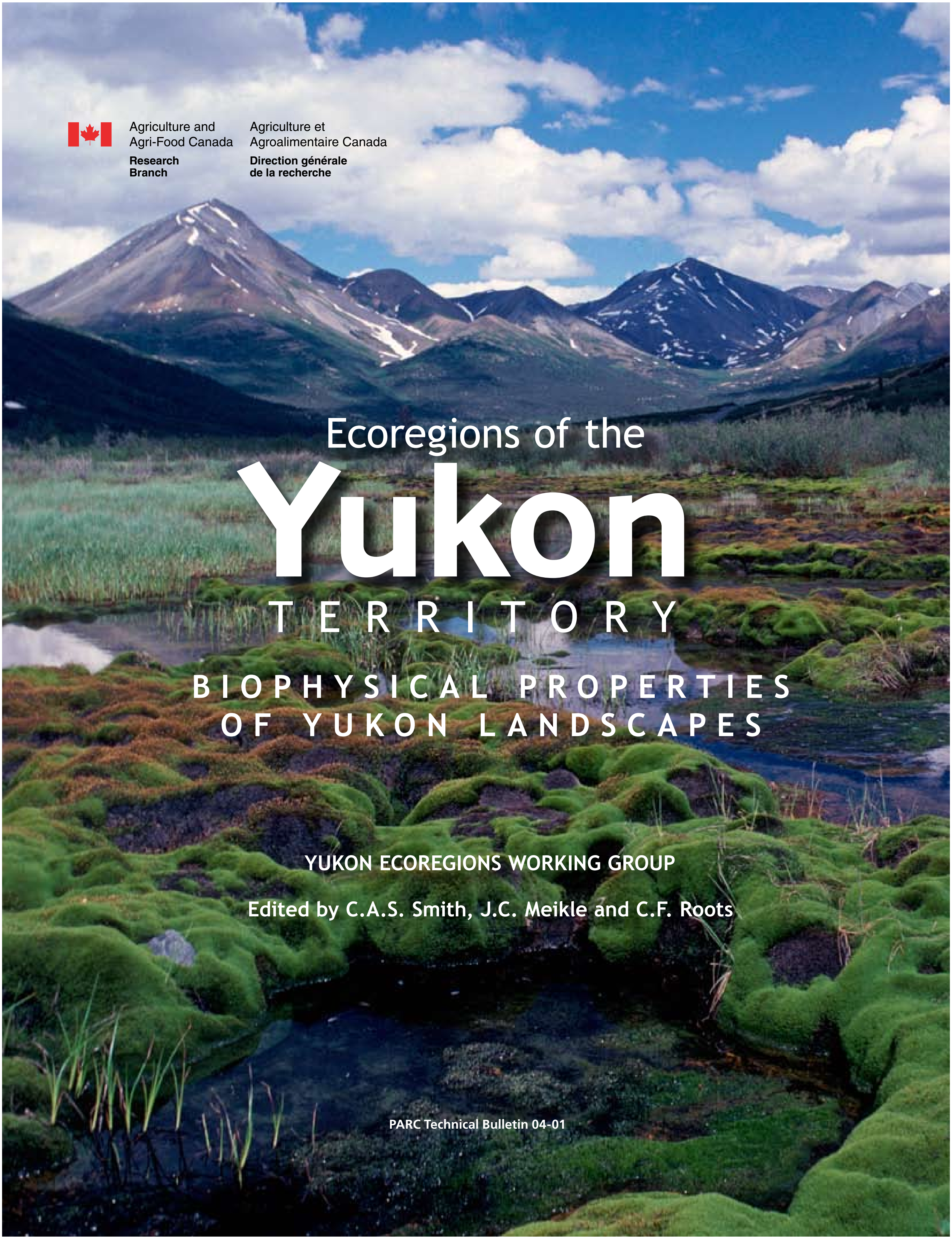

Agriculture and Agri-Food Canada
Research Branch

Agriculture et Agroalimentaire Canada
Direction générale de la recherche

Ecoregions of the Yukon Territory

Biophysical Properties of Yukon Landscapes

YUKON ECOREGIONS WORKING GROUP

Edited by C.A.S. Smith, J.C. Meikle and C.F. Roots

PARC Technical Bulletin 04-01

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Visit the Yukon Geological Survey Website at www.geology.gov.yk.ca.

SUGGESTED CITATIONS

This volume contains two parts: an **Overview**, written for a general audience, and **Ecoregion chapters**, written for a scientific audience. Both parts present information that has been previously published, and these sources are cited throughout. Where this document is considered the most suitable reference, please follow the examples below.

Citation of the entire volume should be:

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In the overview sections of Part 1, each subject has defined authorship. Here is an example of how a citation should be.

> O'Donoghue, M. and Staniforth, J., 2004. Wildlife-Mammals. *In:* **Ecoregions of the Yukon Territory: Biophysical properties of Yukon landscapes,** C.A.S. Smith, J.C. Meikle and C.F. Roots (eds.), Agriculture and Agri-Food Canada, PARC Technical Bulletin No. 04-01, Summerland, British Columbia, p. 42-45.

Citation of material from within any of the ecoregion chapters from Part 2 should be attributed to the group.

> Yukon Ecoregions Working Group, 2004. Yukon Coastal Plain. *In:* **Ecoregions of the Yukon Territory: Biophysical properties of Yukon landscapes,** C.A.S. Smith, J.C. Meikle and C.F. Roots (eds.), Agriculture and Agri-Food Canada, PARC Technical Bulletin No. 04-01, Summerland, British Columbia, p. 63-72.

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FOR MORE INFORMATION: Information in this volume is derived largely from published sources cited in the references. Where references are lacking, the source of information is from the author(s) of that section directly. Their contact information is found in the list of contributors.

FRONT COVER PHOTO: Moss blankets stony substrate within a high elevation wetland in the Hess Mountains near Macmillan Pass in the Selwyn Mountains Ecoregion (photo by M. Hoefs).

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ACKNOWLEDGEMENTS

Ecoregions of the Yukon Territory reflects informal collaboration over the last 10 years by professionals representing federal and territorial government agencies, universities, and private consulting firms. We have collectively termed ourselves the Yukon Ecoregions Working Group. In all cases, members' expertise comes from the first-hand knowledge gained from field work conducted in the territory over the last two and half decades.

Our contributions were edited and assembled by members of the working group at different times, including Charlotte Mougeot (1996), Wendy Nixon (1997-1999) and, for this published version, Scott Smith, John Meikle and Charlie Roots. We would like to thank the contributors for sharing their knowledge to allow the production of this document and for their patience and support during its numerous revisions and final production.

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PREFACE

The Yukon Ecoregions Working Group formed in 1993 to revise the first *Ecoregions of the Yukon* map, which was published by Ed Oswald and John Senyk of the Canadian Forestry Service in 1977. The revisions were to reflect new knowledge, gained over the last 25 years, about the natural landscape in the territory. The result of this effort is this latest volume on the ecoregions of the Yukon.

In addition, the revised boundaries were to be a component of a new ecoregion framework for Canada, and correlated to boundaries designed for the state of Alaska. The mapping review culminated in the 1995 publication of the *Terrestrial Ecozones and Ecoregions of Canada* map at 1:7,500,000 scale by Environment Canada and the Research Branch of Agriculture and Agri-Food Canada. Following the completion of the national map, a number of provinces and territories, including the Yukon, prepared map coverage that conformed to the national ecoregion configurations but was detailed at a larger scale. To this end, a map of the ecozones and ecoregions of the Yukon, matched to the ecoregion boundaries of adjacent jurisdictions, was prepared to accompany this technical report.

The World Wildlife Fund and the North American Free Trade Agreement (NAFTA) Commission for Environmental Cooperation have both published ecoregion maps of North America that differ somewhat from the ecoregions described in this document. Ecologists have often stated that the formulation of ecoregions is as much art as it is science. Ecoregions are merely conceptual stratifications of a landscape; their boundary placements are often subjective, based on both knowledge and local perception. To assist the reader in understanding the relations among the various published ecological map units, we have listed correlations on the introductory page to each Yukon ecoregion. These correlations are correct to 2002 but will change as adjacent jurisdictions revise their ecoregion boundaries. Maintaining seamless map coverage with our neighbours requires negotiated adjustments to the Yukon's ecoregions.

My co-editors, John Meikle and Charlie Roots, worked tirelessly toward the primary objective of this report — to provide generalized, regional biophysical information about the landscapes of the Yukon. We hope it will be of use to anyone interested in the natural history and ecology of the Yukon including naturalists, students, recreationalists and, of course, professionals in natural resource and land management.

C.A.S. (Scott) Smith, Yukon Ecoregions Working Group,
September, 2004

CONTRIBUTORS
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This report is intended to be a comprehensive document of ecoregion descriptions and current scientific references about natural resources in the Yukon. Technical contributions have been gathered from a wide range of resource professionals from federal and territorial agencies, universities and non-government organizations.

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HOW TO USE THIS REPORT

Part 1: Introduction and Yukon overview. Here, the major ecosystem components (that is, physiography, hydrography, geology, climate, permafrost, surficial geology, soils, vegetation, fish and wildlife resources, and traditional land uses) are addressed for the territory as a whole.

Part 2: Ecozone and ecoregion descriptions. Five ecozones are described briefly within a Yukon context. Ecoregion descriptions are grouped by ecozone, and each (23 wholly or partly in the Yukon) is described in detail, following much the same sequence of ecosystem components as in Part 1. Each ecoregion has a unique number within the national ecological framework. The full name of each ecoregion is generally used in the text although several tables and maps use only the number identifiers. The names and corresponding number are shown in Figure 2.

In Part 1, authors are acknowledged at the beginning of each of the ecosystem component sections. These components are described with a minimum of citations to literature of a specific nature, and general references are listed for further reading. In contrast, for Part 2, contributing authors are not given but may be deduced, and then contacted from the list at the front of the report. Within the ecoregion descriptions, numerous citations are included corresponding to the list of references at the end of the report.

Appendices to the report include:

- a glossary of many technical terms used in the report,
- a geologic time scale, and
- a 1:2,500,000 scale map of the ecozones and ecoregions of the Yukon Territory (folded into a pouch on the back cover of hardcopy versions of the report).

In this report, all data are generalized from original sources. While great effort has been made to ensure accuracy and precision of information, the Yukon Ecoregions Working Group assumes no responsibility for errors or omissions in the original data. The maps in the report are for illustrative purposes only; they are intended for use at the published scale and are not suitable for site-specific decision-making.

YUKON-WIDE DATABASES

Some organizations and government departments maintain extensive quantitative records of natural and human-induced phenomena. Typically these are not subdivided along ecoregion boundaries, but are useful for studies of a regional or territory-wide scope. Included below are the current names of some of the organizations that support the gathering of land-based observations. Some of these databases are presented on internet web sites which may be located starting at the home page of the relevant group; the addresses are omitted here because they are subject to change. While by no means an exhaustive directory, some territory-wide data sources of broad interest include the following:

Weather and hydrological data: Environment Canada, through its Atmospheric Monitoring and Water Surveys Directorate, maintains historical climate and streamflow records. The latter include water level, surface water quality and sediment load observations. The Yukon Weather Office in Whitehorse maintains additional records.

Snow thickness and stream levels: Repeated observations from sites across Yukon south of 65°N and on the Dempster Highway are reported periodically each spring by the former Water Resources Division, Indian and Northern Affairs Canada, Yukon Region (now Yukon Department of Environment).

Geology data: Mineralization of potential economic value and human activity on these occurrences are compiled by the Yukon Geological Survey, Yukon Department of Energy, Mines and Resources. The descriptions are organized by map areas of 1:250,000 scale according to the National Topographic System designation. Yukon Geological Survey also lists all geological maps and reports relevant to each of these map areas.

