may be dominated by plains porcupine grass (*H. spartea*). Other mid-grasses that can be important on some sites are green needlegrass (*Nassella viridula*), plains reedgrass (*Calamagrostis montanensis*), little bluestem (*Schizachyrium scoparium*) and, on sandy sites, prairie sandreed (*Sporobolus rigidus* var. *rigidus*) and sand dropseed (*Sporobolus cryptandrus*.

The most important short graminoids are prairie junegrass (*Koeleria macrantha*), blue grama (*Bouteloua gracilis*) and several upland sedges (e.g., blunt sedge [*Carex obtusata*], needle-leaved sedge [*C. duriuscula*], long-stolon sedge [*C. inops* ssp. *heliophila*], thread-leaved sedge [*C. filifolia*]). Other short grasses that can be abundant on some sites include Sandberg's bluegrass (*Poa secunda*), plains muhly (*Muhlenbergia cuspidata*) and saltgrass (*Distichlis spicata*).

Forb/dwarf shrub species include prairie pasqueflower (*Pulsatilla nuttalliana*), prairie sagebrush (*Artemisia frigida*), prairie sage (*A. ludoviciana*), common yarrow (*Achillea millefolium*), scarlet globe-mallow (*Sphaeralcea coccinea*), prairie golden bean (*Thermopsis rhombifolia*), milk-vetches (*Astragalus* spp.), locoweeds (*Oxytropis* spp.), Indian breadroots (*Pediomelum* spp.), American vetch (*Vicia americana*), hairy goldenaster (*Heterotheca villosa*), Missouri goldenrod (*Solidago missouriensis*), winterfat (*Krascheninnikovia lanata*), Hood's phlox (*Phlox hoodii*) and pussytoes (*Antennaria* spp.). Many stands have a ground layer of prairie spikemoss (*Selaginella densa*).

With the exception of prairie rose (*Rosa arkansana*), shrubs are generally infrequent. Western snowberry (*Symphoricarpos occidentalis*) and Woods' rose (*R. woodsii*) can be abundant on moist sites. On alluvial sites in the climatically drier parts of the zone, shrub-grassland develops with silver wormwood (*Artemisia cana*) and/or, on alkaline soils, black greasewood (*Sarcobatus vermiculatus*). Creeping juniper (*Juniperus horizontalis*) occurs with silver wormwood on steep valley slopes, as well as on sandy soils and dunes.

Alluvial forests dominated by plains cottonwood (*Populus deltoides* ssp. *monilifera*), narrow-leaved cottonwood (*P. angustifolia*), balsam poplar (*P. balsamifera*) and/or Manitoba maple (*Acer negundo*) occur on stable floodplains. These stands often have shrub-rich understories.

Wetlands and small water bodies are fairly common on the landscape. They are mainly confined to poorly drained topographic depressions and often dry up during the summer; small alkali wetlands are common occurrences.

Deeper marshes dominated by broad-leaved cattail (*Typha latifolia*), hard-stemmed bulrush (*Schoenoplectus acutus*) and American reed (*Phragmites australis* ssp. *americanus*) occur on the shallow margins of water bodies. Non-saline shallow marshes are dominated by a variety of graminoids, including sedges (e.g., water sedge [*Carex aquatilis*], wheat sedge [*C. atherodes*], northern beaked sedge [*C. utriculata*]), grasses (e.g., tall mannagrass [*Glyceria grandis*], common rivergrass [*Scolochloa festucacea*]) and common spikerush (*Eleocharis palustris*). Non-saline wet meadows are dominated by woolly sedge (*Carex pellita*), tufted hairgrass (*Deschampsia cespitosa*), fowl bluegrass (*Poa palustris*) or a wide variety of forbs. Saline wet meadows and shallow marshes dominated by saltgrass (*Distichlis spicata*), alkali cordgrass (*Spartina gracilis*), Nuttall's alkaligrass (*Puccinellia nuttalliana*) or northern reedgrass (*Calamagrostis stricta* ssp. *inexpansa*) occur on seasonally flooded sites where evaporation concentrates salts.

Shrub communities dominated by willows (e.g., Bebb's willow [*Salix bebbiana*], starved willow [*S. famelica*], meadow willow [*S. petiolaris*]) often line small watercourses and shorelines of waterbodies where water tables remain near the surface throughout the year.

Climate

The *Great Plains Mixedgrass Grassland* zone occurs within the dry continental temperate climate of southeastern Alberta and southern Saskatchewan. Winters are cold and summers are warm; mean annual temperature is approximately 3.6˚ C. Growing degree days above 5˚ C average between about 1550 and 1860. Mean annual precipitation is between 300 and 430 mm, with the majority falling as rain in summer months; winter snowfall is low. This is the driest climatic area in the Canadian Prairies; summer drought is common and a growing season moisture deficit is the norm.

There is pronounced precipitation variation within the zone, with the driest conditions occurring at low elevations in southeastern Alberta and southwestern Saskatchewan. The climate is somewhat more humid in the Cypress Hills and to the west, north and east of this core area. Both stand structure and species composition of mixedgrass prairie communities change in response to this climatic variation. Drought years with extremely low precipitation occur more frequently in the *Great Plains Mixedgrass Grassland* zone than in surrounding vegetation zones with more humid climates, and adaptation to drought is an important feature of the natural vegetation.

Physiography, Geology, Topography and Soils

This zone occupies portions of the Alberta and Saskatchewan Plains, subdivisions of the Interior Plains physiographic region. Elevations are generally <1000 mASL, although some mixedgrass prairie occurs above this elevation in western Alberta and in the Cypress Hills.

The zone is underlain by level Mesozoic and Tertiary sedimentary bedrock. The terrain is

mostly an undulating plain, but local relief is provided by low bedrock hills, badlands and the lower slopes of the Cypress Hills, as well as by postglacial valley complexes, hummocky moraines and sand dunes.

The entire zone was affected by late Pleistocene glaciation. The predominant surficial material is moderately calcareous glacial till. Fine-textured glaciolacustrine and sandy glaciofluvial sediments also cover large areas. Dune complexes are significant in some locations. Soils are primarily deep Chernozems, but Solonetzic soils with an impervious hardpan layer caused by excess sodium (Na+) are common in climatically drier areas.

Notes

In most of Saskatchewan, the *Great Plains Mixedgrass Grassland* zone borders the *Great Plains Parkland* to the north and east. In Alberta, and a small part of western Saskatchewan, its northern boundary is with the *Great Plains Fescue Grassland*. On its western edge, it adjoins the *Rocky Mountains Foothills Fescue Grassland*. To the south, it continues into the US. The *Cypress Hills* map unit is surrounded by this zone; mixedgrass occurs at the lower elevations of the Cypress Hills.

Central Tallgrass Grassland

General Description

The *Central Tallgrass Grassland* zone covers an area of approximately 8900 km² in the Red River basin of southern Manitoba. This zone represents the northern tip of the North American tallgrass prairie that extends south to Texas. The continental temperate climate is the wettest of the grassland vegetation zones in Canada. The majority of the contemporary landscape has been converted to crop cultivation.

Vegetation

Natural tallgrass prairie is characterized by dense stands of tall (up to 2 m) perennial grasses. Beneath the tall grasses, or in gaps within the stands, are shorter grasses (approximately 10-40 cm high). Interspersed among the graminoids is a perennial forb component with high species diversity; some stands are dominated by forbs. Woody vegetation is rare, but clumps of trees and tall shrubs can often be found along the boundary between tallgrass prairie and wetlands. Shrubs and trees are primarily cold-deciduous broad-leaved species. Agricultural activities have altered the structure and species composition of most native grasslands, including the introduction of non-native species.

Dominant tallgrass species include big bluestem (*Andropogon gerardi*), prairie dropseed (*Sporobolus heterolepis*), yellow Indiangrass (*Sorghastrum nutans*) and old switch panicgrass (*Panicum virgatum*). Other important grasses include plains porcupine grass (*Hesperostipa spartea*), mat muhly (*Muhlenbergia richardsonis*), little bluestem (*Schizachyrium scoparium*), prairie junegrass (*Koeleria macrantha*) and slender wildrye (*Elymus trachycaulus*). On moist sites, prairie cordgrass (*Sporobolus michauxianus*), bluejoint reedgrass (*Calamagrostis canadensis*), slim-stemmed reedgrass (*C. stricta*) and sedges (*Carex* spp.) often occur. On sand dunes, communities often include sand bluestem (*Andropogon hallii*) and prairie sandreed (*Sporobolus rigidus* var. *rigidus*).

Common forb species include downy false indigo (*Amorpha canescens*), prairie pasqueflower (*Pulsatilla nuttalliana*), purple prairie-clover (*Dalea purpurea*), narrow-leaved purple coneflower (*Echinacea angustifolia*), sunflowers (*Helianthus* spp.), eastern yellow stargrass (*Hypoxis hirsuta*), blazing stars (*Liatris* spp.), black-eyed Susan (*Rudbeckia hirta*), blue-eyed-grasses (*Sisyrinchium* spp.), goldenrods (*Solidago* spp.), asters (*Symphyotrichum* spp.) and golden alexanders (*Zizia aurea*).

Alluvial forests dominated by plains cottonwood (*Populus deltoides* ssp. *monilifera*), Manitoba maple (*Acer negundo*), red ash (*Fraxinus pennsylvanica*), balsam poplar (*P. balsamifera*), bur oak (*Quercus macrocarpa*) and/or white elm (*Ulmus americana*) occur on stable floodplains. These stands often have shrub-rich understories.

Wetlands occur mostly in the riparian margins of rivers and streams, although some develop in small topographic depressions with poor drainage.

Marshes dominated by broad-leaved cattail (*Typha latifolia*), bulrushes (e.g., slender bulrush [*Schoenoplectus heterochaetus*], hard-stemmed

bulrush [*S. acutus*]) or common spikerush (*Eleocharis palustris*) occur on the shallow margins of water bodies. Fens and wet meadows are dominated by a variety of graminoids, including sedges (e.g., lake sedge [*Carex lacustris*], tussock sedge [*C. stricta*], sterile sedge [*C. sterilis*]) and grasses (e.g., bluejoint reedgrass, slim-stemmed reedgrass, prairie cordgrass, spike muhly grass [*Muhlenbergia glomerata*]). Shrub communities dominated by sandbar willow (*Salix exigua*) often occupy the active flood zone of rivers and streams.

Climate

The *Central Tallgrass Grassland* zone occurs within the subhumid continental temperate climate of southern Manitoba. Winters are cold and summers are warm; mean annual temperature is approximately 2.8˚ C. Growing degree days above 5˚ C vary between 1780 and 1950. Annual precipitation is approximately 525 mm.

In this zone, the climate is relatively wet and warm compared to other Canadian grassland vegetation zones but, in spite of the greater amount of precipitation, evapotranspiration is high enough to produce a moisture balance that supports natural grassland vegetation rather than forest.

Physiography, Geology, Topography and Soils

This zone lies on the Manitoba Plain, a subdivision of the Interior Plains physiographic region. Elevations are <300 mASL.

The zone is underlain by level Mesozoic and Tertiary sedimentary bedrock. During and immediately following late Pleistocene glaciation, the entire area was inundated by glacial Lake Agassiz. The terrain is mainly a level plain of deep glaciolacustrine silts and clays. Local relief is provided by postglacial valley complexes and Lake Agassiz beach and delta features, together with associated sand dunes. Soils are predominantly Vertisols and Chernozems, with Gleysols occurring on moist, poorly drained sites.

Notes

The *Central Tallgrass Grassland* zone is surrounded on the north, west and east by the *Great Plains Parkland*. To the south, it continues into the US.