Forest resources: Forest cover maps, lightning strike maps and related forest resource databases are maintained by and available from the Yukon Department of Energy, Mines and Resources, Forest Management Branch.

continued…

Wildlife resources: The Yukon Bird Club is a volunteer network in Whitehorse with records of species observed on regular dates such as Christmas week. The Environmental Assessment and Monitoring Network of Environment Canada supports a program of regular observations by volunteers of selected biotic and abiotic (such as the date of lake freezing) features at known locations across Canada. The Fish and Wildlife Branch of the Yukon Department of Environment maintains records on most large mammal species, most fish species of recreational value as well a herbarium of collected plant species from across the territory.

Other resources: Many government agencies now maintain certain databases that are now accessible on the internet. For example, extensive map information on geology and surficial geology is maintained by the Geological Survey of Canada. Soil maps for the Yukon are maintained by Agriculture and Agri-Food Canada through its Canadian Soil Information System.

PART 1

Introduction and overview

INTRODUCTION

by Scott Smith

BACKGROUND

Activities relating to mineral exploration, recreation, tourism, land development, ecosystem protection, park development, wildlife and forest management require knowledge of the land, its biota, as well as its capability and suitability to support a range of uses. Land use policies and resource management guidelines are established based on this knowledge. Better and more accessible resource information leads to better land use decisions. To assess the best use of land or the impacts of development, one needs both generalized regional information, such as is in this report, and more detailed site-specific information typically conducted project by project.

In 1977, Ed Oswald and John Senyk of the Canadian Forest Service published the first Ecoregions of the Yukon report with a map at 1:1,500,000 scale. The work was based on interpretations of aerial photographs, satellite imagery, physiographic and geologic mapping, forest inventory and climate data, supplemented by limited fieldwork. Both report and map have been used extensively and have proven to be an invaluable general resource to professionals in many fields.

In 1995, the 1977 ecoregion map was reviewed and revised by the Yukon Ecoregions Working Group to reflect the most recent research and fieldwork in various disciplines. Boundaries were redrawn using the polygon linework of the Soil Landscape of Canada-Yukon map sheet. In a few areas, boundaries were modified to match those of adjoining ecoregion maps of British Columbia, Alaska and the Northwest Territories. The result, part of a national effort to standardize an ecological framework for Canada (Fig. 1), shows five ecozones identified in the Yukon subdivided into 23 ecoregions (Fig. 2).

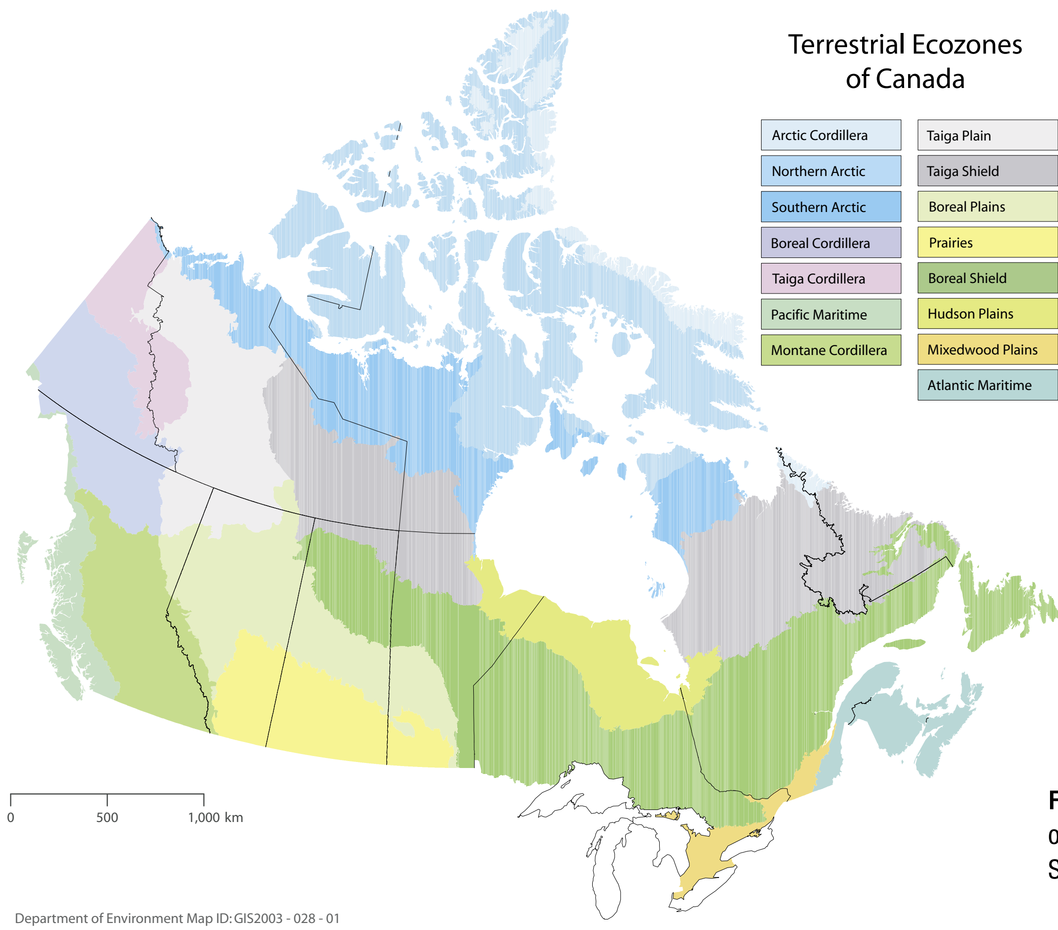

Figure 1. Terrestrial ecozones of Canada. Source: Ecological Stratification Working Group, 1996.

Figure 2. Ecoregions of Yukon, from Department of Renewable Resources, Government of the Yukon. Ecoregions are numbered according to a national classification (Ecological Stratification Working Group, 1996).

THE ECOLOGICAL FRAMEWORK: ECOZONES AND ECOREGIONS OF THE YUKON

THE DEFINITION OF ECOZONES AND ECOREGIONS

In the mid-1970s, Environment Canada initiated the Canada Committee on Ecological Land Classification (CCELC) to encourage the development of both a uniform national ecological approach to terrestrial ecosystem classification and mapping, and to encourage a sound application of the approach to sustainable resource management and planning.

Land can be organized in geographic units at different scales within a hierarchical framework so that the broader levels give information on the variety and distribution of landscapes, whereas site specific data yield information on a single landscape on which various interpretations can be made. A hierarchical terrestrial ecological classification evolved from CCLEC, originally with seven levels of generalization. Of these seven, five levels are often used today in regional ecological classification: ecozone (the broadest), ecoprovince, ecoregion, ecodistrict, and ecosection.

This classification is a process of delineating and classifying ecologically distinctive areas of the earth's surface (Table 1). Each area can be viewed as a discrete system that has resulted from the mesh and interplay of the geologic, landform, soil, vegetation, climatic, wildlife, water and human factors that may be present. The ecozone and ecoregion levels of the hierarchy are mapped for the Yukon and described in this report.

The broadest category (ecozone) delineates large tracts of land where general ecological conditions and processes are similar. These ecozones are subdivided into ecoregions by taking into account areas with similar biophysical and climatic parameters discernible at a regional scale.

Table 1. Levels of generalization used in the national ecological framework.

Ecozone
an area of the earth's surface representative of large and very generalized ecological units characterized by interactive and adjusting abiotic and biotic factors.

Ecoprovince
a part of an ecozone characterized by major assemblages of structural or surface forms; faunal realms; and vegetation, hydrological, soil and climatic zones.

Ecoregion
a part of an ecoprovince characterized by distinctive physiography and ecological responses to climate as expressed by the development of vegetation, soil,water, fauna, etc.

Ecodistrict
a part of an ecoregion characterized by distinctive assemblages of relief, geology, landforms, soils and vegetation.

Ecosection
a part of an ecodistrict throughout which there is a recurring assemblage of terrain, soils and vegetation communities.

Level of generalization	Examples of common benchmarks for recognition					
Common map scale*	**Geomorphology**	**Soils**	**Vegetation**	**Climate**	**Water**	**Fauna**
Ecoregion 1:3,000,000 to 1:1,000,000	Large-order landforms or assemblages of regional landforms	Great groups or associations thereof	Plant regions or assemblages thereof	Meso- or small-order macro	Large water basins	Assemblages of faunal communities
Ecodistrict 1:500,000 to 1:125,000	Regional landforms or assemblages thereof	Subgroups or associations thereof	Plant districts or assemblages thereof	Meso- or large-order micro	Drainage pattern: water quality	Faunal community or some specialized habitat
Ecosection 1:250,000 to 1:50,000	Assemblages of local landforms or a local landform	Families or associations thereof	Plant associations or assemblages thereof	Large-order micro to small-order micro	River reaches, lakes and shoreland	Specialized habitat within a community or a lower- order community

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

In many cases, the name of an ecoregion is based on the predominant physiographic unit (e.g. Klondike Plateau). In some cases, the boundaries of the ecoregion correspond closely to the boundaries of the physiographic unit. The area of the Old Crow Flats Ecoregion is identical to the area of the Old Crow Flats physiographic unit. However, the Mackenzie Mountains Ecoregion extends beyond what has traditionally been described as the Mackenzie Mountains physiographic unit. The modifier "Ecoregion" or "physiographic unit" has been added after any reference to these terms to specify its usage and reduce confusion.

HOW ECOREGION BOUNDARIES ARE ESTABLISHED AND MAPPED

Ecosystems are numerous and complex. The challenge is to make the ecological map units workable and understandable to reflect this complexity. It is equally important to recognize that while ecological land classification is science-based, it is also an art in the sense that ecological cycles, characteristics and interactions are not always readily apparent or measured, and therefore need to be interpreted from the development of vegetation, soil, and landform characteristics or other factors.

Criteria used to partition tracts of land are usually based on shared characteristics, such as similar climatic, physiographic, or vegetative conditions, or the presence or absence of significant components such as permafrost, or a plant species. In most cases, topographic features dictate the position of an ecoregion boundary, such as the break between a prominent mountain range and the adjacent plateau, or a large basin within a surrounding highland.

Some ecoregion boundaries are relatively subjective, being characterized by gradual transitions, such as where climate is thought to change over a physiographically uniform region. This is the case in the boundary placement between the Yukon Southern Lakes and the Yukon Plateau–Central ecoregions, as is the decision to segment the broad physiographic unit of the Yukon Plateau into northern and central units.

In other cases, the position of the boundary is relatively clear and the transition from one ecoregion to another is abrupt. For instance, the limit of moraine deposits marks the boundary between the glaciated Yukon Plateau–Central and the unglaciated Klondike Plateau ecoregions. The Old Crow Flats Ecoregion is delineated based on its rather level, lake-rich surface that distinctly differentiates it from the gently sloping pediments of the surrounding Old Crow Basin Ecoregion. In the same way, the British-Richardson Mountains Ecoregion is clearly distinct from the adjacent Yukon Coastal Plain Ecoregion in the northern Yukon.

To create a digital map of ecoregions for the country, an existing 1:1,000,000 soil landscape map set was used as a basis for placing ecoregion boundaries. As such, each ecoregion boundary corresponds to a change in general soil conditions. Nesting ecoregion boundaries with the more detailed soil landscape polygons allowed data from that level of mapping to be used to describe the larger ecoregions. Because soil landscape mapping existed for all of Canada, a consistent method of locating ecoregion boundaries was used across the country. However, for local depictions of ecoregion boundaries this scale may be too coarse and boundary placements must be logically refined to fit a 1:250,000 topographic base.

Sector-specific resource mapping (i.e. geological, soil, forest cover or habitat maps) is well suited for specific purposes and is designed to meet focused needs. It has limitations, however, for state of the environment and resource sustainability reporting, which must consider linkages both between and among the various ecosystem components. Conversely, ecological classification, at any given level of generalization, gives up the specific detail found in single resource surveys in favour of more general integrated data from many resources. This integrated view of landscape is essential to ecological status reporting, land use and protected area planning, and environmental assessment.

Therefore, there is no absolutely correct shape, size, or number of ecoregions for the Yukon. These divisions are based on concepts of ecological structure and the perceptions of resource specialists. It is inevitable that, as more is learned about ecological processes on our landscapes and those of our neighbouring jurisdictions, the ecological framework in the territory will be revised.

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YUKON OVERVIEW

■ GEOGRAPHIC SETTING

The Yukon Territory, situated in the northwestern part of Canada (Fig. 1), shares its southern boundary along 60°N latitude with British Columbia and the western boundary borders Alaska at 141° longitude. The Beaufort Sea forms its northern coastline. The eastern boundary, for the most part, follows the height of land between the Yukon and Mackenzie River watersheds, from about 130°30'W longitude in the north to about 124°W longitude in the south. The total area of the Yukon Territory, including all land and enclosed waterbodies, is approximately 483,450 km^2 (Yukon Bureau of Statistics, 1999).

At the end of 2001, the Yukon human resident population was 30,418 (Yukon Bureau of Statistics March, 2002). The largest population centre is Whitehorse (pop. 23,310), followed by Dawson City (pop. 2,059), Watson Lake (pop. 1,652), and Haines Junction (pop. 797).

■ PHYSIOGRAPHY

by Karen McKenna and Scott Smith

The Yukon is part of the Canadian Cordillera, the system of mountain ranges that run generally in a north–south direction from the U.S. border to the Beaufort Sea. The complex topography of rugged mountains, plateaus, lowlands and valleys is a result of deposition, volcanic activity, deformation and plate movement along the western margins of the North American craton, extensively modified by glaciation, erosion and weathering.

The physiography of the territory varies from the gently sloping Yukon Coastal Lowland along the Beaufort Sea in the north to the ice-covered Icefield Ranges in the southwest. Between these two extremes are extensive plateaus, lowlands and numerous mountain ranges (Fig. 3). The physiographic elements (Fig. 4) and nomenclature

J. Meikle, Yukon Government

Figure 3. Dragon Lake and the Macmillan Highland within the Yukon Plateau–North Ecoregion illustrate the diversity of landscapes within the Omineca physiographic belt. One of five physiographic belts in the Yukon, the Omineca Belt lies northeast of the Tintina Trench and is comprised of old North American craton rocks punctuated by massifs such as Mount Sheldon (middle distance). Most of the belt has been recently glaciated. An esker forms a long peninsula extending into the lake.

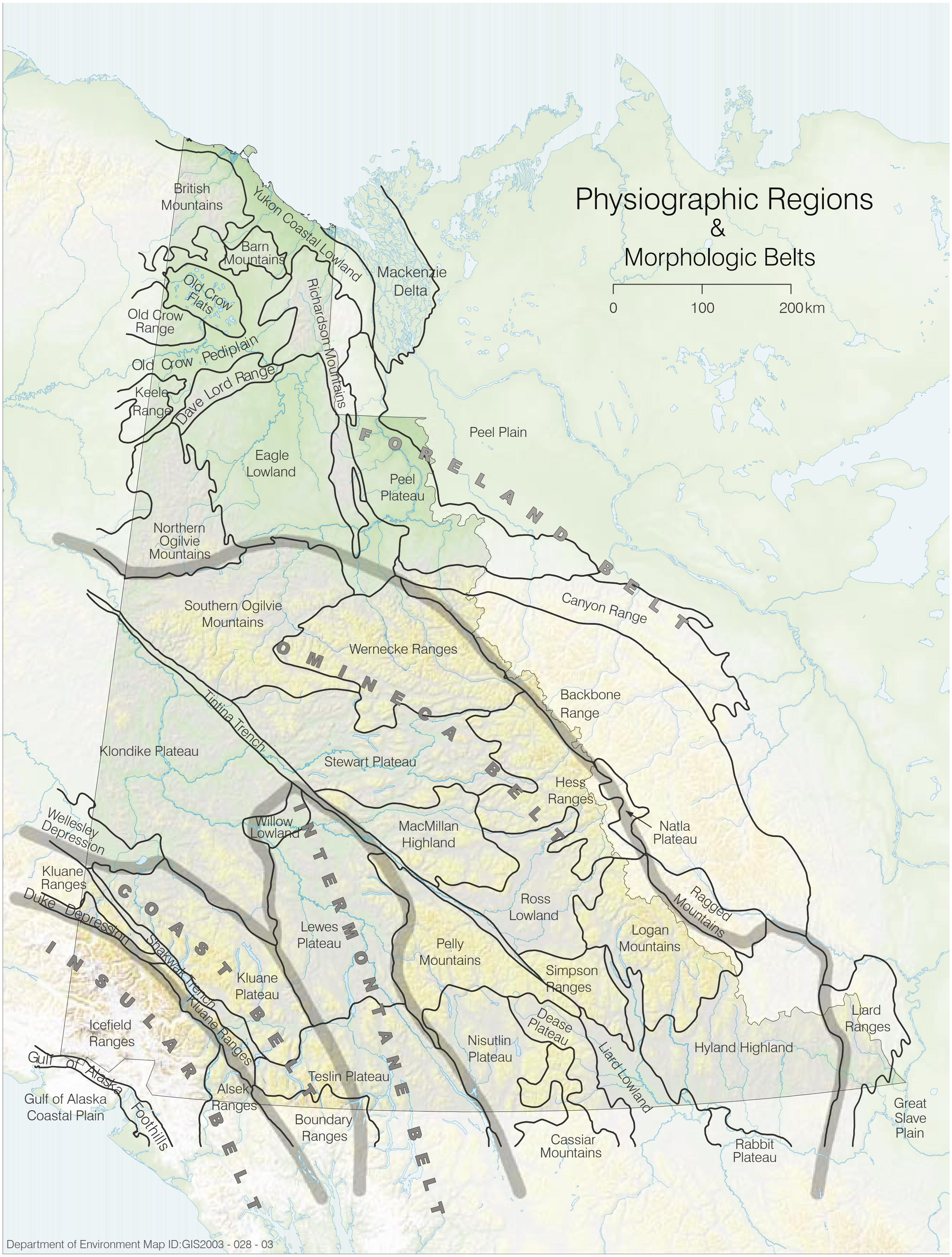

Figure 4. Physiographic regions and morphologic belts of the Yukon. Adapted from Mathews (1986) and Gabrielse *et al.* (1991).

of Mathews (1986) are used in these descriptions of Yukon ecoregions.

The Canadian Cordillera is composed of five physiographic or morphogeologic belts (Fig. 4). They are, from east to west: the Foreland, Omineca, Intermontane, Coast and Insular belts. These narrow elongated belts trend northwest–southeast and extend over much of the western Canadian cordillera.

The Foreland Belt is composed of deformed sedimentary rocks deposited on or adjacent to the stable North American craton. In the Yukon, the Foreland Belt covers the northern portion of the territory and includes the following major physiographic units: the British, Barn, Richardson and Northern Ogilvie mountains; the Yukon Coastal Lowland; the Eagle Lowlands; Old Crow Pediplain; Old Crow Flats; and Peel Plateau.

The Omineca Belt is an uplifted area underlain mainly by metamorphic and granitic rocks. It includes the Wernecke, Hess, Logan, Pelly and Southern Ogilvie mountains physiographic units as well as the Stewart, Klondike and Nisutlin plateaus; MacMillan and Hyland highlands; and Ross and Liard lowlands. The northwest–southeast-trending Tintina Trench bisects the belt separating the old North American craton from more recent geology. Most of the belt was glaciated and is characterized by large massifs, rounded hills and broad U-shaped valleys (Fig. 3). In contrast, the unglaciated northwest part of the Omineca Belt is a maze of unglaciated, steep-sided valleys separating small level plateaus, which are remnants of an old erosion surface.

The Intermontane Belt, as its name suggests, is an area of more subdued topography underlain by slightly metamorphosed volcanic and sedimentary rocks. It is separated from the Omineca Belt to the east by the Teslin fault. To the west, it is distinguished from the Coast Belt by its more subdued topography. In the Yukon, it includes the area around Whitehorse, Lake Laberge, and Atlin Lake and the Teslin and Lewes plateaus.

The Coast Belt is composed of Coast Plutonic granitic and metamorphic rocks. The major physiographic units included in the Coast Belt include the Kluane Ranges and Kluane Plateau. The Shakwak Trench separates it from the Insular Belt to the west.

The Insular Belt incorporates the Icefield and Alsek ranges. These are high, rugged mountains composed of sedimentary rocks, intruded by igneous rocks, and dominated by icefields and mountain glaciers. The rugged topography reflects tectonic uplift and rapid denudation by glaciers during the last 15 million years.

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BEDROCK GEOLOGY

by Charlie Roots and Craig Hart

Most of the Yukon comprises the northern part of a broad mountain belt known as the Cordillera; only the Peel Plateau Ecoregion lies within the adjacent Western Canadian Sedimentary Basin. Sedimentary, igneous and metamorphic rocks of different ages are present and these are defined in five belts that largely coincide with the physiographic belts previously described. Bedrock is abundantly exposed in the Yukon because much of the land surface is relatively high and the soil cover is thin. Exceptions, where a thick mantle of unconsolidated deposits cover the bedrock, are the Coastal Plain, Old Crow Flats and Basin, Eagle Plains, Peel Plateau and Liard Basin ecoregions.

Ecoregion boundaries in the Yukon rarely coincide with geological boundaries, because the latter are based solely upon the age and composition of the rocks. Geological maps (the commonly used scales are 1:50,000, 1:250,000 and 1:1,000,000) are available from government map outlets. These maps show the distribution of rock formations of various ages, and landscape features that are variably influenced by the nature of the underlying rocks.

Two extinct faults slice northwestward across the Yukon. The Tintina and Denali faults were active over tens of millions of years; along each the south side was offset hundreds of kilometres to the northwest. Thus, the geological map of the Yukon (Fig. 5) depicts three disparate rock packages, separated for the most part by the linear valleys of Tintina and Shakwak (Denali) trenches.

The Tintina Trench is nearly parallel to the fundamental break between sedimentary rocks that were originally deposited on the ancient continental margin (known as the miogeocline), and a mosaic of terranes. These terranes are interpreted as fragments of the earth's crust that originated as islands, former continents and slivers of ocean floor that formed as much as 3000 km away. The convergence of these terranes and resulting crumpling of the miogeoclinal sediments began at about 190 million years (Ma) and continues today. This orogeny defines these rocks as the Cordilleran mountain belt.

The terranes came into contact with the miogeoclinal sedimentary package because they were riding on plates of oceanic crust that subducted eastward beneath the western margin of the continental plate. Some terranes that were caught up between the plates were moved or smeared along faults parallel to the continental margin. The interactions of tectonic plates that formed the Yukon (called accretion) resulted in regional buckling and heating (called deformation and metamorphism) and were over by about 160 Ma, except in the southwest.

A third component in Yukon geology are overlap assemblages. These are much less deformed sedimentary and volcanic rock units deposited atop both the deformed miogeocline and terranes after they were tectonically joined. Erosion has removed much of the uppermost portion of these formations, and only the largest remnants are shown on Figure 4. Erosion has also exposed many granitic intrusions (also known as plutons) that resulted from cooling of molten magma that was trapped in the crust. Granitic rocks that cooled in the Cretaceous period (at 100±10 Ma) predominate in the Yukon.

As a handy reference, a geologic time scale is reproduced as an appendix at the back of this report.

MIOGEOCLINE

Prior to 190 million years ago, a broad shallow marine continental shelf characterized North America's western continental margin. The shelf accumulated carbonate and clastic sediments for over a billion years. These rocks now define what is called the Mackenzie Platform. The total thickness of sedimentary layers is as much as 14 km. The oldest strata (from 1850 to 500 Ma) are exposed in uplifted blocks in the Ogilvie, Wernecke and Mackenzie mountains.