Other

Two **Level 2** descriptions in this section:

- **Cypress Hills**
- **Glaciers**

Cypress Hills

General Description

The Cypress Hills is a landscape feature that contains multiple vegetation zones that cannot be mapped at the scale of the *Vegetation Zones of Canada*. The *Cypress Hills* map unit covers approximately 6000 km² at elevations >1000 mASL, spanning the provincial border in southeastern Alberta and southwestern Saskatchewan. The prevailing dry temperate climate is modified by elevation effects that generate a gradient of vegetation characteristics similar to those found in four nearby vegetation zones: *Great Plains Mixedgrass Grassland*, *Great Plains Fescue Grassland*, *Rocky Mountains Foothills Fescue Grassland* and *Cordilleran Montane Forest*. The majority of the contemporary landscape has been converted to crop cultivation and grazing.

Vegetation

Natural vegetation for most of the Cypress Hills is mixedgrass and fescue grassland. At lower elevations, the main mixedgrass species are needle-and-thread grass (*Hesperostipa comata*), northern porcupine grass (*H. curtiseta*), thick-spike wildrye (*Elymus lanceolatus*), prairie junegrass (*Koeleria macrantha*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*) and a number of upland sedges (*Carex* spp.). At mid-elevations, because of a slightly moister climate, plains rough fescue (*Festuca hallii*) becomes prominent in the species composition. At the highest elevations, on the Cypress Hills plateau (approximately >1300 mASL), mountain rough fescue (*Festuca campestris*) dominates natural grassland communities, together with northern porcupine grass, Idaho fescue (*F. idahoensis*), timber oatgrass (*Danthonia intermedia*) and shrubby cinquefoil (*Dasiphora fruticosa*).

Above approximately 1150 mASL, conditions are cool and moist enough to support upland forest and woodland communities, mostly on northerly aspects and in sheltered ravines. Forests are dominated by lodgepole pine (*Pinus contorta* var. *latifolia*), trembling aspen (*Populus tremuloides*) and/or white spruce (*Picea glauca*), with understories that are floristically similar to those in the montane forests of the Rocky Mountains foothills, approximately 300 km to the west. Understories include snowberries (*Symphoricarpos albus, S. occidentalis*), prickly rose (*Rosa acicularis*), white meadowsweet (*Spiraea lucida*), pinegrass (*Calamagrostis rubescens*), rough-leaved mountain rice (*Oryzopsis asperifolia*) and a variety of forb species. Balsam poplar (*Populus balsamifera*) occurs in riparian areas, moist ravines and near waterbodies.

Wetlands are relatively rare and not extensive. They are mainly confined to lake margins, riparian valleys, and northerly aspects near springs and streams.

Marshes dominated by broad-leaved cattail (*Typha latifolia*) and hard-stemmed bulrush (*Schoenoplectus acutus*) occur on the shallow margins of water bodies on the plateau. Wet meadows and shallow marshes, mostly at lower elevations, are floristically similar to those

described for the *Great Plains Mixedgrass Grassland*.

Shrub communities dominated by willows (e.g., [*Salix bebbiana*]) and/or silverberry (*Elaeagnus commutata*) often line small watercourses, swales and shorelines of waterbodies where additional moisture is available throughout the year. Extensive hawthorn (*Crataegus* spp.) shrublands are unique to the lower and mid slopes of the Cypress Hills, usually along minor draws and seepages or on some mesic sites.

Climate

The Cypress Hills occur in the dry continental temperate climate of southeastern Alberta and southwestern Saskatchewan. Winters are cold and summers are warm. On average, because of orographic effects, temperatures are cooler and precipitation higher than on the surrounding plains. Pronounced microclimate variation occurs in relation to abrupt topographic changes.

At mid-elevations on the hills (1200 mASL), mean annual temperature is about 3˚ C and growing degree days above 5˚ C are a little less than 1300. Mean annual precipitation averages between 500 and 600 mm, with approximately 50% occurring as rain in summer months.

Physiography, Geology, Topography and Soils

The *Cypress Hills* map unit is an isolated group of hills that rises approximately 600 m above the mostly level terrain of the surrounding Alberta Plain, reaching a maximum elevation of 1466 mASL. This is the highest point of elevation in southern Canada between the Rocky Mountains and Labrador.

The *Cypress Hills* map unit is a complex of eroded bedrock hills with a flat plateau at the uppermost elevations. On the north and west sides of the plateau are steep escarpments, while on the southern and eastern sides the hills slope gently down to the plain. The Cypress Hills are underlain by Mesozoic and Tertiary marine and non-marine sedimentary rocks. A cap of Tertiary gravels and conglomerate is characteristic of the uppermost plateau surface. The hills resulted from differential erosion of the surrounding areas, creating a raised feature on the plains. Local relief is provided by river valleys, rolling hills, hummocky moraines and steep escarpments.

Most of the area was affected by late Pleistocene glaciation, but during this period the highest elevation on the Cypress Hills plateau was ice-free. The predominant surficial material is moderately calcareous glacial till, except on the plateau where ancient gravelly deposits prevail. These paleosols (“fossil” soils) are, in some places, covered by a veneer of post-glacial loess up to 1.5 m thick. Soils are primarily Chernozems, wherever grassland vegetation has historically predominated, and Brunisols and Luvisols, where forests have been the primary vegetation.

Notes

The *Cypress Hills* map unit is surrounded at lower elevations by the *Great Plains Mixedgrass Grassland*.

Glaciers

General Description

The *Glaciers* zone is an area containing over 12,000 km² of high elevation ice fields, alpine glaciers and summit outcrops in southwestern Yukon. This zone includes the highest mountains in Canada and represents the Canadian portion of the largest expanse of nonpolar ice fields in the world, extending west into Alaska. The northern maritime alpine climate is characterized by wind, heavy snowfall and cold temperatures. Rock, ice and snow constitute the dominant landcover; vegetation cover is minimal.

Vegetation

Vegetation covers <5% of the zone and consists of a sparse cover of lichens, bryophytes, herbs and dwarf shrubs growing on exposed bedrock and colluvium above the surface of permanent ice.

Vascular plant species include polar willow (*Salix polaris*), net-veined willow (*S. reticulata*), northern rough fescue (*Festuca altaica*), white mountain heather (*Cassiope mertensiana*), Alaska moss heather (*Harrimanella stelleriana*), icegrass (*Phippsia algida*), pygmy buttercup (*Ranunculus pygmaeus*), Alaska mountain avens (*Dryas alaskensis*), mouse-tail bog sedge (*Carex myosuroides*) and several species of saxifrage (*Saxifraga* spp.).

Lichens are an important component of the vegetation, including crustose lichens (e.g. firedot lichens [*Caloplaca* spp.] and map lichens [*Rhizocarpon* spp.]) on exposed rock surfaces. Common ground lichen species include crinkled snow lichen (*Flavocetraria nivalis*), curled snow lichen (*F. cucullata*), frosted finger lichen (*Dactylina ramulosa*), green witch's hair lichen (*Alectoria ochroleuca*) and whiteworm lichen (*Thamnolia vermicularis*).

Mosses include curly heron's-bill moss (*Dicranum fuscescens*), juniper haircap moss (*Polytrichum juniperinum*), red-stemmed feathermoss (*Pleurozium schreberi*), mountain groove moss (*Aulacomnium turgidum*), ribbed bog moss (*A. palustre*) and sidewalk screw moss (*Syntrichia ruralis*).

Climate

The *Glaciers* zone lies in the transition between the moist northern maritime climate of southern Alaska and the drier continental boreal climate of west-central Yukon. It is subject to very heavy orographic snowfall from wet Pacific air masses. Extensive ice fields develop on the windward southwestern side of the zone, but ice cover is restricted to valley glaciers on the leeward northeastern side.

Temperatures and precipitation vary according to elevation, as well as location relative to the St. Elias Mountains. Mean annual temperatures at 2500 mASL on the windward side of the mountains are estimated to be -10°C, and on the leeward side, -8°C. Mean annual precipitation on the windward side and at the highest elevations can be significantly greater than 1000 mm per year, mostly as snow. Precipitation drops off toward the northeastern boundary of the zone, amounting to approximately 400 mm annually.

Physiography, Geology, Topography and Soils

This zone contains the highest elevations of the St. Elias Mountains, including 26 of the 30 highest peaks in Canada, all exceeding 3700 mASL. The lower elevation of the zone lies at approximately 1000 mASL.

The St. Elias Mountains are geologically young, resulting from tectonic uplift at the edge of the North American Plate. Although there are some rocks of volcanic origin, the geology is mostly faulted and folded Mesozoic and Tertiary sedimentary rocks.

Active glaciation dominates surficial processes. The southwestern portion of the zone consists of a virtually continuous ice sheet. To the north, numerous valley glaciers emerge from the high elevation ice cap. Surface materials are dominated by ice and snow, with exposed bedrock and colluvial deposits on nunataks and cliff faces of mountain summits.

Notes

To the east and north, the *Glaciers* zone borders the *Western Boreal Alpine Tundra*. To the south and west, it continues into the US.

Although alpine glaciers exist in many high elevation locations within Canada, they cover relatively minor proportions of the vegetation zones within which they occur, and the dominant vegetation is arctic or alpine tundra.

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APPENDICES

Appendix I: Sources of Linework for Vegetation Zones

Level 1 Vegetation Zone	Level 2 Vegetation Zone	Line Source
Arctic Tundra		Linework was from the Circumpolar Arctic Vegetation Map (CAVM) (CAVM Team 2003). Continental treeline (and thus the southern boundary of the *Low Arctic Shrub Tundra* level 2 vegetation zone) is that of Brandt (2009) except for northern Yukon and the western Mackenzie delta where the treeline of the Yukon Bioclimate Classification is used (Ecological and Landscape Classification Technical Working Group 2017).
	High Arctic Sparse Tundra	*High Arctic Sparse Tundra* includes bioclimate subzone A of the Circumpolar Arctic Vegetation Map (CAVM) (CAVM Team 2003).
	Mid-Arctic Dwarf Shrub Tundra	*Mid-Arctic Dwarf Shrub Tundra* includes bioclimate subzones B, C, D of the Circumpolar Arctic Vegetation Map (CAVM) (CAVM Team 2003).
	Low Arctic Shrub Tundra	*Low Arctic Shrub Tundra* includes bioclimate subzone E of the Circumpolar Arctic Vegetation Map (CAVM) (CAVM Team 2003), except in Yukon where it includes the Arctic Low Shrub [ARLS] and Arctic Dwarf Shrub [ARDS] bioclimate zones of the Yukon Arctic Bioclimate Region (Ecological and Landscape Classification Technical Working Group 2017). See note above for the Level 1 vegetation zone re: source of linework for continental treeline (and thus the southern boundary of *Low Arctic Shrub Tundra*).
Alpine Tundra		Linework was integrated from multiple map sources or derived by elevation analyses and by expert opinion. In some cases, level 2 alpine vegetation zones include the subalpine transition, while in others the subalpine is included in the zone lying immediately below (elevationally) the alpine zone. Characterization of subalpine vegetation is provided in the description of the vegetation zone within which it is mapped.
	Subarctic Alpine Tundra	*Subarctic Alpine Tundra* includes both subalpine and alpine conditions. For Yukon, *Subarctic Alpine Tundra* includes the Alpine [ALP] and Subarctic Subalpine [SUS] bioclimate zones of the Yukon Subarctic Bioclimate Region, as well as the Alpine [ALP] bioclimate zone of the Arctic Bioclimate Region (Ecological and Landscape Classification Technical Working Group 2017). For Northwest Territories (NWT), spatial analyses were employed to delineate the alpine and subalpine elevational bands within the NWT Level II ecoregions Taiga Cordillera and Tundra Cordillera (Ecosystem Classification Group 2010). See Appendix II for details of the NWT elevation analyses.
	Western Boreal Alpine Tundra	*Western Boreal Alpine Tundra* includes both subalpine and alpine conditions. For Yukon, *Western Boreal Alpine Tundra* includes the Alpine [ALP] and Boreal Subalpine [BOS] bioclimate zones of the Yukon Boreal Bioclimate Region (Ecological and Landscape Classification Technical Working Group 2017).