Beginning during the Ordovician period (at about 450 Ma), a submarine rift valley developed within the continental shelf. This region of deeper water accumulated sediments in what is now known as the Selwyn Basin. Its oldest rocks are sandstone and grit, overlain by dark shale and chert, with volcanic flows that erupted from undersea rifts. In the Devonian period (about 380 Ma), black siltstone and pebble conglomerate were deposited over both the Selwyn Basin and adjacent Mackenzie Platform. These were subsequently covered by extensive sandstone, limestone, and shale until about 170 Ma, when they were uplifted above sea level.

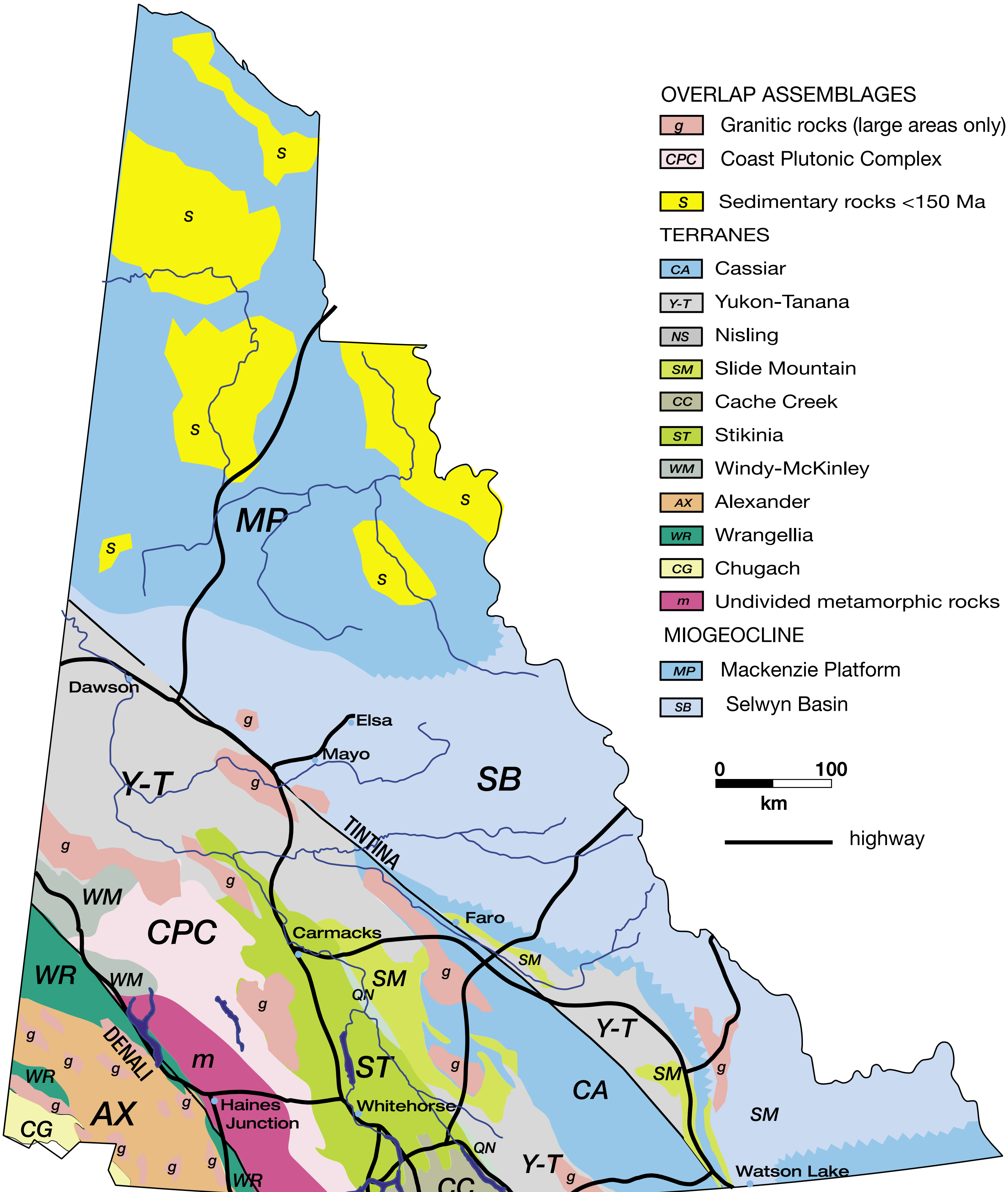

Figure 5. Major associations of bedrock in the Yukon, from Bedrock Geology of Yukon Territory (Gordey and Makepeace, compilers, 2001); Geological Survey of Canada, Open File map 3754; and Exploration and Geological Services Division, Indian and Northern Affairs Canada, Open File 2001-1; map scale 1:1,000,000.

TERRANES

Ten terranes, each separated from the others by faults, are recognized in the Yukon. Some terranes consist of fault-bounded packages of miogeoclinal sedimentary rocks (e.g. Cassiar). Others contain continent-derived sediments overlain by remnants of volcanic arc rocks (Yukon–Tanana, Nisling). In contrast, Slide Mountain and Cache Creek terranes consist of ocean floor volcanic rocks as well as deep-sea sediments and fossils from far-away oceans.

Yukon–Tanana Terrane underlies most of the Omineca morphogeological belt in the Yukon and extends into adjacent Alaska and British Columbia. Dominant rocks are quartzite, quartz–mica schist and marble older than 360 Ma, granitic and volcanic rocks between 350 and 250 Ma.

Stikinia, a large terrane in northern British Columbia, contains Triassic (220 Ma) volcanic rocks, limestone, sandstone, conglomerate and volcanic tuff. It contains remnants of an ancient volcanic island arc system, with flanking limestone reefs and sediments. The red conglomerate near Braeburn and the limestone of the light-coloured mountains east of Lake Laberge and Whitehorse are conspicuous members of Stikinia.

Quesnellia, an extensive terrane in central British Columbia, is represented in the Yukon by several ridges of volcanic and sedimentary rocks east of the Teslin River.

Slide Mountain, Cache Creek and Windy–McKinley terranes include sea-floor volcanic rocks overlain by chert, limestone and shale deposited between 320 and 190 Ma. Both Slide Mountain and Cache Creek terranes represent slices of ancient oceanic crust and contain ultramafic rocks so rich in iron and magnesium and poor in alkaline nutrients that covering vegetation is stunted or non-existent.

The remaining terranes are southwest of Denali Fault. Wrangellia and Alexander terranes are island-arc and ocean-floor volcanic rocks with thick assemblages of overlying oceanic sediments, including a white limestone band several kilometres thick. Further southwest, separated by the Border Ranges Fault, are Chugach and Yakutat terranes composed of 20 to 90 Ma sediments that were originally deposited on the Pacific Ocean floor. They were uplifted and accreted onto the western margin of North America as oceanic crust was subducted beneath the Gulf of Alaska.

OVERLAP ASSEMBLAGES

The geological framework of the Yukon includes several volcanic and sedimentary rock formations, as well as granitic intrusions that post-date the amalgamation and accretion of the terranes.

Sedimentary rocks

Younger sedimentary rocks (less than 150 Ma) are sparse in the southern Yukon, but underlie the Eagle Plains and are scattered outcrops surrounding the Old Crow basin and the coastal plain. Shale, mudstone and fine brown sandstone are the predominant rock types in the northern Yukon. They formed in a shallow marine and non-marine basin that received sediments from the rising mountains to the southwest.

During the Late Jurassic and Early Cretaceous periods (100 to 150 Ma), an intermontane basin formed in the central Yukon. Its remnants are the Tantalus Formation of sandstone and conglomerate with significant coal deposits.

Uplift of what is now the central Yukon resulted in the deposition of a large submarine fan to the southwest. Muddy sandstone of the Dezadeash Formation is presently exposed in the Front Ranges of the St. Elias Mountains. Much later the rising St. Elias ranges gave rise to the youngest sedimentary rocks in the Yukon. Crumbling remnants of alluvial conglomerate and sandstone during the Oligocene epoch (about 25 Ma) comprise the Amphitheater Formation.

Volcanic rocks

Major volcanic rock formations that formed in the Yukon after accretion of the terranes include:

- felsic to intermediate centres and dyke swarms of the Mount Nansen suite (100 Ma) in Yukon Plateau–Central Ecoregion;
- the South Fork volcanics of similar age in large (40 km across) sub-circular calderas (no volcanic landform remains) north of Ross River;
- plateau-like flood basalts (70 Ma) west and south of Carmacks; and
- semi-circular areas of high peaks and cliff-lined ridges in the southern Yukon that consist of colourful fragmental volcanic rocks (55 Ma).


J. Meikle, Yukon Government

Figure 6. View north of Volcano Mountain, the only volcanic landform remaining in the Yukon. The cinder cone remains from an eruption 5,000 to 10,000 years ago. Toward the end of the eruption, lava flows breached the cone (to left and right, foreground). Common herbs, such as fireweed (*Epilobium angustifolia*) and gentian *(Gentianella propinqua)*, display a uniquely stunted growth form on the vesicular lava.

Reddish-brown basalt lava are visible at Miles Canyon, Whitehorse Rapids and Fort Selkirk. These flows erupted in several episodes between 8.5 and 15 Ma. The only volcano of geologically recent age is Volcano Mountain, a large cinder cone north of the confluence of the Yukon and Pelly rivers (Fig. 6). The last eruption of this volcano could have been as recent as 5,000 to 10,000 years ago. A white tephra layer within the soil profile of the southern Yukon results from an eruption in AD 803.

Granitic rocks

Almost 30% of the southwestern Yukon is underlain by plutons that include a wide spectrum of rock types; tonalite and granodiorite are the most common. The Coast Plutonic Complex contains intermingled intrusions that range between 185 and 55 Ma. The western side of this belt was dramatically uplifted at 50 Ma, exposing deeper granites at the White and Chilkat passes that originally cooled 20 km beneath the surface.

Hundreds of small, typically sub-circular, intrusions are exposed in the Selwyn Basin. The more prominent ones are mentioned in the ecoregion descriptions. Some granitic bodies are exposed as jagged ridges and dramatically steep walls. Others are relatively easily eroded, but the surrounding sedimentary or volcanic rocks are thermally hardened and much more resistant. These are important in an ecoregion context, because they weather differently and lead to different soil types. Typically, the igneous rocks are low in soluble calcium, so that resulting soil and runoff are acidic.

Faults

Tintina Fault has at least 450 km of right lateral displacement, where the south side moved northwest, between 55 and 100 Ma and possibly more recently. At least 350 km of offset is inferred on the Denali Fault. Both faults remain as weak zones that respond to minor tectonic strain. Large earthquakes periodically occur along the Duke River Totschunda and Columbia fault segments of the Denali Fault System in the St. Elias Mountains of the Yukon, and southwest in the Alaska panhandle.

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WATERSHEDS AND HYDROLOGIC REGIONS

by Ric Janowicz

The Yukon is drained through six major watersheds, each composed of several tributaries (Fig. 7). Southerly flowing rivers usually freeze in a progressively downstream direction; northerly flowing rivers are frequently hampered by the freezing of water at downstream points, often resulting in the formation of aufeis. This condition is particularly common in the northern half of the Yukon.

The Liard River, a tributary of the Mackenzie River, drains the southeast corner, comprising about 12% or approximately 58,000 km^2 of the Yukon. Major tributaries include the Rancheria, Meister, Frances, Hyland, Coal, Rock, Beaver and La Biche rivers. This watershed drains most of the Logan and Cassiar mountains and the southeast portion of the Saint Cyr Range of the Pelly Mountains (Fig. 4). Frances Lake is by far the largest in the watershed; Finlayson, McEvoy, McPherson, Tillie, Sambo, Simpson, Watson and Toobally lakes are of moderate size.

The Aishihik Basin, east of the St. Elias Mountains, is drained to the south by the Alsek River, which crosses the extreme northwest corner of British Columbia and a portion of Alaska to enter the Gulf of Alaska. This watershed comprises about 4% or approximately 19,000 km^2 of the Yukon. Major tributaries include the Aishihik, Dezadeash, Kaskawulsh and Dusty rivers. Aishihik, Dezadeash and Sekulman lakes are relatively large; Kathleen, Mush and Bates lakes are of moderate size.