Level 1 Vegetation Zone	Level 2 Vegetation Zone	Line Source
		For Northwest Territories (NWT), spatial analyses were employed to delineate the alpine and subalpine bands within the NWT Level II ecoregion Boreal Cordillera (Ecosystem Classification Group 2010). See Appendix II for details of the NWT elevation analyses. For British Columbia (BC), *Western Boreal Alpine Tundra* includes the Boreal Altai Fescue Alpine [BAFA] zone of the BC Biogeoclimatic Ecosystem Classification (BEC), plus "scrub" subzones (i.e., SWBuns, SWBvks, SWBmks) of the Spruce-Willow-Birch [SWB] BEC zone (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	Cordilleran Alpine Tundra	C*ordilleran Alpine Tundra* includes only alpine conditions (subalpine conditions are included in *Cordilleran Montane Forest*). For British Columbia (BC), *Cordilleran Alpine Tundra* includes the Interior Mountain-heather Alpine [IMA] zone of the BC Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018). For Alberta, *Cordilleran Alpine Tundra* includes the Alpine subregion of the Alberta Rocky Mountain Natural Region (Natural Regions Committee 2006).
	Pacific Alpine Tundra	*Pacific Alpine Tundra* includes only alpine conditions (subalpine conditions are included in *Pacific Montane Forest)*. *Pacific Alpine Tundra* includes the Coastal Mountain-heather Alpine [CMA] zone of the British Columbia Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	Eastern Alpine Tundra	*Eastern Alpine Tundra* includes both subalpine and alpine conditions. For Quebec, *Eastern Alpine Tundra* includes subalpine, alpine and some montane conditions; montane forests are not described (Major 2018). For Labrador, *Eastern Alpine Tundra* includes Alpine polygons from Brandt (2009). For insular Newfoundland, the lower elevational boundary for alpine and subalpine conditions assigned to *Eastern Alpine Tundra* was approximated at 400 mASL by W. Meades, based on his expert knowledge of the area.
Boreal Forest & Woodland		Linework was taken from multiple map sources, or derived by analyses of pre-classified plot data, by expert opinion, or by elevational analyses.
	Subarctic Woodland-Tundra	Continental treeline is that of Brandt (2009); this is the northern boundary of *Subarctic Woodland-Tundra*. In the Taiga Plains portion of the Northwest Territories (NWT), *Subarctic Woodland-Tundra* includes NWT Level IV ecoregions Campbell Hills HS, Sitidgi Plain HS, Grandin Plain HS, Grandin Upland HS and portions of Mackenzie Delta HS, Travaillant Upland HS, Anderson Plain HS and Great Bear Upland LA*n* (Ecosystem Classification Group 2007). The latter four ecoregions were subdivided by D. Downing, based on his expert knowledge of the area. In the Taiga Shield portion of the Northwest Territories (NWT), *Subarctic Woodland-Tundra* includes all of the Taiga Shield High Subarctic NWT Level III ecoregion (Ecosystem Classification Group 2008). Within Nunavut, *Subarctic Woodland-Tundra* includes portions of ecoregions Kazan River Upland and Selwyn Lake Upland of the Terrestrial Ecozones and Ecoregions of Canada (Ecological Stratification Working Group 1995).

Level 1 Vegetation Zone	Level 2 Vegetation Zone	Line Source
	Subarctic Woodland-Tundra	Within Manitoba, *Subarctic Woodland-Tundra* includes portions of ecoregions Kazan River Upland and Coastal Hudson Bay Lowland of the Terrestrial Ecozones and Ecoregions of Canada (Ecological Stratification Working Group 1995; Manitoba Protected Areas Initiative 2005). For Ontario, *Subarctic Woodland-Tundra* includes Ontario ecoregion 0E [Hudson Bay Coast] (Crins et al. 2009). For Quebec, *Subarctic Woodland-Tundra* includes the Quebec Forest Tundra bioclimatic domain (Saucier et al. 2009). For Labrador, *Subarctic Woodland-Tundra* includes portions of land regions E, G, H, I, J, K, M, N and P (Lands Directorate, Atlantic Region 1977), as interpreted by W. Meades based on his expert knowledge of the area.
	Northern Boreal Woodland	For Yukon, *Northern Boreal Woodland* includes the Subarctic Woodland [SUW] bioclimate zone of the Yukon Subarctic Bioclimate Region (Ecological and Landscape Classification Technical Working Group 2017). In the Cordillera portion of the Northwest Territories (NWT), *Northern Boreal Woodland* includes NWT Level IV ecoregions Arctic Red Upland LS*b*, Carcajou Plain LS*b*, Mackenzie Foothills HB*bs* and Central Mackenzie Plain LS*b* in their entirety. For all other Level IV ecoregions within the NWT Level II ecoregions Taiga Cordillera and Tundra Cordillera (Ecosystem Classification Group 2010), spatial analyses were employed to delineate the low elevation woodlands. See Appendix II for details of the NWT elevation analyses. In the Taiga Plains portion of the Northwest Territories (NWT), *Northern Boreal Woodland* includes the entirety of NWT Level III ecoregion Taiga Plains Low Subarctic, the entirety of Level IV ecoregions Arctic Red Plain HS, Colville Upland HS, Colville Plain HS, Colville Hills HS, Great Bear Plain HS and Great Bear Upland HS, and portions of Mackenzie Delta HS, Travaillant Upland HS and Anderson Plain HS (Ecosystem Classification Group 2007). The latter three ecoregions were subdivided by D. Downing, based on his expert knowledge of the area. In the Taiga Shield portion of the Northwest Territories (NWT), *Northern Boreal Woodland* includes the entirety of NWT Level III ecoregion Taiga Shield Low Subarctic (Ecosystem Classification Group 2008). Within Nunavut, *Northern Boreal Woodland* includes a portion of ecoregion Selwyn Lake Upland of the Terrestrial Ecozones and Ecoregions of Canada (Ecological Stratification Working Group 1995). For Alberta, *Northern Boreal Woodland* includes the Boreal Subarctic subregion of the Alberta Boreal Forest Natural Region (Natural Regions Committee 2006). Within Saskatchewan, *Northern Boreal Woodland* includes a portion of ecoregion Selwyn Lake Upland of the Terrestrial Ecozones and Ecoregions of Canada (Ecological Stratification Working Group 1995; Acton et al 1998). Within Manitoba, *Northern Boreal Woodland* includes portions of ecoregions Selwyn Lake Upland and Hudson Bay Lowland of the Terrestrial Ecozones and Ecoregions of Canada (Ecological Stratification Working Group 1995; Manitoba Protected Areas Initiative 2005). For Ontario, *Northern Boreal Woodland* includes Ontario ecoregion 1E [Northern Taiga] (Crins et al. 2009). For Quebec, *Northern Boreal Woodland* includes the Quebec Spruce-lichen bioclimatic domain (Saucier et al. 2009). For Labrador, *Northern Boreal Woodland* includes portions of land regions L, M, O, Q and R (Lands Directorate, Atlantic Region 1977), as interpreted by W. Meades based on his expert knowledge of the area.

Level 1 Vegetation Zone	Level 2 Vegetation Zone	Line Source
	Northwestern Boreal Forest	For all of Yukon, *Northwestern Boreal Forest* includes the Boreal High [BOH] bioclimate zone of the Yukon Boreal Bioclimate Region; in western Yukon, *Northwestern Boreal Forest* also includes the Boreal Low [BOL] bioclimate zone (Ecological and Landscape Classification Technical Working Group 2017). For Northwest Territories (NWT), areas with elevations between 800 and 1200 mASL within the NWT Level II ecoregion Boreal Cordillera (Ecosystem Classification Group 2010) were assigned to *Northwestern Boreal Forest*. See Appendix II for details of the NWT elevation analyses. For British Columbia (BC), *Northwestern Boreal Forest* includes the Spruce-Willow-Birch [SWB] zone of the BC Biogeoclimatic Ecosystem Classification (BEC), except the "scrub" subzones (i.e., SWBuns, SWBvks, SWBmks) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	West-Central Boreal Forest	For Yukon, east of approximately Swift River *West-Central Boreal Forest* includes the Boreal Low [BOL] bioclimate zone of the Yukon Boreal Bioclimate Region (Ecological and Landscape Classification Technical Working Group 2017). For Northwest Territories (NWT), areas with elevations <800 mASL within the NWT Level II ecoregion Boreal Cordillera (Ecosystem Classification Group 2010) were assigned to *West-Central Boreal Forest*. See Appendix II for details of the NWT elevation analyses. Elsewhere in the Northwest Territories, *West-Central Boreal Forest* includes the NWT Level III ecoregions Taiga Plains High Boreal, Taiga Plains Mid-Boreal, Taiga Shield High Boreal and Taiga Shield Mid-Boreal in their entirety (Ecosystem Classification Group 2007; 2008). For British Columbia (BC), *West-Central Boreal Forest* includes the Boreal White and Black Spruce [BWBS] zone of the BC Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018). For Alberta, *West-Central Boreal Forest* includes the Alberta Foothills and Canadian Shield Natural Regions in their entirety, all of the Boreal Forest Natural Region except the Boreal Subarctic subregion, and the Peace River Parkland subregion of the Parkland Natural Region (Natural Regions Committee 2006). Within Saskatchewan, *West-Central Boreal Forest* includes a portion of the Tazin Lake Upland ecoregion as well as all of the Boreal Plains and Boreal Shield ecozones of the Terrestrial Ecozones and Ecoregions of Canada (Ecological Stratification Working Group 1995; Li & Hélie 2014), with the exception that the southern boundary of the zone uses the linework of Brandt (2009). Within Manitoba, *West-Central Boreal Forest* includes most of the Boreal Shield ecozone and all of the Boreal Plains ecozone of the Terrestrial Ecozones and Ecoregions of Canada (Ecological Stratification Working Group 1995; Li & Hélie 2014; Manitoba Protected Areas Initiative 2005), with the exception that the southern boundary of the zone uses the linework of Brandt (2009). Ecoregion Lake of the Woods and the portion of ecoregion Lac Seul Upland lying south of the Berens River are excluded. For Ontario, *West-Central Boreal Forest* includes Ontario ecoregions 2W [Big Trout Lake], except for some smoothing at the southeastern tip, and 3S [Lake St. Joseph] (Crins et al. 2009).

Level 1 Vegetation Zone	Level 2 Vegetation Zone	Line Source
	Eastern Boreal Forest	Within Manitoba, *Eastern Boreal Forest* includes the portion of Terrestrial Ecozones and Ecoregions of Canada ecoregion Lac Seul Upland that lies south of the Berens River, and the portion of ecoregion Lake of the Woods that lies north of Highway 1 (Ecological Stratification Working Group 1995; Manitoba Protected Areas Initiative 2005). The western boundary of *Eastern Boreal Forest* south of Lake Winnipeg was determined by map analysis for *Great Plains Parkland* (see Appendix III for details of this analysis). For Ontario, *Eastern Boreal Forest* includes the entirety of Ontario ecoregions 2E [James Bay], 3E [Lake Abitibi] and 3W [Lake Nipigon] (plus the southeastern tip of 2W [Big Trout Lake], as well as ecodistricts 4S-1 [Sydney Lake], 4S-2 [Lac Seul], 4S-3 [English River] and 4S-4 [Dryden] (Crins et al. 2009; Wester et al. 2018). For Quebec, *Eastern Boreal Forest* includes the Quebec Spruce-moss and Balsam fir - White birch bioclimatic domains (Saucier et al. 2009). For Nova Scotia, *Eastern Boreal Forest* includes the Nova Scotia Northern Plateau ecoregion (Neily et al 2017). For insular Newfoundland, *Eastern Boreal Forest* includes ecoregions Northern Peninsula, Southwestern Newfoundland, Central Newfoundland, Northeastern Newfoundland and Avalon Forest of the Terrestrial Ecozones and Ecoregions of Canada (Damman 1983; Ecological Stratification Working Group 1995), as well as those portions of the Long Range Mountains ecoregion <400 mASL. For Labrador, *Eastern Boreal Forest* includes portions of land regions O, Q, R, S, T, V, X and Y (Lands Directorate, Atlantic Region 1977), as interpreted by W. Meades based on his expert knowledge of the area.
	Atlantic Maritime Heathland	For insular Newfoundland, *Atlantic Maritime Heathland* includes ecoregions South Avalon - Burin Oceanic Barrens, Maritime Barrens and Strait of Belle Isle of the Terrestrial Ecozones and Ecoregions of Canada (Damman 1983; Ecological Stratification Working Group 1995). For Labrador, *Atlantic Maritime Heathland* includes Terrestrial Ecozones and Ecoregions of Canada ecoregion Coastal Barrens, south of approximately Makkovik (Ecological Stratification Working Group 1995). The zone also includes portions of land regions Z and AA (Lands Directorate, Atlantic Region 1977) on the southern coast of Labrador (and extended a short distance into Quebec), as interpreted by W. Meades based on his expert knowledge of the area.
Pacific Cool Temperate Forest		Linework was taken from the British Columbia (BC) Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	Pacific Maritime Rainforest	*Pacific Maritime Rainforest* includes the Coastal Western Hemlock [CWH] zone of the BC Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	Pacific Dry Forest	*Pacific Dry Forest* includes the Coastal Douglas-fir [CDF] zone of the BC Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	Pacific Montane Forest	*Pacific Montane Forest* includes the Mountain Hemlock [MH] zone of the BC Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).

Level 1 Vegetation Zone	Level 2 Vegetation Zone	Line Source
Cordilleran Cool Temperate Forest		Linework was taken from the British Columbia (BC) Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018) and from the Alberta Natural Regions and Subregions (Natural Regions Committee 2006).
	Cordilleran Subboreal Forest	*Cordilleran Subboreal Forest* includes the Sub-Boreal Spruce [SBS] and Sub-Boreal Pine - Spruce [SBPS] zones of the BC Biogeoclimatic Ecosystem Classification (BEC), plus BEC subzones MSdv and MSxv from the Montane Spruce [MS] zone (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	Cordilleran Montane Forest	For British Columbia (BC), *Cordilleran Montane Forest* includes zones Engelmann Spruce – Subalpine Fir [ESSF] and Montane Spruce [MS] (except subzones MSdv & MSxv) of the BC Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018). For Alberta, *Cordilleran Montane Forest* includes the Subalpine and Montane subregions of the Alberta Rocky Mountain Natural Region (Natural Regions Committee 2006).
	Cordilleran Rainforest	*Cordilleran Rainforest* includes the Interior Cedar - Hemlock [ICH] zone of the BC Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	Cordilleran Dry Forest	*Cordilleran Dry Forest* includes the Interior Douglas-fir [IDF] and Ponderosa Pine [PP] zones of the BC Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
Eastern Cool Temperate Forest		Linework was taken from multiple map sources, or derived by analyses of pre-classified plot data and by expert opinion.
	Eastern Temperate Mixed Forest	For Manitoba, *Eastern Temperate Mixed Forest* includes the portion of Terrestrial Ecozones and Ecoregions of Canada ecoregion Lake of the Woods that lies south of Highway 1 (Ecological Stratification Working Group 1995; Manitoba Protected Areas Initiative 2005). The western boundary of *Eastern Temperate Mixed Forest* was determined by map analysis for *Great Plains Parkland* (see Appendix III for details of this analysis). For Ontario, *Eastern Temperate Mixed Forest* includes the entirety of Ontario ecoregions 4E [Lake Temagami], 4W [Pigeon River], 5E [Georgian Bay] and 5S [Agassiz Clay Plain], as well as ecodistricts 4S-5 [Manitou] and 4S-6 [Sioux Narrows] (Crins et al. 2009; Wester et al. 2018). For Quebec, *Eastern Temperate Mixed Forest* includes the Quebec bioclimatic domains Balsam fir - Yellow birch, Sugar maple - Yellow birch and Sugar maple - Basswood (Saucier et al. 2009).
	Eastern Temperate Deciduous Forest	For Ontario, *Eastern Temperate Deciduous Forest* includes Ontario ecoregions 6E [Lake Simcoe-Rideau] and 7E [Lake Erie-Lake Ontario] (Crins et al 2009). For Quebec, *Eastern Temperate Deciduous Forest* includes the Quebec bioclimatic domain Sugar maple – Bitternut hickory (Saucier et al. 2009).
	Acadian Temperate Forest	For Quebec, *Acadian Temperate Forest* includes Quebec ecological subregions 4fM and 4fS (Saucier et al. 1998). For New Brunswick and Prince Edward Island, *Acadian Temperate Forest* includes the entirety of each province. For Nova Scotia, *Acadian Temperate Forest* includes the entirety of the province except for Nova Scotia ecoregion Northern Plateau (Neily et al 2017).

Level 1 Vegetation Zone	Level 2 Vegetation Zone	Line Source
Grassland, Parkland & Steppe		Linework was taken from multiple map sources, or derived by analyses of plot data, aerial photography and existing map treatments.
	Rocky Mountains Foothills Parkland	*Rocky Mountains Foothills Parkland* includes the Foothills Parkland subregion of the Alberta Parkland Natural Region (Natural Regions Committee 2006).
	Great Plains Parkland	For Alberta, *Great Plains Parkland* includes the Central Parkland subregion of the Alberta Parkland Natural Region (Natural Regions Committee 2006). For Saskatchewan, the northern boundary of *Great Plains Parkland* uses the linework of Brandt 2009; the southern boundary was established by analysis of aerial photography by Jeff Thorpe. See Appendix III for details of the analysis. For western Manitoba, the northern boundary of *Great Plains Parkland* uses the linework of Brandt 2009; elsewhere, the extents of the zone were defined by analysis of existing map treatments by Jeff Thorpe. See Appendix III for details of this analysis.
	Intermontane Shrub-Steppe	*Intermontane Shrub-Steppe* includes the Bunchgrass [BG] zone of the British Columbia Biogeoclimatic Ecosystem Classification (BEC) (Biogeoclimatic Ecosystem Classification Program of British Columbia 2018).
	Rocky Mountains Foothills Fescue Grassland	*Rocky Mountains Foothills Fescue Grassland* includes the Foothills Fescue subregion of the Alberta Grassland Natural Region (Natural Regions Committee 2006).
	Great Plains Fescue Grassland	For Alberta, *Great Plains Fescue Grassland* includes the Northern Fescue subregion of the Alberta Grassland Natural Region (Natural Regions Committee 2006). For Saskatchewan, the extent of *Great Plains Fescue Grassland* was derived by analysis of plot data and aerial photography by Jeff Thorpe. See Appendix III for details of these analyses.
	Great Plains Mixedgrass Grassland	For Alberta, *Great Plains Mixedgrass Grassland* includes the Mixedgrass and Dry Mixedgrass subregions of the Alberta Grassland Natural Region (Natural Regions Committee 2006). For Saskatchewan, the extent of *Great Plains Mixedgrass Grassland* was derived by analysis of plot data and aerial photography by Jeff Thorpe. See Appendix III for details of these analyses.
	Central Tallgrass Grassland	The extent of *Central Tallgrass Grassland* was derived by analysis of existing map treatments by Jeff Thorpe. See Appendix III for details of this analysis.

Level 1 Vegetation Zone	Level 2 Vegetation Zone	Line Source
Other	**Cypress Hills**	The boundary of *Cypress Hills* is the 1000 mASL elevation contour, derived from a national 30 arcsecond digital elevation model (Lawrence et al. 2008).
	Glaciers	*Glaciers* includes the Pacific Maritime Glacierized [PMG] bioclimate zone of the Yukon Pacific Maritime Bioclimate Region (Ecological and Landscape Classification Technical Working Group 2017).

Appendix II: Delineating Vegetation Zones in the Northwest Territories Cordillera

Using the 100 m contour representation of the 30 arcsecond digital elevation model, elevation analyses were conducted on all Level IV ecoregions in the Boreal Cordillera, Taiga Cordillera and Tundra Cordillera Level II ecoregions (Ecosystem Classification Group 2010) of the Northwest Territories (NWT) to delineate the NWT components of the *Alpine Tundra* and *Boreal Forest & Woodland* level 1 vegetation zones in these areas. Guidance was provided by the published descriptions for each NWT Cordilleran ecoregion, by Appendix VI in Ecosystem Classification Group (2010), and by D. Downing, one of the authors of the NWT Ecosystem Classification.

Elevation treatments described below were applied individually to the NWT Level IV ecoregions (Ecosystem Classification Group 2010), unless noted otherwise.

Boreal Cordillera:

1. Forest treatment:
   a) Mid-Boreal (Level III ecoregion):
      - *West-Central Boreal Forest* (level 2 vegetation zone): ≤800 mASL;
      - *Northwestern Boreal Forest* (level 2 vegetation zone): between 800 mASL and 1200 mASL.

   b) High Boreal (Level III ecoregion):
      - *West-Central Boreal Forest* (level 2 vegetation zone): ≤800mASL;
      - *Northwestern Boreal Forest* (level 2 vegetation zone): between 800 mASL and 1000 mASL, except for Liard Plateau, Hyland Plateau & Tlogotsho Range Level IV ecoregions, where it lies between 800 mASL and 1200 mASL.
2. Subalpine and alpine treatments (Note: for the *Western Boreal Alpine Tundra* level 2 vegetation zone, the respective subalpine and alpine elevation bands defined below were combined):
   - Mid-Boreal (Level III ecoregion) Subalpine: >1200 mASL (except Natla Plateau Level IV ecoregion);
   - High Boreal (Level III ecoregion) Subalpine: >1000 mASL, except for Liard Plateau, Hyland Plateau & Tlogotsho Range Level IV ecoregions, where High Boreal Subalpine >1200 mASL;
   - Hyland Plateau: No alpine present;
   - Natla Plateau (Level IV ecoregion): Boreal Alpine ≥1200 mASL;
   - The remaining Boreal Cordillera Level IV ecoregions were assigned a Boreal Alpine rule of ≥1500 mASL;
   - Thus, in the Mid-Boreal Level III ecoregion, the *Western Boreal Alpine Tundra* level 2 vegetation zone occurs at elevations >1200 mASL (i.e., Mid-Boreal Subalpine + Boreal Alpine);
   - Thus, in the High Boreal Level III ecoregion, the *Western Boreal Alpine Tundra* level 2 vegetation zone occurs at elevations >1000 mASL (i.e., High Boreal Subalpine + Boreal Alpine), except for Liard Plateau, Hyland Plateau & Tlogotsho Range Level IV ecoregions, where *Western Boreal Alpine Tundra* occurs at elevations >1200 mASL.