The Yukon River watershed comprises approximately 54% or about 260,000 km^2 of the Yukon Territory and drains to the northwest. Its major tributaries include the White, Donjek, Nisling, Nordenskiold, Takhini, Teslin, Pelly, MacMillan, Stewart and Klondike rivers. The Yukon River traverses Alaska to empty into the Bering Sea, a total length of over 3,680 km. Many large lakes are present, including Teslin, Tagish, Bennett, Marsh, Laberge, Wellesley and Kluane — the largest in the Yukon.

The Peel River watershed, also a tributary of the Mackenzie River, drains about 14% or approximately 68,000 km^2 of the Yukon, providing drainage

Figure 7. Major drainage systems of the Yukon.

for the main portion of the Wernecke Mountains, the northwestern portion of the Ogilvie Mountains and the southwestern portion of the Richardson Mountains. Major tributaries include the Ogilvie, Blackstone, Hart, Wind, Bonnet Plume, Snake, Vittrekwa, Road, and Caribou rivers (Fig. 7). Several small lakes occur in the watershed, especially in the Bonnet Plume Basin.

The Porcupine River watershed drains about 12% or 58,000 km^2 of the Yukon, including the southern portion of the British Mountains, the western portion of the Richardson Mountains and the northeastern portion of the Ogilvie Mountains. Though the Porcupine River drains into the Yukon River at Fort Yukon, Alaska, and is actually a part of the Yukon watershed to the south, the two portions are treated as separate watersheds. Major tributaries include the Bell, Rock, Eagle, Whitestone, Miner, Bluefish, and Old Crow rivers. Small- to moderate-sized lakes are abundant in the watershed, especially in the Bluefish, Bell and Old Crow Basin areas. Many of these lakes are oriented in a northwest–southeast direction.

The remaining portion of the Yukon, about 4% or 19,000 km^2, drains northward directly into the Beaufort Sea. Major drainages include the Big Fish, Blow, Babbage, Firth and Malcolm rivers. Small lakes are abundant in the coastal plain portion of the North Slope watershed.

YUKON HYDROLOGIC REGIONS

The Yukon landscape consists of four major drainage reservoirs: the Bering Sea (Yukon and Porcupine rivers), the Gulf of Alaska (Alsek River), the Beaufort Sea via the Mackenzie River (Liard and Peel rivers) and the Beaufort Sea via direct, north slope drainage. Hydrologic response characteristics are grouped into four categories (regions) based on streamflow magnitude and timing. Though there are some similarities, these regions do not directly correspond to the major drainage basins, which are largely related to physiography. The four Yukon hydrologic regions are related to climate: directly through response to precipitation and temperature; and indirectly through its effect on vegetation, permafrost and glacier distribution and coverage. For reference, the hydrologic regions are named Western, Interior, Northern and Arctic (Fig. 8) and correspond roughly to the Pacific Maritime, Boreal Cordillera, Taiga Cordillera and Southern Arctic ecozones, respectively. Table 2 summarizes streamflow within each ecoregion based upon data from measuring stations.

The Western Hydrologic Region, which is comprised primarily of the St. Elias and Coast mountains, includes the eastern portion of the Pacific Maritime Ecozone. This hydrologic region experiences both the highest mean annual precipitation and temperature in the territory, and subsequently has the greatest mean annual runoff. Streamflow response is characterized by a rapid increase in discharge in the early summer in response to snowmelt at lower elevations, which increases to the annual peak later in the summer in response to higher elevation snow and glacier melt (Fig. 9). Summer rainstorms often produce secondary peak events, and sometimes the annual peak after intense rain events. Minimum streamflow generally occurs during March in response to minimum groundwater inputs. Because of the relatively mild winter temperatures, minimum winter streamflow amounts are the highest in the

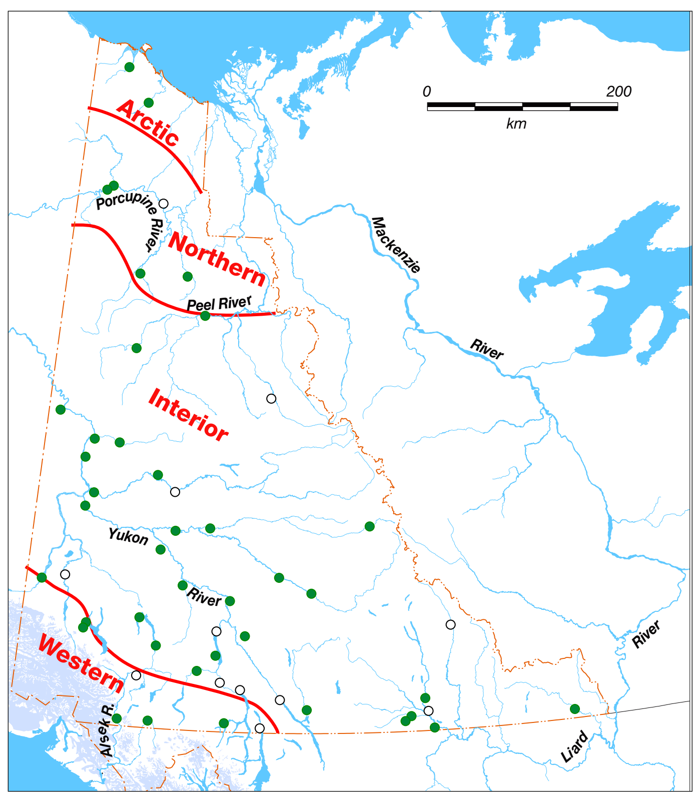

Figure 8. The four hydrologic regions of the Yukon. The dots indicate hydrometric stations used to compile streamflow statistics (Table 2). Open dots are inactive stations; solid dots represent active stations.

territory. Even the smallest streams generally have some winter flow during the coldest years.

The Interior Hydrologic Region is the largest of the four Yukon hydrologic regions, and is comprised of the plateaus and highland areas south and west of the Ogilvie and Mackenzie mountains, respectively. Streamflow is characterized by a rapid increase in streamflow discharge in May due to snowmelt, rising to a peak in June, after which summer rainfall maintains high flow for a few weeks. Summer rain events produce secondary peaks, and sometimes the annual maximum, especially from mountainous regions. Minimum streamflow generally occurs during March, when the relative magnitude is generally lower than in the Western region, due to lower winter temperatures limiting groundwater contributions. Some small streams may experience zero winter flows.

The Northern Hydrologic Region encompasses the Mackenzie Mountains Ecoregion in the south and the British–Richardson Mountains Ecoregion in the north. Streamflow characteristics are largely controlled by the continuous underlying permafrost (see Fig. 20). Peak flows, which normally occur in June, are greater relative to areas with less permafrost, due to shorter pathways through the watershed as a result of limited infiltration rates. As in other regions, summer rain events will produce

Table 2. Hydrological characterization of Yukon ecoregions. Flow and flood values are averages generated from all gauged streams expressed on a per area of watershed basis. Runoff is expressed in millimetres. As there is a strong relationship between total discharge and drainage basin area, these values are considered reasonable for overall ecoregion characterization. Mean seasonal flow covers the period from May through September and includes the spring freshet; mean summer flow covers the period July through September only.

Ecoregion Number	Name	Mean annual runoff	Mean annual flow	Mean seasonal flow	Mean summer flow	Mean annual flood	Maximum summer flood	Minimum summer flow	Minimum annual flow
		mm	(1 x 10^{-3} $m^3/s/km^2$)						
32	Yukon Coastal Plain	168	5.32	14.42	6.93	175.50	39.77	0.63	0.00
51	Peel River Plateau	193	6.11	12.61	9.40	108.02	35.81	1.59	0.11
53	Fort McPherson Plain	99	3.15	5.05	2.68	73.43	9.23	0.28	0.00
66	Muskawa Plateau	169	5.37	9.39	8.74	131.08	45.70	0.51	0.25
165	British-Richardson Mountains	208	6.60	15.78	11.40	127.61	35.07	1.89	0.01
166	Old Crow Basin	201	6.39	12.37	10.06	92.60	30.65	1.98	0.34
167	Old Crow Flats	98	3.09	7.05	3.53	55.83	11.87	0.34	0.03
168	North Ogilvie Mountains	324	10.28	22.18	16.95	92.40	46.22	7.49	0.90
169	Eagle Plains	201	6.39	12.37	10.06	92.60	30.65	1.98	0.34
170	Mackenzie Mountains	377	11.97	26.14	19.63	91.71	52.22	8.34	1.29
171	Selwyn Mountains	535	16.99	37.59	29.55	127.35	75.57	8.81	1.29
172	Klondike Plateau	NA	5.56	7.42	7.06	52.17	43.25	1.78	1.78
173	St. Elias Mountains	NA	15.62	30.76	32.24	93.83	137.99	6.12	1.61
174	Ruby Ranges	120	3.80	6.69	5.86	23.31	20.91	1.60	0.75
175	Yukon Plateau–Central	125	5.16	9.94	9.07	37.28	20.62	3.59	0.85
176	Yukon Plateau–North	309	9.80	18.82	13.68	69.71	39.79	4.74	1.04
177	Yukon Southern Lakes	245	7.78	14.43	10.90	43.97	28.58	3.91	1.61
178	Pelly Mountains	296	9.80	19.26	14.59	NA	36.62	6.14	1.66
179	Yukon–Stikine Highlands	316	10.05	20.73	17.31	63.29	41.73	6.88	1.65
180	Boreal Mountains and Plateaus	576	18.30	39.29	35.99	92.43	78.14	11.25	2.58
181	Liard Basin	260	8.26	14.75	11.41	41.11	32.59	4.52	1.67
182	Hyland Highland	250	7.91	11.97	10.26	61.69	32.84	3.33	1.76
184	Mount Logan: icefields	no streams							
NA: not available									

secondary peaks, and sometimes an annual peak on smaller streams, especially in mountainous areas. Minimum flows generally occur in March and tend to be lower than the Interior and Western hydrologic regions to the south, because of the effect of lower winter temperatures on groundwater flow. Small streams within this region frequently experience zero flow, while some intermediate-sized streams may occasionally experience zero winter flow.

The Arctic Hydrologic Region is bounded in the south by the British–Richardson Mountains Ecoregion, and in the north by the Beaufort Sea. The controlling influence of the underlying continuous permafrost on hydrologic response is extreme. Although the area receives very little precipitation, streamflow generation is significant. Peak flows, which generally occur in June, exhibit very quick response times because of the shallow active layer. There is very little infiltration to groundwater and evapotranspiration rates are low resulting in snowmelt runoff, which is quickly transported to the stream channel with little loss. Likewise, summer rain events produce significant peak flows that are flashy in nature. Because of the relatively small streamflow generating areas, the largest streams within this region may be considered intermediate. All streams likely experience zero winter flows from November to April.

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J. Meikle, Yukon Government

Figure 9. The White River drains northeast from the St. Elias Mountains and then north through the Klondike Plateau Ecoregion. Streams that drain the Kluane Ice Fields, such as the Generc, White and Donjek rivers, are heavily laden with glacial silt and tend to braid as the silt load is deposited. The primary peak flow in these rivers is during midsummer at the peak of melting in the icefields.

■ CLIMATE

by Herb Wahl

The Yukon's climate is subarctic continental — it is relatively dry with major temperature variability both daily and seasonally. Major orographic barriers, oriented in a southeast to northwest through the Yukon, strongly affect precipitation and temperature patterns. These broad physiographic barriers are composed of a series of broad mountain ranges and complexes of ranges and are used as the names for the climatic zones shown on Figure 10. Annual precipitation on coastal Alaska varies between 2,000 to 3,500 mm, whereas within the Yukon, low elevation valley floors receive only 250 to 300 mm (Fig. 11). Over the higher barriers within the Yukon, amounts are nearer 400 to 600 mm.

Temperature regimes are much more complex, due to both latitude and elevation. On an annual mean basis, the latitude effect is evident, showing a range from near –2°C over the southern Yukon to below –10°C along the Arctic Coast (Fig. 12).