3. Sapper Ranges (Level IV ecoregion):

As described in the NWT ecoregion publication for the Cordillera (Ecosystem Classification Group 2010), the Sapper Ranges Level IV ecoregion is sub-divided into northern & southern sub-sections. The northern sub-section is assigned to the Low Subarctic climatic regime, while the southern is considered Mid-Boreal. Accordingly, using the Upper Nahanni/Natla (Keele) River watershed boundary as the divide between north and south Sapper Ranges, we used different elevation zonation treatments for each sub-section (Note: for the *Western Boreal Alpine Tundra* and *Subarctic Alpine Tundra* level 2 vegetation zones, the respective subalpine and alpine elevation bands defined below were combined):

a) In the northern portion, subarctic rules were applied:
    - *Northern Boreal Woodland* (level 2 vegetation zone): ≤1000 mASL;
    - Low Subarctic Subalpine: between 1000 mASL and 1400 mASL;
    - Subarctic Alpine: ≥1400 mASL;
    - Thus, in the northern portion of the Sapper Ranges Level IV ecoregion the *Subarctic Alpine Tundra* level 2 vegetation zone occurs at elevations >1000 mASL (i.e., Low Subarctic Subalpine + Subarctic Alpine).

b) In the southern portion, mid-boreal rules were applied:
    - *West-Central Boreal Forest* (level 2 vegetation zone): ≤800 mASL;
    - *Northwestern Boreal Forest* (level 2 vegetation zone): between 800 mASL and 1200 mASL;
    - Mid-Boreal Subalpine: between 1200 mASL and 1500 mASL;
    - Boreal Alpine: ≥1500 mASL;
    - Thus, in the southern portion of the Sapper Ranges Level IV ecoregion the *Western Boreal Alpine Tundra* level 2 vegetation zone occurs >1200 mASL (i.e., Mid-Boreal Subalpine + Boreal Alpine).

4. Taiga Plains and Taiga Shield (Level III ecoregions):

All elevational polygons (i.e., subalpine) were removed except the Cameron Plateau Low Subarctic Level IV ecoregion, which is classed as *Northern Boreal Woodland* level 2 vegetation zone.

Taiga Cordillera:

For the *Subarctic Alpine Tundra* level 2 vegetation zone, the subarctic subalpine and subarctic alpine elevation bands defined below were combined:

1. Low Subarctic (Level III ecoregion):
    - *Northern Boreal Woodland* (level 2 vegetation zone): ≤1000 mASL;
    - Low Subarctic Subalpine: between 1000 mASL and 1400 mASL;
    - Subarctic Alpine: ≥1400 mASL;
    - Thus, in the Low Subarctic Level III ecoregion, the *Subarctic Alpine Tundra* level 2 vegetation zone occurs at elevations >1000 mASL (i.e., Low Subarctic Subalpine + Subarctic Alpine).

2. High Subarctic (Level III ecoregion):
    - *Northern Boreal Woodland* (level 2 vegetation zone): ≤800 mASL;
    - High Subarctic Subalpine: between 800 mASL and 1200 mASL;
    - Subarctic Alpine: ≥1200 mASL;
    - Thus, in the High Subarctic Level III ecoregion, the *Subarctic Alpine Tundra* level 2 vegetation zone occurs at elevations >800 mASL (i.e., High Subarctic Subalpine + Subarctic Alpine).
3. Franklin Mountains (Level IV ecoregion):
    - *Northern Boreal Woodland* (level 2 vegetation zone): ≤600 mASL;
    - Low Subarctic Subalpine: between 600 mASL and 1000 mASL;
    - Subarctic Alpine: ≥1000 mASL;
    - Thus, in the Franklin Mountains Level IV ecoregion, the *Subarctic Alpine Tundra* level 2 vegetation zone occurs at elevations >600 mASL (i.e., Low Subarctic Subalpine + Subarctic Alpine).
4. Southern Backbone Ranges (Level IV ecoregion):

All Low Subarctic Subalpine that is situated within the Upper Nahanni River watershed boundary (i.e., feeding into the Sapper Ranges & Ragged Range Valley Level IV ecoregions) was re-themed to Boreal Subalpine (and thus to the *Western Boreal Alpine Tundra* level 2 vegetation zone).

Tundra Cordillera:
For the *Subarctic Alpine Tundra* level 2 vegetation zone, the subarctic subalpine and subarctic alpine elevation bands defined below were combined:

1. Richardson Mountains (Level IV ecoregion):
    - *Northern Boreal Woodland* (level 2 vegetation zone): ≤600 mASL;
    - High Subarctic Subalpine: between 600 mASL and 700 mASL;
    - Subarctic Alpine: ≥700 mASL;
    - Thus, in the Richardson Mountains Level IV ecoregion, the *Subarctic Alpine Tundra* level 2 vegetation zone occurs at elevations >600 mASL (i.e., High Subarctic Subalpine + Subarctic Alpine).
2. Richardson Plateau (Level IV ecoregion):

As described in the NWT ecoregion publication for the Cordillera (Ecosystem Classification Group 2010), the Richardson Plateau Level IV ecoregion is sub-divided into northern & southern sub-sections. The northern sub-section was assigned to the *Low Arctic Shrub Tundra* level 2 vegetation zone, while the southern sub-section was assigned to the *Northern Boreal Woodland* level 2 vegetation zone.

Appendix III: Delineating Vegetation Zones in Southern Saskatchewan and Manitoba

Great Plains Parkland

Natural upland vegetation of the *Great Plains Parkland* level 2 vegetation zone is characterized by a mosaic of woodlands and grasslands. The northern edge of the zone occurs where grassland covers only a small part of the landscape, corresponding to the southern boundary of the *West-Central Boreal Forest* level 2 vegetation zone.

The southern edge of the *Great Plains Parkland* zone occurs where the cover of woodlands shrinks to a small part of the landscape. In Alberta, this is considered to be the southern edge of the Central Parkland subregion of the Parkland Natural Region (Natural Regions Committee 2006). In Saskatchewan, a new southern boundary was drawn for the *Great Plains Parkland* zone by photo-interpretation of grassland/woodland patterns in natural areas. The new Saskatchewan boundary is similar to that previously developed for the Atlas of Saskatchewan (Thorpe 1999). The concept of parkland used here is similar to that described in the Alberta mapping work (Natural Regions Committee 2006) and, in fact, the new line matches nicely with the southern edge of the Alberta Central Parkland subregion.

In Saskatchewan, the area south of the *Great Plains Parkland* zone has traditionally been mapped as mixedgrass prairie, except for the Cypress Hills. In Manitoba, most of the area south of the *West-Central Boreal Forest* zone is included in the *Great Plains Parkland* zone, because natural upland areas show the characteristic mosaic of grassland and woodland, except the area mapped as the *Central Tallgrass Grassland* level 2 vegetation zone (see below).

Great Plains Fescue Grassland

In Alberta, the Northern Fescue subregion of the Grassland Natural Region has been mapped as an area of fescue-dominated grassland occurring south of the Central Parkland subregion (i.e., in areas with little tree cover) (Natural Regions Committee 2006). This concept has not previously been used in Saskatchewan. Analysis of Saskatchewan grassland plot data shows that most plots dominated by plains rough fescue (*Festuca hallii*) occur in the *Great Plains Parkland* level 2 vegetation zone (as well as in the Cypress Hills) (Figure III-1). However, there is a small area close to the Alberta border in which fescue dominated grassland occurs south of the *Great Plains Parkland* zone as an eastern extension of the Alberta Northern Fescue subregion. Fescue dominated plots in this area appear to be associated with somewhat higher elevations, so elevation contours were used to extend the boundary of the *Great Plains Fescue Grassland* level 2 vegetation zone into western Saskatchewan. It is possible that this zone extends further east into central Saskatchewan, but there is so little natural grassland in that area that there are no data to confirm its species composition. A few plots with abundant plains rough fescue occur to the south, but these are on steep north-facing (i.e., azonal) slopes in the hummocky Missouri Coteau, an area that is best placed in the *Great Plains Mixedgrass Grassland* level 2 vegetation zone.

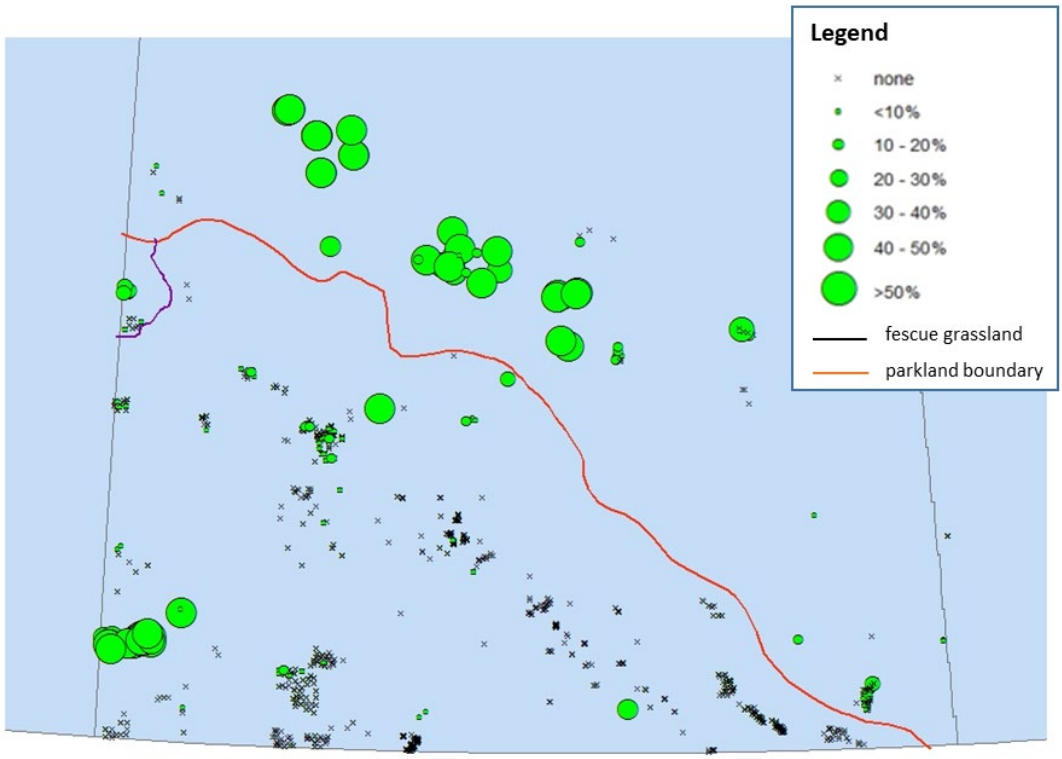

Figure III-1. Relative abundance of plains rough fescue (*Festuca hallii*) in grassland plots on loamy upland sites in southern Saskatchewan. Also shown are the new boundaries for the southern edge of the *Great Plains Parkland* level 2 vegetation zone and for the extension of the *Great Plains Fescue Grassland* level 2 vegetation zone into Saskatchewan.

Central Tallgrass Grassland

The extent of tallgrass prairie in Manitoba has been mapped in a variety of ways. The National Ecological Framework for Canada does not separate the area of tallgrass grassland from the larger Lake Manitoba Plain ecoregion (Ecological Stratification Working Group [ESWG] 1995). However, the map of Natural Regions in Manitoba [NRM] (Manitoba Protected Areas Initiative 2005) does make this distinction and was used for the *Vegetation Zones of Canada* exercise.

Historically, the core area of tallgrass grassland in Canada was considered to include about 6,000 km^2 south of the Assiniboine River and from the Red River valley west to the Manitoba Escarpment (Johnson 1987). In this area, tree cover is restricted to narrow strips along streams. Uplands supported tallgrass grassland (Baldwin & Thorpe 2016), but there were also extensive poorly drained sites supporting wet meadow vegetation. Almost all of this area has been drained and cultivated and only tiny remnants of grassland remain on the contemporary landscape. The largest remaining patches of tallgrass prairie are not in this core area, but rather in the *Great Plains Parkland* level 2 vegetation zone to the north and east, where grassland is interspersed with groves of trembling aspen (*Populus tremuloides*) and bur oak (*Quercus macrocarpa*) (Johnson 1987).

The NRM map was used to draw the boundaries of the *Central Tallgrass Grassland* level 2 vegetation zone (Figure III-2), because it corresponds closely to the core area described above. However, the easternmost part of this polygon, extending into the Interlake Plain ecoregion (ESWG 1995), was removed and included in the *Great Plains Parkland* zone because there is significant tree cover in this area.

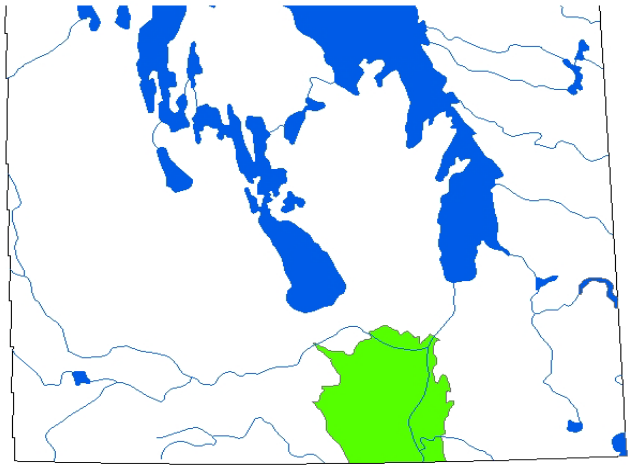

Figure III-2. Boundary of the *Central Tallgrass Grassland* level 2 vegetation zone in southern Manitoba.

Appendix IV: Climate Tables for South – North Transects

South - north transects of selected climatic variables with southern starting points in Vegetation Zones: a) *Acadian Temperate Forest*, b) *Eastern Temperate Deciduous Forest*, c) *Central Tallgrass Grassland*, d) *Great Plains Mixedgrass Grassland*, and e) *Cordilleran Dry Forest*. Climate data are normals for the period 1961-1990 (Environment Canada 2019), unless marked with an * (these are normals for 1971-2000). Weather station locations are shown in Figure 3. Variables are:

- **Lat.** – north latitude (degrees)
- **Long.** – west longitude (degrees)
- **Elev.** – elevation (metres above sea level)
- **MAT** – mean annual temperature (°C)
- **MTWM** – mean temperature for the warmest month of the year (°C)
- **MTCM** – mean temperature for the coldest month of the year (°C)
- **# >0°C** – annual number of days with maximum temperature >0°C
- **GDD5** – annual number of growing degree days >5°C
- **MAP** – mean annual total precipitation (mm)

IV-a)

Location	Veg Zone	Lat.	Long.	Elev.	MAT	MTWM	MTCM	# >0°C	GDD5	MAP
Alert	High Arctic	82.5	62.3	31	-18.0	3.4	-33.6	77	30	154
Clyde River	Mid-Arctic	70.5	68.5	27	-12.4	4.2	-28.0	119	45	226
Iqaluit	Mid-Arctic	63.8	68.5	34	-9.5	7.7	-26.8	150	179	424
Kuujjuaq	Subarctic	58.0	68.4	34	-5.8	11.0	-23.5	184	492	524
Schefferville	N. Bor. Wdl.	54.8	66.8	522	-5.0	12.4	-23.4	190	604	794
Sept-Isles	E. Boreal	50.2	66.3	55	0.9	15.2	-14.6	248	1005	1128
Fredericton	Acadian	45.9	66.6	40	5.3	19.1	-9.6	288	1768	1095

IV-b)

Location	Veg Zone	Lat.	Long.	Elev.	MAT	MTWM	MTCM	# >0°C	GDD5	MAP
Alert	High Arctic	82.5	62.3	31	-18.0	3.4	-33.6	77	30	154
Eureka	Mid-Arctic	80.0	85.9	10	-19.9	5.4	-38.4	94	61	68
Hall Beach	Mid-Arctic	68.8	81.3	8	-14.4	5.8	-32.7	113	77	215
Inukjuak	Low Arctic	58.5	78.1	3	-6.8	9.1	-25.5	175	333	418
Moosonee	E. Boreal	51.3	80.7	10	-1.3	15.1	-20.5	229	1078	700
Timmins	E. Boreal	48.5	81.4	295	1.2	17.3	-17.2	246	1395	873
Sudbury	Mixed Forest	46.6	80.8	347	3.5	19.1	-13.5	258	1680	872
London	Decid. Forest	43.0	81.1	278	7.2	20.3	-6.7	300	2121	955

IV-c)

Location	Veg Zone	Lat.	Long.	Elev.	MAT	MTWM	MTCM	# >0°C	GDD5	MAP
Eureka	Mid-Arctic	80.0	85.9	10	-19.9	5.4	-38.4	94	61	68
Resolute	Mid-Arctic	74.7	95.0	68	-16.6	4.0	-33.0	87	29	140
Cambridge Bay	Mid-Arctic	69.1	105.1	31	-14.9	8.0	-33.5	115	177	141
Baker Lake	Low Arctic	64.3	96.1	19	-12.2	11.1	-32.6	136	389	262
Churchill	Subarctic	58.7	94.1	28	-7.1	11.8	-26.9	169	562	412
The Pas	WC. Boreal	54.0	101.1	271	-0.3	17.7	-21.4	228	1395	452
Winnipeg	Tallgrass	49.9	97.2	239	2.4	19.8	-18.3	246	1802	504

IV-d)

Location	Veg Zone	Lat.	Long.	Elev.	MAT	MTWM	MTCM	# >0°C	GDD5	MAP
Sachs Harbour	Mid-Arctic	72.0	125.3	87	-13.7	6.2	-30.0	108	122	127
Tuktoyaktuk	Low Arctic	69.5	133.0	18	-10.5	10.9	-27.6	138	410	142
Norman Wells	N. Bor. Wdl.	65.3	126.8	67	-6.0	16.7	-27.4	181	1069	317
Fort Nelson	WC. Boreal	58.8	122.6	382	-1.1	16.7	-22.0	228	1289	449
Peace River	WC. Boreal	56.3	117.4	571	0.7	15.9	-17.5	254	1276	388
Edmonton	GP. Parkland	53.3	113.6	715	2.1	16.0	-14.2	269	1352	466
Coronation	GP. Fescue	52.1	111.5	791	2.3	17.1	-14.8	263	1467	387
Lethbridge	Mixedgrass	49.6	112.8	929	5.6	18.4	-8.4	309	1799	398

IV-e)

Location	Veg Zone	Lat.	Long.	Elev.	MAT	MTWM	MTCM	# >0°C	GDD5	MAP
Old Crow*	N. Bor. Wdl.	67.6	139.8	250	-9.0	14.6	-31.1	104	------	266
Dawson*	NW. Boreal	64.1	139.1	370	-4.4	15.6	-26.7	208	1007	324
Whitehorse	NW. Boreal	60.7	135.1	703	-1.0	14.0	-18.7	243	871	269
Watson Lake	WC. Boreal	60.1	128.8	689	-3.1	14.9	-24.6	227	955	414
Prince George	Cord Subbor	53.9	122.7	676	3.7	15.3	-9.9	294	1238	615
Kelowna	Cord. Dry	50	119.4	429	7.4	18.8	-4.5	326	1864	366

Appendix V: Climate Tables for West – East and Elevational Transects

West – east transects of selected climatic variables for a) temperate portions of Canada; b) boreal portions of Canada; and c) the *Mid-Arctic Dwarf Shrub Tundra* level 2 vegetation zone. Climate data are normals for the period 1961-1990 (Environment Canada 2019), unless marked with an * (these are normals for 1971-2000). Weather station locations are shown in Figure 6. Variables are:

- **Lat.** – north latitude (degrees)
- **Long.** – west longitude (degrees)
- **Elev.** – elevation (metres above sea level)
- **MAT** – mean annual temperature (°C)
- **MTWM** – mean temperature for the warmest month of the year (°C)
- **MTCM** – mean temperature for the coldest month of the year (°C)
- **# >0°C** – annual number of days with maximum temperature >0°C
- **GDD5** – annual number of growing degree days >5°C
- **MAP** – mean annual total precipitation (mm)

V-a)

Location *(Level 2 Veg. Zone)*	**Vancouver** *(Pacific Rainforest)*	**Kamloops** *(Shrub-Steppe)*	**Revelstoke** *(Cord. Rainforest)*	**Golden** *(Cordilleran Dry)*	**Calgary** *(Foothills Fescue)*	**Medicine Hat** *(Mixedgrass)*	**Regina** *(Mixedgrass)*	**Winnipeg** *(Tallgrass)*	**Thunder Bay** *(Mixed Forest)*	**Sudbury** *(Mixed Forest)*	**Montreal** *(Deciduous)*	**Sherbrooke** *(Mixed Forest)*	**Fredericton** *(Acadian)*	**Halifax** *(Acadian)*
Lat.	49.3	50.7	51.0	51.3	51.1	50.0	50.4	49.9	48.4	46.6	45.5	45.4	45.9	44.9
Long.	122.6	120.5	118.2	117.0	114.0	110.7	104.7	97.2	89.3	80.8	73.7	71.7	66.6	63.5
Elev.	143	345	443	785	1077	717	577	239	199	347	31	238	40	126
MAT	9.4	8.6	6.7	4.6	3.9	5.5	2.6	2.4	2.4	3.5	6.1	4.1	5.3	6.1
MTWM	16.8	20.8	18.2	17.2	16.4	19.8	19.1	19.8	17.7	19.1	20.8	18.0	19.1	18.3
MTCM	1.9	-4.8	-5.6	-10.1	-9.6	-10.7	-16.5	-18.3	-15.0	-13.5	-10.3	-11.6	-9.6	-5.8
# >0°C	358	324	312	292	298	299	256	246	263	258	286	279	288	305
GDD5	1915	2259	1729	1497	1435	1971	1723	1802	1427	1680	2079	1621	1768	1707
MAP	2184	270	950	491	399	323	364	504	704	872	940	1109	1095	1474

V-b)

Location (*Level 2 Veg. Zone*)	**Dawson*** (*NW. Boreal*)	**Watson Lake** (*WC. Boreal*)	**Fort Nelson** (*WC. Boreal*)	**Fort McMurray** (*WC. Boreal*)	**La Ronge** (*WC. Boreal*)	**The Pas** (*WC. Boreal*)	**Geraldton*** (E. *Boreal*)	**Val d'Or** (E. *Boreal*)	**Sept-Isles** (E. *Boreal*)	**Corner Brook** (E. *Boreal*)	**St. John's** (*Atl. Mar. Heath*)
Lat.	64.1	60.1	58.8	56.7	55.2	54.0	49.8	48.1	50.2	49.0	47.6
Long.	139.1	128.8	122.6	111.2	105.3	101.1	86.9	77.8	66.3	58.0	52.7
Elev.	370	689	382	369	375	271	348	337	55	5	134
MAT	-4.4	-3.1	-1.1	0.2	-0.5	-0.3	0.3	1.2	0.9	5.2	4.7
MTWM	15.6	14.9	16.7	16.6	16.9	17.7	16.9	17.1	15.2	17.4	15.4
MTCM	-26.7	-24.6	-22.0	-19.8	-20.9	-21.4	-19.2	-17.0	-14.6	-6.8	-4.3
# >0°C	208	227	228	245	233	228	244	245	248	291	297
GDD5	1007	955	1289	1352	1300	1395	1315	1379	1005	1432	1209
MAP	324	414	449	465	489	452	760	927	1128	1186	1482

V-c)

Location (*Level 2 Veg. Zone*)	**Sachs Harbour** (*Mid-Arctic*)	**Cambridge Bay** (*Mid-Arctic*)	**Resolute** (*Mid-Arctic*)	**Hall Beach** (*Mid-Arctic*)	**Clyde River** (*Mid-Arctic*)	**Iqaluit** (*Mid-Arctic*)
Lat.	72.0	69.1	74.7	68.8	70.5	63.8
Long.	125.3	105.1	95.0	81.3	68.5	68.6
Elev.	87	31	68	8	27	34
MAT	-13.7	-14.9	-16.6	-14.4	-12.4	-9.5
MTWM	6.2	8.0	4.0	5.8	4.2	7.7
MTCM	-30.0	-33.5	-33.0	-32.7	-28.0	-26.8
# >0°C	108	115	87	113	119	150
GDD5	122	177	29	77	45	179
MAP	127	141	140	215	226	424

V-d) West – east transect of selected climatic variables across the southern Coast Mountains. Climate data are normals for the period 1961-1990 (Environment Canada 2019), unless marked with an * (these are normals for 1971-2000).