Seasonal temperature variations in the Yukon are the most extreme in Canada, ranging from a minimum of –62.8°C at Snag to a maximum of 36.1°C at Mayo. Daily temperature variations of 20 to 30°C are not uncommon. Although summers are relatively cool, mean daily temperatures are generally above zero from May through September. July is the only month when temperatures below freezing do not occur at all in most of the territory. As both the Arctic and the North Pacific oceans are subject to frequent storms, the southwestern Yukon and the Arctic Coast are subject to more wind and cloud than the rest of the Yukon.

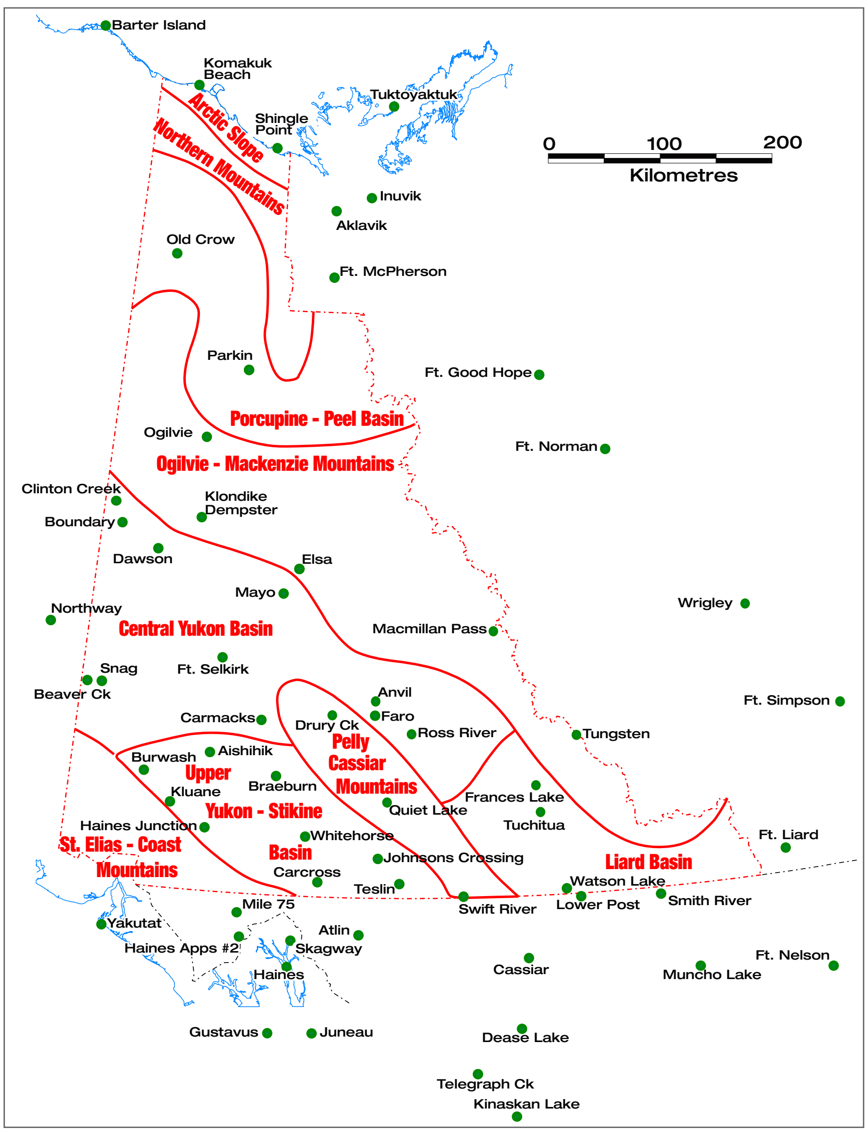


Figure 10. The climatic zones of the Yukon and the weather stations, both active and inactive, that were used to generate regional climate values. These also appear in Figures 11 and 12. (Adapted from Wahl *et al.* 1987)

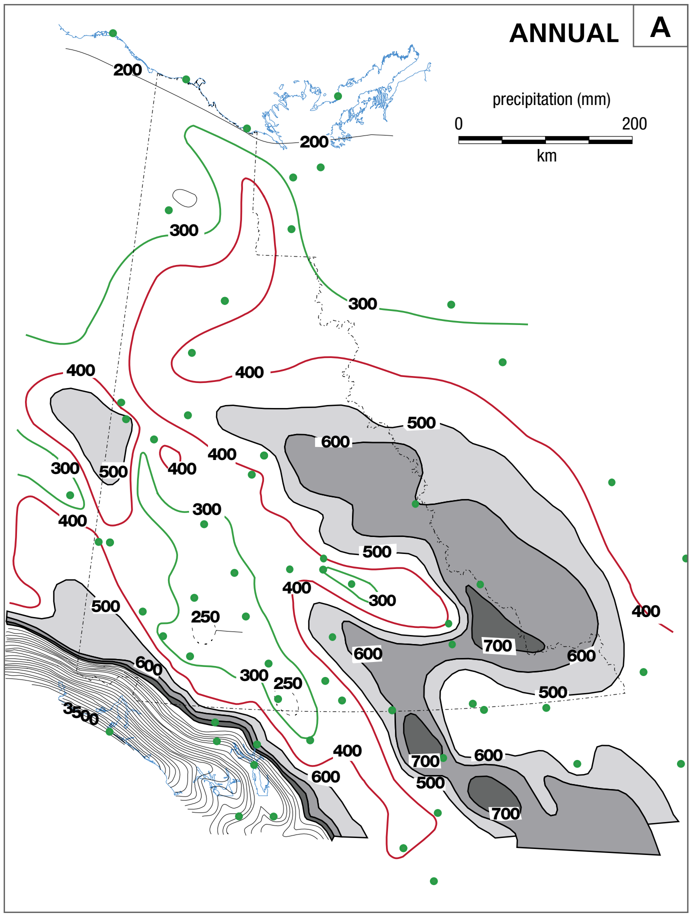
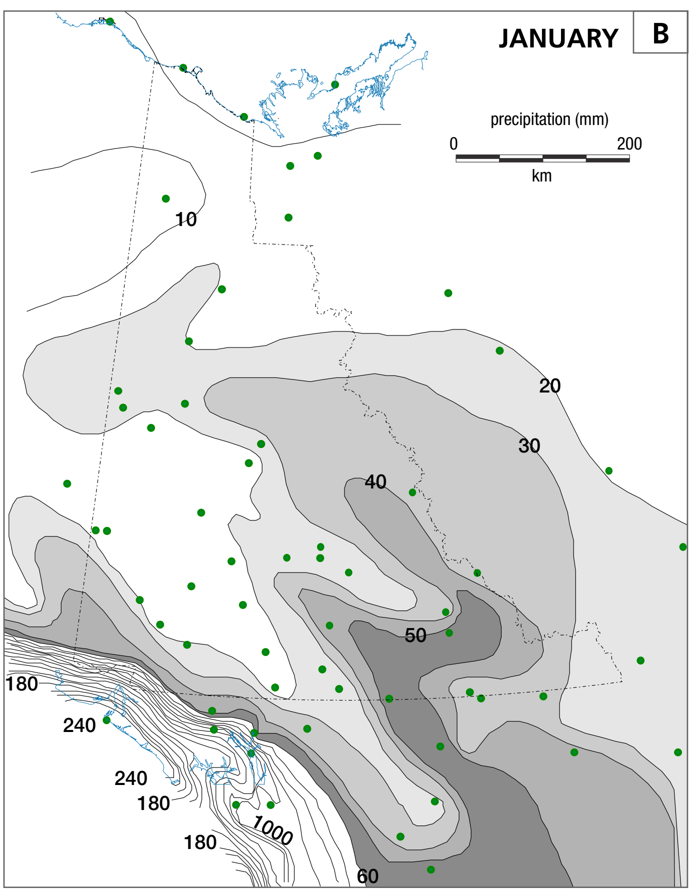
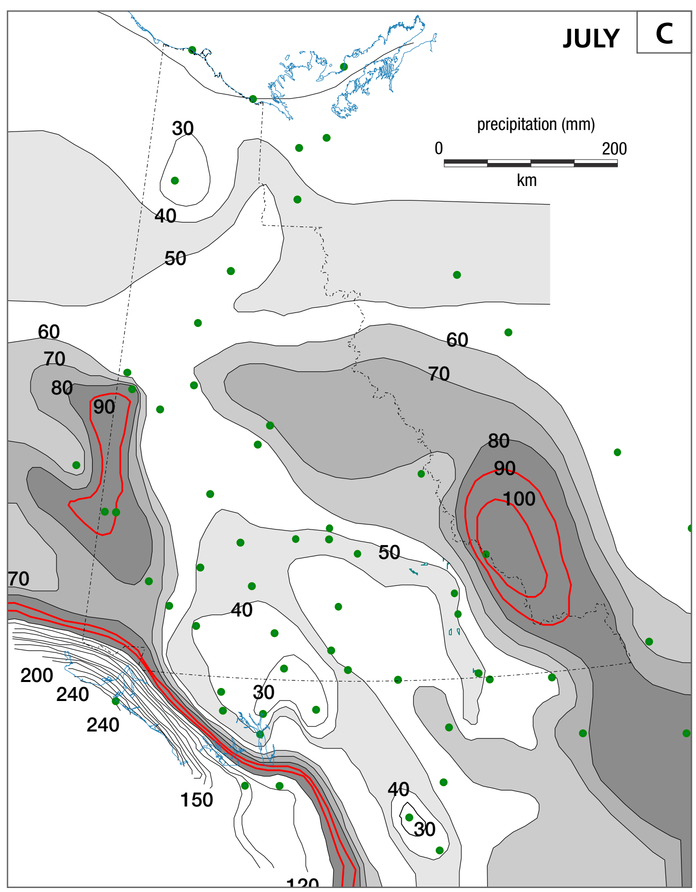


Figure 11. Mean total precipitation: (a) annual, (b) January, (c) July.