Location (*Level 2 Veg. Zone*)	**Vancouver*** (*Pacific Rainforest*)	**Hollyburn Ridge** (*Pacific Montane*)	**Whistler Rdhouse*** (*Pacific Alpine*)	**Lytton** (*Cordilleran Dry*)	**Kamloops** (*Shrub-Steppe*)
Lat.	**49.3**	**49.4**	**50.1**	**50.2**	**50.7**
Long.	122.6	123.2	123.0	121.6	120.5
Elev.	143	930	1902	258	345
MAT	9.4	4.8	0.1	9.7	8.6
MTWM	16.8	13.0	10.4	21.4	20.8
MTCM	1.9	-1.7	-4.3	-2.3	-4.8
# >0°C	358	320	-----	331	324
GDD5	1915	943	-----	2451	2259
MAP	2184	2916	1749	423	270

Appendix VI: Climate terminology

For terminology describing the climatic conditions of the vegetation zones, we mostly use definitions of the Worldwide Bioclimatic Classification (WBC) System (Sanchez-Mata & Rivas-Martinez 2010; Rivas-Martinez & Rivas-Saenz 2017).

At the broadest level of its classification, the WBC recognizes five globally distributed macrobioclimates, mostly representing a latitudinal temperature gradient (Rivas-Martinez & Rivas-Saenz 2017). Four of these macrobioclimates occur in Canada (Sanchez-Mata & Rivas-Martinez 2010): Polar (Arctic), Boreal, Temperate and Mediterranean. Classes are defined as follows, where Tp (yearly positive temperature) is the sum of the monthly average temperature of those months whose average temperature is higher than 0°C:

Polar: Tp<380; the polar climate occurs in the arctic and is characterized by very long, very cold winters and short, cool summers; mean annual temperatures are <0°C.

Boreal: 380<Tp<800; the boreal climate is characterized by long cold winters, and short warm to cool summers (depending on proximity to oceans); mean annual temperatures are typically <0°C.

Temperate: 800<Tp<2450; temperate climates are warmer than the boreal, with shorter winters; mean annual temperatures are typically >0°C.

Mediterranean: 900<Tp<2400; Mediterranean climates are characterized by having at least two consecutive dry months during the summer (the warmest period in the year). In Canada, a cool Mediterranean climate occurs on part of the southern British Columbia coast (in the *Pacific Dry Forest* vegetation zone) where orographic rainshadow effects affect the seasonality of precipitation.

To describe regional variation within these broad macrobioclimate zones (mostly on east – west subgradients), we recognize two classes of continentality: “continental” and “maritime” or “maritime-influenced”, and four classes of climatic moisture: “dry”, “subhumid”, “humid” and “very humid”.

Continentality is an indication of the influence of large water bodies on climatic temperatures. In the WBC system, the “continentality index (Ic)” is the difference between the average temperatures of the warmest (Tmax) and the coldest (Tmin) months of the year: Ic = Tmax – Tmin.

Continental, including Subcontinental: Ic≥21;

Maritime (Oceanic), including Hypermaritime: Ic<21

Vegetation that occurs in a maritime climate but near marine coastlines receives additional moisture inputs from frequent fog. These situations are termed “hypermaritime” (Biogeoclimatic Ecosystem Classification, see: https://www.for.gov.bc.ca/hre/becweb/system/how/index.html).

Moisture classes designating “precipitation effectiveness” (*sensu* Thornthwaite 1931) give an estimate of the annual climatic water balance after accounting for evapotranspiration. For these purposes, the WBC system calculates an “ombrotrophic index (Io)” as Io = (Pp/Tp) x 10, where Pp, yearly positive precipitation, is the total average precipitation of those months whose average temperature is higher than 0°C. Classes are as follows:

Very Humid: Io>12;

Humid: 6<Io<12;

Subhumid: 3.6<Io<6;

Dry: 2.2<Io<3.6.

Appendix VII: Glossary

- **active soil layer** – the layer of soil above permafrost that thaws and freezes annually.
- **aeolian** – pertaining to the erosive and transporting action of the wind, or to sediments that have been moved and sorted by wind. Aeolian deposits are usually fine sands and coarse silt.
- **alluvial** – pertaining to rivers and streams, or to features produced by the actions of rivers and streams. Alluvial soil deposits are generally coarse-textured and stratified (also *fluvial*).
- **alvar** – an ecosystem that develops where shallow soils overlie a limestone bedrock plain.
- **aspect** – the orientation of a slope face, expressed as a compass direction.
- **azonal sites** – sites where the primary ecological influences on vegetation reflect local topography and/or soil properties (e.g., wetlands); see *zonal sites*.
- **azonal vegetation** – vegetation characteristic of azonal sites.
- **badlands** – dry terrain where bedrock and soil have been extensively eroded by wind and water; vegetation cover is minimal.
- **bedrock** – the solid rock underlying soil parent materials, or exposed at the ground surface.
- **bedrock controlled terrain** – terrain where surface relief is determined by the expression of the underlying bedrock surface, instead of by deep deposits of unconsolidated parent materials.
- **Beringia** – an area including large parts of Alaska, eastern Siberia and western Yukon that remained unglaciated during repeated glaciations dating to approximately 3 million years BP.
- **bioturbation** – reworking of soils by living organisms.
- **blanket bog** – an extensive bog form without surface pools that covers gently sloping terrain around shallow valleys.
- **bog** – an ombrotrophic peatland receiving water exclusively from precipitation and not influenced by groundwater; bogs can be treed or non-treed, but vegetation is characterized by *Sphagnum* spp. and ericaceous shrubs (see *fen, marsh, swamp*).
- **broad-leaved** – plant species with flat leaves containing a network of veins, and that produces seeds within flowers (angiosperm).
- **brown mosses** – a group of minerotrophic moss species that commonly occur together and are valuable classification indicators of richer, wetter habitat conditions. Species in Canada include *Aulacomnium palustre*, *Tomentypnum nitens*, *Scorpidium* spp., *Drepanocladus* spp., and *Campylium stellatum.*
- **bryophyte** – a division of nonvascular land plants (*Bryophyta*), including mosses, liverworts and hornworts; bryophytes lack vascular tissues for circulating liquids, and reproduce via spores.
- **bunchgrass** – a grass that grows in clumps or tussocks, often forming hummocks.
- **calciphile** – a plant species that thrives on calcareous soils (i.e., rich in calcium or magnesium carbonate).
- **cation** – a positively charged ion.
- **Chinook winds** – warm dry air masses in the lee of the Rocky Mountains, especially in southern Alberta, that can significantly raise temperatures for short periods, melting and sublimating parts of the snowpack.
- **cold air drainage** – the downslope movement of dense cold air.
- **cold air ponding** – an accumulation of cold air in a landscape depression, as a result of cold air drainage.

- **cold-deciduous** – dropping leaves in the autumn.
- **colluvium** - heterogeneous mixture of soil materials that has reached its present position as a result of direct, gravity-induced movement; usually associated with steep slopes.
- **conifer** – plant species that produces seeds in woody cones. Most conifer species in Canada are evergreen, but some (e.g., *Larix* spp.) are cold-deciduous; native conifer species in Canada have needle-like or scale-like leaves.
- **continuous permafrost** – perennially frozen ground in which permafrost is present everywhere except under lakes and rivers that do not freeze to the bottom.
- **crustose lichens** – a group of lichens with a thin thallus that adheres closely to its substrate.
- **cryogenic** – caused by repeated freeze/thaw cycles, typically in association with permafrost.
- **cryoturbation** – churning and heaving of the soil by freeze/thaw cycles.
- **cryptogam** - a plant that reproduces by means other than the production of seeds (e.g., spore-producing bryophytes, lichens, ferns and horsetails).
- **cyanobacteria** – a group of photosynthetic bacteria that live in a wide variety of moist soils and water, either freely or in a symbiotic relationship with plants or lichen-forming fungi. Cyanobacteria, also referred to as "blue-green algae", often form soil crusts that help to stabilize terrestrial substrates and retain water.
- **discontinuous permafrost** – terrain where permafrost occurs in patches amidst permafrost-free areas.
- **epiphyte** – a plant that grows on another plant, but is not parasitic.
- **ericaceous** – species of the family *Ericaceae* (e.g., blueberries, cranberries, huckleberries).
- **esker** – a former sub-glacial streambed that, with retreat of the glacier, is exposed on the landscape as a narrow, sinuous, often steep-sided ridge comprising coarse-textured materials.
- **fen** – a minerotrophic peatland receiving water enriched by dissolved minerals and oxygen; water levels often fluctuate; fens can be treed or non-treed, but vegetation is typically dominated by shrubs, graminoid species and brown mosses (see *bog, marsh, swamp*).
- **fire cycle** – the theoretical time (in years) required to burn an area equivalent to the size of an area of interest. Thus, fire occurs more frequently in areas with short fire cycles.
- **fluvial** – see *alluvial.*
- **forb** – a non-graminoid herb with relatively broad leaves and/or showy flowers.
- **forest** – a vegetation community characterized by tree species >5 m tall (by CNVC convention), the crowns of which generally form a continuous canopy with typically >30% cover (by CNVC convention); a large area of tree-dominated stands (see *woodland*).
- **gap dynamics** – a process of vegetation succession, especially in forests, where replacement plant species enter the stand canopy by colonizing and growing into gaps created by the death of an individual or small number of canopy trees.
- **glaciofluvial** – pertaining to meltwater streams flowing from or under melting glacier ice. Glaciofluvial deposits are generally coarse-textured.
- **glaciolacustrine** – pertaining to or characterized by glacial and lacustrine conditions; sediment deposits made in lakes affected by glacier ice or by meltwaters flowing directly from glaciers. Glaciolacustrine deposits are generally stratified silt, clay and/or fine sand.

- **glaciomarine** – relating to processes that involve the action of glaciers and the sea, or the action of glaciers in the sea; sediments of glacial origin laid down from suspension in a marine environment in close proximity to glacier ice. Glaciomarine deposits are generally fine-textured.
- **graminoid** - a flowering, monocotyledonous herb with relatively long, narrow leaves and inconspicuous flowers with some parts reduced to bracts, primarily including grasses (*Poaceae*), sedges (*Cyperaceae*) and rushes (*Juncaceae*).
- **heath** – a plant community dominated by ericaceous species.
- **herb** – a non-woody vascular plant; including pteridophytes, forbs and graminoids.
- **high-centre polygon** – a form of permafrost patterned ground; after a long period of peat development within a low-centre polygon, the peat surface forms a dome-shaped mound in the centre that is above the local water table and, thus, relatively dry (see *low-centre polygon*).
- **hydrophyte** – plant species that is adapted morphologically and/or physiologically to grow in water or very wet environments.
- **ice-wedge polygon** – a form of permafrost patterned ground; ice wedges develop vertically when water flows into cracks in the soil and then freezes. When an ice wedge grows over time, it can become a raised polygon with eroded edges.
- **igneous rock** – rock that is formed by the solidification of molten magma or lava from within the Earth's crust.
- **insolation** – the amount of solar radiation reaching the earth's surface.
- **isostatic rebound** – the rise of land masses that were depressed by the weight of ice sheets during the last ice age.
- **karst** – terrain where soluble bedrock (e.g., limestone) has been dissolved by water, creating subterranean drainage structures including cave systems, underground rivers and sinkholes.
- **krummholtz** – a scrubby, stunted growth form of trees caused by wind exposure in extreme environments.
- **lacustrine** – pertaining to freshwater lakes. Lacustrine sediments deposited on a lake bed generally consist of stratified fine sand, silt and/or clay.
- **lichen** – a composite organism consisting of a fungus living in symbiosis with an alga.
- **loess** – a deposit of wind-blown silt (see *aeolian*).
- **low-centre polygon** – a form of permafrost patterned ground that is typical of continuous permafrost in wet terrain, with a high-rimmed perimeter surrounding a pool of shallow water; ice wedges develop in soil cracks pushing up soil ridges that trap water inside the resulting polygons (see *high-centre polygon*).
- **marine** – pertaining to the sea. Marine deposits consist of clay, silt, sand or gravel (sometimes containing shells) that have settled from suspension in salt or brackish water bodies or have accumulated at their margins through shoreline processes such as wave action and longshore drift.
- **marsh** – a non-treed mineral wetland with periodic or persistent standing water that is generally nutrient-rich; vegetation is dominated by graminoids, shrubs, forbs or emergent aquatic plants (see *fen, bog, swamp*).
- **meadow** – a vegetation community characterized by grass and/or forb species, often occurring on moist sites.
- **metamorphic rock** – rock that has been altered from its original characteristics by heat and pressure.

- **microphyll** – a plant leaf with a flat blade of small size containing a single vein.
- **minerotrophic** – nourished by mineral water; referring to wetlands that receive nutrients from flowing or percolating groundwater (and surface water), in addition to precipitation.
- **moisture deficit** (growing season) – during the growing season, a moisture deficit occurs when the available water in the soil (from storage and precipitation) is insufficient to meet the combined demands of evaporation and plant transpiration.
- **moraine** – a heterogeneous mixture of soil and rock, typically unsorted and unstratified, which has been transported and deposited directly by glacial ice; moraines form a variety of surficial landforms that can occur in both currently glaciated and formerly glaciated regions (also *till*).
- **net fen** – string fens with a broad pattern of interconnected peat ridges, often resembling polygons (although not related to permafrost action); see *string fen*.
- **non-sorted circles and polygons** – permafrost patterned ground with a small sparsely vegetated dome or hummock surrounded by a vegetated perimeter; the freeze/thaw cycle forces soil materials upward and outward from the raised centre (see *sorted circles and polygons*).
- **nunatak** – an isolated peak protruding from its surrounding ice sheet.
- **ombrogenous** – an ecosystem that derives its nutrients solely (or primarily) from precipitation (also *ombrotrophic*).
- **ombrotrophic** – see *ombrogenous*.
- **organic deposit** – mostly organic soil parent materials resulting from the accumulation of decayed vegetative matter; usually ≥ 40 cm thick.
- **orographic** – relating to mountains.
- **palsa** – permafrost mound containing a core of alternating layers of ice and peat or mineral soil materials.
- **paludification** – the process of gradual peat accumulation under poor drainage conditions and a slowly rising water table.
- **parent material** – the unconsolidated and more or less chemically unweathered material from which soil develops by pedogenic processes (also *surficial material*).
- **peat** – partially decomposed plant material deposited and accumulated under saturated soil conditions.
- **permafrost** – ground in which temperatures have been <0°C for at least 2 years; perennially frozen ground.
- **permafrost patterned ground** – a generic term for more or less symmetrical surface soil features characteristic of ground that is subject to intensive frost action. These features include circles, polygons, stripes and other geometric shapes, sometimes with fine- and coarse-textured soil materials sorted by repeated freeze/thaw cycles. Circles and polygons tend to form on level ground; stripes develop on slopes.
- **pingo** – a permafrost feature produced when water freezes under the basin of a recently drained lake, pushing the sediments up into a dome-shaped mound of earth-covered ice.

- **potential vegetation** – the plant species and vegetation structure (i.e., plant community) that would become established if all successional sequences were completed at a given location without anthropogenic interference under the present climatic and edaphic conditions. Potential vegetation is conceptually similar to 'climax vegetation', however, in areas of frequent, on-going natural disturbance (e.g., boreal climatic regions with a short fire-return interval) 'climax' is a difficult concept to apply; in these situations, the potential vegetation concept can be applied to the community that theoretically best typifies the projected successional endpoint.
- **pro-glacial** – in front of, and usually in contact with, the face of a glacier; especially pro-glacial lakes.
- **pteridophyte** – a vascular plant that reproduces by spores, e.g., ferns, horsetails, etc.
- **raveling** – deterioration of soil structure from the bottom up.
- **rime ice** – an accumulation of ice on the windward sides of exposed objects that is formed from supercooled fog or cloud and built out directly towards the wind.
- **riparian** – referring to terrain, vegetation or simply a landscape position adjacent to or associated with freshwater; generally used for rivers and streams, but can include the fringe of lakes, ponds and floodplains.
- **sclerophyllous** – plant species with thick, leathery evergreen leaves.
- **scree** – see *talus*
- **sedimentary rock** – rock that is formed at or near the Earth's surface by the accumulation and solidification of sediment, or by the precipitation of dissolved chemicals (e.g., calcium carbonate).
- **seep** – a location where water oozes from the ground; seepage area.
- **serpentine soil** – soil developed from weathered ultramafic rocks; typically rich in magnesium, lacking in calcium, phosphorus and potassium, and with high concentrations of heavy metals such as iron, cobalt, nickel and chromium (see *ultramafic*).
- **shrub** – a perennial woody plant, shorter than a tree (i.e., by CNVC convention <5 m tall), that generally has several erect or prostrate stems which give it a bushy appearance (see *tree*).
- **shrub-carr** – vegetation dominated by low shrubs occurring on moist mineral soils in areas prone to growing-season frosts; these sites would support forested communities under normal circumstances.
- **slope bog** – a bog form that develops in areas of high rainfall on sloping terrain without permafrost.
- **soil creep** – slow, down-slope movement of soil and loose rock under the influence of gravity.
- **soil types** (from the Canadian System of Soil Classification). Each term refers to an order of soils:
    - **Brunisol** – soils whose horizons are developed sufficiently to exclude the soils from the Regosolic order but that lack the degrees or kinds of horizon development specified for soils of the other orders. These soils, which occur under a wide variety of climatic and vegetative conditions, all have Bm or Btj horizons.
    - **Chernozem** – soils that have developed under xerophytic or mesophytic grasses and forbs, or under grassland-forest transition vegetation, in cool to cold subarid to subhumid climates. The soils have a dark-colored surface (Ah or Ahe or Ap) horizon and a B and/or C horizon of high base saturation. Chernozemic soils mainly occur in the Great Plains of west-central Canada.

- **Cryosol** – soils that form in either mineral or organic parent materials where permafrost exists close to the surface, typical of northern Canada and some alpine areas. Cryoturbation is common in these soils, usually indicated by surficial features such as earth hummocks, and sorted and non-sorted polygons, circles and stripes.
- **Folisol** – *(*see *Organic)*.
- **Gleysol** – soils that are saturated with water and under chemical reducing conditions either continuously or during some period of the year, as indicated either by gleying (a greenish-blue-grey soil colour) or mottling in the soil profile.
- **Luvisol** – soils that have eluvial (Ae) horizons, and illuvial (Bt) horizons in which silicate clay is the main accumulation product. The soils develop in base-saturated parent materials under forest or forest-grassland transition vegetation in subhumid to humid, mild to very cold climates.
- **Organic**– soils that have developed dominantly from organic deposits. The majority of Organic soils are saturated for most of the year, unless artificially drained, although some of them are not usually saturated for more than a few days. They include most of the soils commonly known as peat, muck, or bog and fen soils. These soils occur widely in poorly and very poorly drained depressions and level areas in regions of subhumid to perhumid climates and are derived from vegetation that grows on such sites. However, one group of Organic soils (**Folisols**) consists of upland (folic) organic materials, generally of forest origin. These Folisols are well to imperfectly drained, although they may become saturated after rainfall or snowmelt.
- **Podzol** – soils having B horizons in which the dominant accumulation product is amorphous material composed mainly of humified organic matter combined in varying degrees with Al and Fe ions. Typically Podzolic soils occur in coarse- to medium-textured, acid parent materials, under forest or heath vegetation in cool to very cold, humid to perhumid climates.
- **Regosol** – soils having no horizon development or development of the A and B horizons insufficient to meet the requirements of the other soil orders.
- **Solonetzic** - soils having B horizons that are very hard when dry and swell to a sticky mass of very low permeability when wet. They occur on saline parent materials in some areas of the semiarid to subhumid Great Plains of west-central Canada in association with Chernozemic soils and to a lesser extent with Luvisolic and Gleysolic soils. Most Solonetzic soils are associated with a vegetative cover of grasses and forbs.
- **Vertisol** – soils that occur in heavy-textured materials (>60% clay) that shrink and swell due to wetting and drying. As a result, horizons diagnostic of other soil orders have either been prevented from forming or have been severely disrupted. Vertisolic soils occur in the cool, subarid to subhumid, grassland portion of the Great Plains of west-central Canada.

- **sorted circles and polygons** – permafrost patterned ground similar to non-sorted circles/polygons, but with vegetated centres of fine-textured soil materials surrounded by a perimeter of sparsely vegetated coarse-textured soil materials and rocks (see *non-sorted circles and polygons*).
- **stand structure** – the spatial pattern of growth forms in a plant community, especially with regard to height and abundance within and between individual layers.
- **string bog/fen** – a bog and fen form that develops on slightly sloping terrain that is characterized by narrow, peaty ridges (“strings”) that are oriented at right angles to the direction of drainage; wet depressions or pools of open water occur between the ridges.

- **stripes** – permafrost patterned ground in the form of stripes that are oriented up and down a slope; non-sorted stripes comprise alternating parallel lines of vegetated ground and relatively bare ground; sorted stripes comprise alternating parallel lines of fine-textured and coarse-textured soil materials.
- **succession** – the temporal progression within vegetation or a plant community whereby one plant species is replaced by another until a stable species assemblage for a particular environment is attained.
- **surficial geology** – the geological characteristics of unconsolidated surface deposits.
- **surficial material** – see *parent material*.
- **swamp** – a minerotrophic wetland with vegetation characterized by woody plants (trees and/or tall shrubs); swamps can be either peatlands or mineral wetlands (see *fen, marsh, bog*).
- **talus** – an accumulation of rock fragments at the base of cliffs, etc. (also *scree*).
- **tarn** – a small, mountain water body found in a depression excavated by glacial action.
- **tectonic** – pertaining to the movement and deformation of the Earth's crust.
- **thermophilic** – heat-loving.
- **till** – see *moraine*.
- **tree** – a perennial woody plant, typically with a single stem and a more or less definite crown, that is capable of growing >5 m tall (by CNVC convention); see *shrub*.
- **ultramafic** – rocks with very low silica content, low potassium content, and high magnesium and iron content (see *serpentine soil*).
- **vegetative layering** – asexual reproduction of a plant by sprouting new roots and erect stems from a living branch or stem that is growing in prolonged contact with the ground, often covered by moist moss and/or leaf litter; ultimately the connection with the parent plant is broken and a new individual is produced.
- **woodland** – a vegetation community characterized by tree species >5 m tall (by CNVC convention), the crowns of which form a sparse, discontinuous canopy as a result of ecological limitations such as climate, shallow soils, wetlands, etc; by CNVC convention, woodland canopies are typically between 10% and 30% cover (see *forest*).
- **xerophyte** – plant species that is adapted morphologically and/or physiologically to grow in very dry environments and withstand drought.
- **zonal sites** – sites that best reflect the regional climate and are least influenced by the local topography and/or soil properties. They tend to have intermediate soil moisture and nutrient regimes, mid-slope positions on gentle to moderate slopes, with moderately deep to deep soils and free drainage (see *azonal sites*).
- **zonal vegetation** – potential vegetation characteristic of zonal sites.