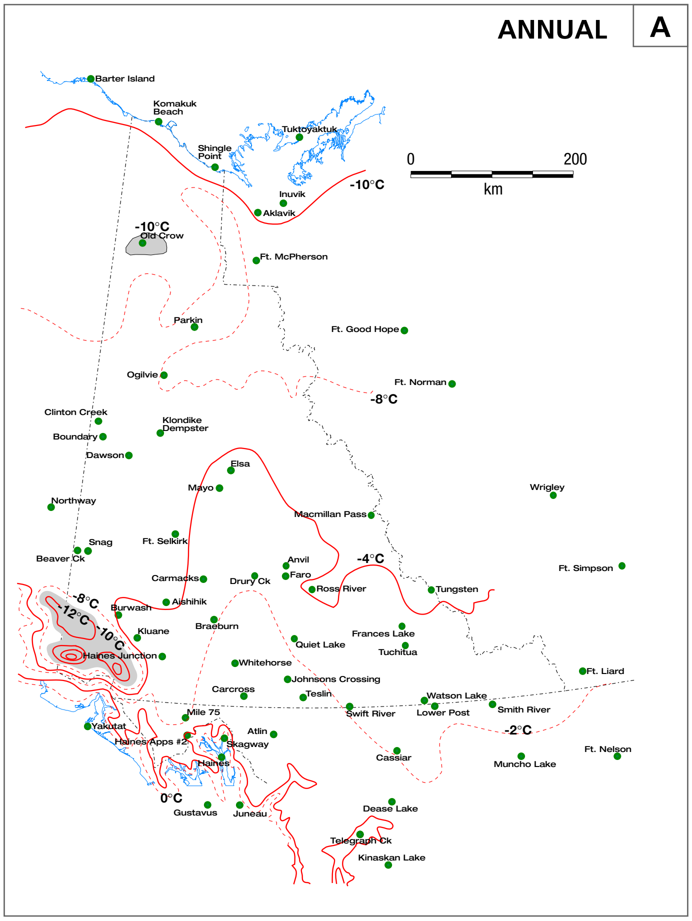
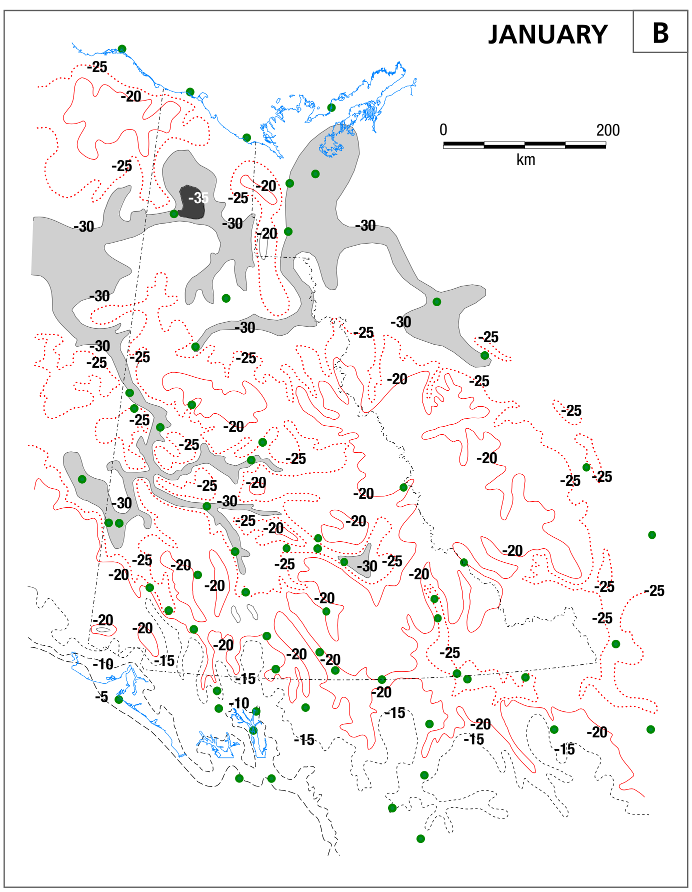
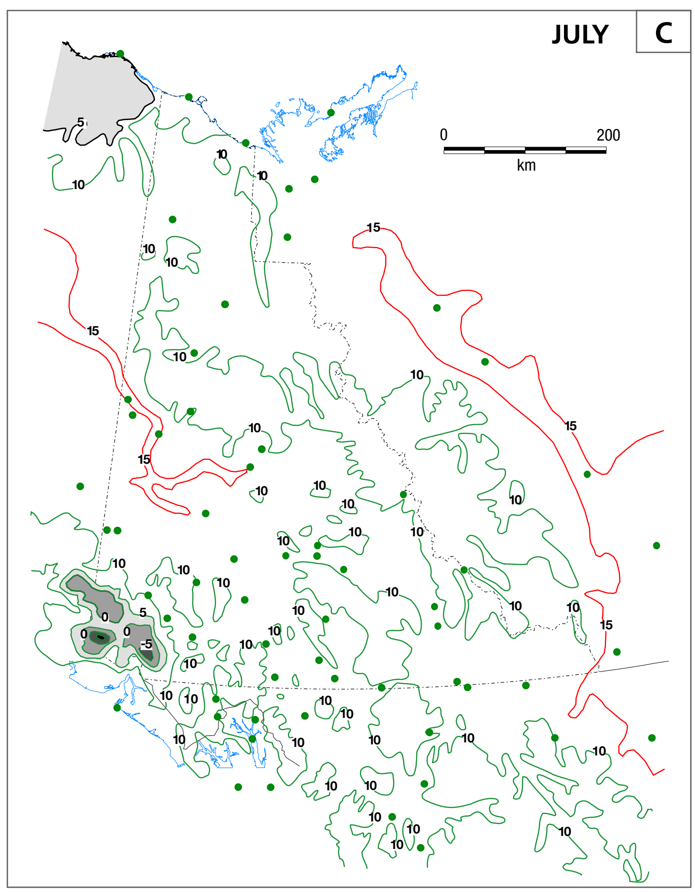


Figure 12. Mean daily temperature in °C: (a) annual, (b) January, (c) July.





CLIMATIC CONTROLS

Latitudinal effects and solar radiation

The Yukon lies between latitudes 60°N and 70°N. At these latitudes, the hours of possible sunshine in the southern Yukon range from 19 hours per day on June 21 to less than 6 hours per day on December 21. At Herschel Island, on the Yukon's north coast, there is continuous sunshine from May 20 to July 23 and the sun is continually below the horizon from December 1 to January 3. The angle of the sun above the horizon is lower over the Yukon than in southern Canada, therefore, the solar energy available to the Yukon averages only 60% of that of extreme southern Canada. Furthermore, the Earth itself is a radiating body and loses heat steadily through long-wave radiation cooling. When the sun is well above the horizon, the solar radiation being absorbed exceeds the long-wave cooling; the earth warms and the air temperature rises. From November to February when the sun is low above the horizon, more energy is lost than gained and the temperature will fall even during a clear, sunny day and, of course, more rapidly after the sun sets. When microclimates are being evaluated, it should be recognized that slopes facing to the east, south or west are more perpendicular to the sun's rays and therefore absorb more of the sun's heat.

The distribution of land and water masses

Land masses react quickly to radiation heating and cooling but only to a relatively shallow depth. Large waterbodies however, with their high heat capacity, appear to react more slowly since, through mixing, the heat is distributed through a greater depth and thus is available for a longer time.

The Pacific Ocean (Gulf of Alaska) has a great control on the territory's climate. Always a source of moist air, its relatively constant temperature is a potential heat source during the winter and has a moderating influence on summer temperature. Its effectiveness is dependent on weather patterns and wind direction; the predominant airflow over the Yukon is from the south and west.

The Arctic Ocean is a cold body of water and is predominantly covered with ice even in the summer. Therefore, its effect as a climate modifier is limited primarily to the immediate Arctic Coast.

Orographic barriers and their effect on precipitation

The primary prerequisites for precipitation are a moisture source and a lifting mechanism. Air that is lifted cools and the moisture in the air mass turns into cloud and precipitation. The lifting can be caused by storms, by convection, or by air being forced to rise over an orographic barrier. Conversely, air that is forced to descend on the lee of an orographic barrier will be warm and dry and result in what is known as a rain shadow effect.

The main source of moisture for the Yukon is the Pacific Ocean. In a typical storm system, southerly winds force air masses to rise over the massive St. Elias–Coast Mountains. Consequently, most of the moisture is precipitated out on southern and western slopes of the barrier. The air then descends and dries, resulting in a rain shadow over the Ruby Ranges and Southern Lakes ecoregions. Air masses are then forced to rise over the Pelly and Cassiar mountains repeating, to a lesser degree, a cycle of increasing cloud and precipitation. A rain shadow is evident in the Finlayson Lake–Ross River portion of the Pelly Valley. The Mackenzie Mountains and Selwyn Mountains ecoregions act as a further orographic barrier. The British–Richardson Mountains Ecoregion, although not as formidable, also has enhanced precipitation compared with the surrounding lower terrain.

Less frequent are weather conditions that result in northerly or easterly winds. In these cases, the northern and eastern slopes would receive the heavier precipitation.

The relationship between orographic barriers and precipitation patterns is evident in Figure 13. Generally, precipitation increases with elevation with a maximum near 2,000 m asl. A review of Yukon data comparing precipitation amounts with elevation, allows a crude approximation of an increase of 8% for every 100-m increase of elevation, up to a maximum at 1,500 to 2,000 m asl and then a slow decrease with increased elevations. Stations being used in such calculations should lie on the same side of the mountain range as the area under consideration, where possible.

J. Meikle, Yukon Government

Figure 13. Rain clouds typically form on the south sides of prominent mountains in central Yukon. Here, the Kalzas Range in Yukon Plateau North Ecoregion acts as an orographic barrier. The local "rain shadow" on the north slope of this and the adjacent McArthur Range is important winter ground for woodland caribou of the Ethel Lake herd because the snow cover there is relatively thin.

TEMPERATURE AND ELEVATION

Normally, air temperature decreases with an increase in elevation at the rate of 6°C per 1,000 m. This change, known as the lapse rate, is in effect throughout the southern Yukon from April through October and in the northern Yukon from May through September. As days shorten during the winter, surface heat loss increases due to the long-wave radiation. Cold air will develop over all surfaces, although on mountain slopes this air, being relatively heavy, will slide into the valley bottoms. The result is a reversal of the normal lapse rate, known as an inversion. Air temperature, instead of being cooler with increased elevation, will remain isothermal through a vertical portion of the atmosphere or, in some cases, the temperature will actually rise with increased elevation.

In addition, inversions may be caused at lower elevations by very cold air masses from the Arctic. This arctic inversion is generally in place over the Yukon from late October to early March and is at its extreme in January. For example, temperatures in the valley floors may range from –20 to –30°C, but will increase at a rate of 3 to 5°C per 1,000 m to temperatures near –10 to –15°C at the 1,500-m above sea level. They will remain isothermal until they begin cooling again above 2,500 m at a more normal lapse rate of 5°C per 1,000 m. These inversions can be temporarily destroyed by strong winds mixing the warm air from above into the colder valley floors. This occurs most frequently over the southwestern Yukon.

Air temperature changes are greater in the vertical profile than in the horizontal. A change of 6°C per 1,000 m in the vertical is common. Yet in the horizontal, changes of 5 to 10°C are normal over distances of 500 to 1,000 km.

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■ GLACIAL HISTORY

by Alejandra Duk-Rodkin

The Yukon has a complex glacial history. Ice advanced northeastward and westward from lobes of the Cordilleran ice sheet, and westward in northern Yukon from the continental Laurentide ice sheets. These were augmented by montane glaciers during interglacial periods. Hills and valley walls were sculpted by moving ice, but the principal effect on Yukon landscape has been the landforms of glacial debris left in the valleys (Fig. 14), and the diversion of former drainage systems.

Glaciations in northwestern Canada were in part controlled by relative uplift of the coastal ranges (southwest Yukon/southeast Alaska) and the continental divide (Mackenzie/Selwyn mountains). These served as "snow fences" blocking northeastern incursions of moisture from the northern Pacific Ocean. During early glaciations, the coastal mountain barrier was lower than the continental divide. As the St. Elias/Wrangell/Alaska ranges uplifted from 4.0 Ma onward, less moisture crossed the coast ranges, resulting in progressively smaller icefields on the continental divide (Mackenzie/Selwyn and Richardson mountains) and the development of an extensive Cordilleran ice sheet. The stratigraphic record suggests that the older glaciers were more extensive than younger glaciers but the pattern of ice distribution was repeated. As the continental divide was lowered by successive Cordilleran glaciations and by erosion during interglacial periods, increasing moisture reached the interior plains where continental ice sheets accumulated.

CHRONOLOGY

The Yukon has one of the oldest records of glacial history in North America. Tidewater glaciers of the Alaska coastal ranges were probably present in the Miocene (5 Ma). The Cordilleran glaciation of southwestern Yukon may also be this old, but the extensive stratigraphic record of glaciations in central Yukon extends back only to the Late Pliocene (younger than 2.9 Ma). The chronology of Cordilleran glaciations in the Yukon is best documented for the most recent event, because evidence of earlier glaciations is mostly destroyed by subsequent advances. Different nomenclature has been used by various workers, but in central Yukon the glaciations described in this volume are called McConnell (from about 28 ka to 15 ka), Reid (from about 300 ka to 230 ka, but may be younger, based on revised tephra dating) and pre-Reid (probably many advances from 2.9 Ma to ca. 400 ka) (Fig. 15).

The Laurentide ice sheet covered all of the northern Interior Plains and reached the northeastern Yukon Territory about 30 ka. The top of the ice sheet ranged from an elevation of 1,585 m in the southern

J. Meikle, Yukon Government

Figure 14. The portion of the Yukon that experienced the most recent glaciation, the McConnell Glaciation, contains a wide range of glacial features such as these esker complexes north of Lake Laberge at Frank Lake (Yukon Plateau–Central Ecoregion). Eskers are smooth, sinuous, sandy ridges that formed as the riverbeds of torrents that flowed at the base of large glaciers that filled the valleys until about 13,000 years ago.

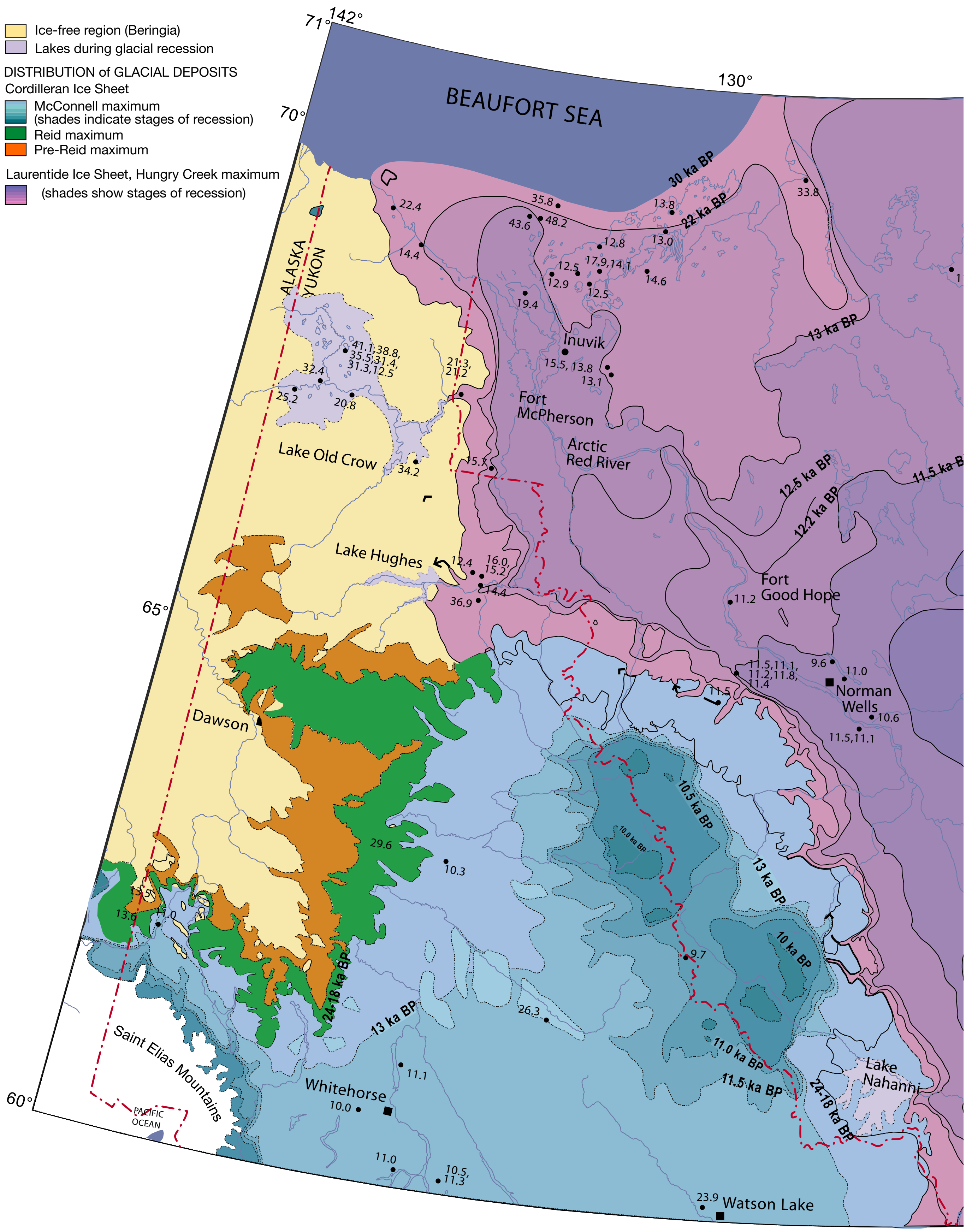

Figure 15. Areas of the Yukon and western Northwest Territories covered by glaciations in the past 3 million years. The timing and extent of glaciation are shown by shading and solid linework. Dotted lines represent stages of recession during the last glaciation. Points represent carbon dates used to establish time of deglaciation. (Adapted from A. Duk-Rodkin, 1999)

Mackenzie Mountains to sea level in the Mackenzie Delta region near Herschel Island. It left sediments which cover Bonnet Plume Depression and the eastern slopes of Peel Plateau.

DIVERTED DRAINAGES

Until at least 10 Ma, the Yukon contained headwaters of drainage systems that reached three oceans, namely the Arctic (antecedents of the Peel–Anderson, Porcupine rivers), Atlantic (former Bell River system) and Pacific (a paleo-Yukon River draining into the Gulf of Alaska) (Fig. 16a). Glaciation produced significant changes to the landscape. The most significant was the diversion of the Yukon River to the northwest, joining the Kwikhpak River in Alaska during the first regional glaciation (Fig. 16b). A major pro-glacial lake (Lake Yukon) was formed, which occupied the western part of the Yukon Valley in the Dawson Range. This glaciation also cut off the headwaters of the Tanana River, diverting it across the Dawson Range (now the White River). The diversion of the Yukon River added 20% to the present-day drainage basin. The last Cordilleran glaciation is responsible for most of the well-preserved features seen today, including meltwater channels, now abandoned or partially occupied by present day streams.

The Laurentide ice covered the Mackenzie region and changed the Cordilleran landscape dramatically by permanently diverting the Porcupine River into the Yukon River Basin, adding 7% to its present area. Furthermore, the ice sheet integrated all drainages along the eastern flanks of the northern Cordillera into a single drainage system, the Mackenzie River (Fig. 16b).

In total, glaciation has altered drainages in over 95% in northwest Canada. Most of the modern drainage of the Yukon is into only two major basins entering the Arctic Ocean via the Mackenzie River and the Bering Strait via the Yukon River (Fig. 16b).

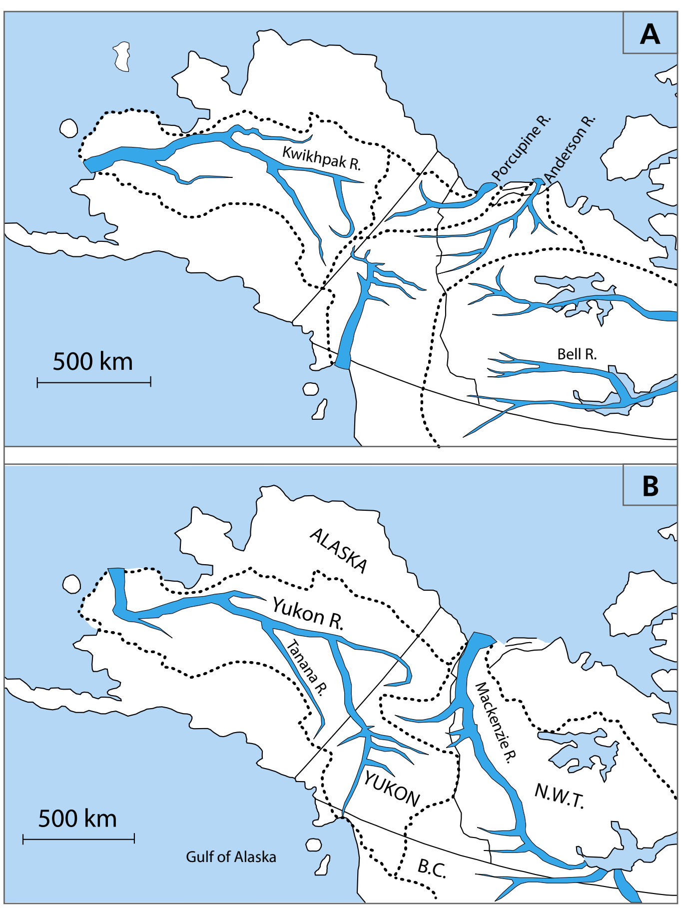

Figure 16. Dramatic changes in the drainage of northwestern North America occurred between pre-glacial (5 Ma) (Fig. 16A), and postglacial (since about 15 ka((Fig. 16B). Dotted lines outline watershed boundaries. Thickness of the drainage outline indicates relative volume of flow.

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SURFICIAL GEOLOGY

by Jeffrey Bond, Edward Fuller, Lionel Jackson and Charlie Roots

Some 60 million years ago, the Yukon was less mountainous than now, and the linear valleys underlain by active faults (Denali and Tintina) were swampy and periodically supported lush vegetation. For many millions of years, the higher ground was eroded by rain and wind, producing a landscape of rounded summits and broad peneplains. Most of the central Yukon drained southward and the trunk stream flowed westward through the Takhini valley to the proto-Pacific Ocean west of Dezadeash Lake. Until about 20 Ma, the area now occupied by Mount Logan Ecoregion consisted of low hills; these were periodically flooded by basaltic lava from volcanoes in the Wrangell Mountains of eastern Alaska (remnants of these lava flows are now perched above 2,000 m asl in the northern Kluane Ranges).

Evidence of the successive Quaternary glaciations is preserved within the surficial geology, although generally the older stages are only preserved where subsequent advances were less extensive; older deposits were largely reworked where over-run by younger ice. Glacial limits and surficial deposits from the McConnell (28 ka to 15 ka) and Reid (300 ka to 230 ka) glaciations are easily distinguished in the central Yukon, but older glacial deposits, beyond the limit of the Reid, cannot be differentiated and are therefore grouped as pre-Reid (Fig. 15). Where the age of the deposits can be determined, valuable climatic data on the warmer interglacial periods have been gleaned from relic soils or paleosols preserved on the older glacial surfaces. Pedological studies indicate that previous interglacials were probably warmer and moister than the current climate.

During periods of continental glaciation, the reduction of precipitation, aided by lower sea levels and modified global circulation patterns, allowed western Yukon and central Alaska to remain free of ice. An ancient land called Beringia reached from central Yukon across to Kamchatka and far-eastern Russia (Fig. 17). This subcontinent-sized area was isolated by ice from the rest of North America and Eurasia. In this refugium, many species evolved separately, and some plant and insect subspecies found in Yukon reflect this — a direct link with a prehistoric past.

Other dramatic changes resulted from the continental ice sheets, and their subsequent melting. The penetration of the Laurentide Ice Sheet into the Bonnet Plume Basin caused the diversion of the Peel River northwards. The influx of water into the Old Crow and Bell River basins created large glacial lakes. These glacial lakes have drained, leaving large wetland environments perched on the glacial silts. With the onset of the current interglacial about 12 ka, a period of intense fluvial erosion began. Streams eroded vigorously into the thick glacial deposits, leaving complex alluvial deposits in the valley floors. Today, Holocene alluvial environments provide important biogeographic diversity for Yukon’s flora and fauna.

Tephra beds are important markers in sediments because they can often be precisely dated. A tephra within the White Channel Gravel (Klondike area) is dated at 2.7 Ma, and in the Old Crow area the Mosquito Gulch tephra is dated at 1.22 Ma. There are many Pleistocene-aged tephras in the sediments of central and northern Yukon, and more are being discovered as field research continues in these areas. The White River Ash, prominently exposed across central Yukon, was erupted about AD 803, and an earlier eruption about AD 60 spread an ash blanket northward across east-central Alaska. Both were short-lived eruptions from Mount Churchill in the Wrangell Mountains of eastern Alaska (Fig. 18). The area of tephra deposition reflects the prevailing wind at the time of eruption.

GEOMORPHOLOGY

The landforms and surficial deposits of regions covered by Pleistocene ice differ from the west–central and northern Yukon, which remained unglaciated. Figure 19 shows the general distribution of surficial geological deposits.

Unglaciated areas

Smooth, interconnected ridgelines and deep narrow valleys characterize the unglaciated Klondike Plateau Ecoregion. Tors, erosional remnants of bedrock, occur on crests while higher ground reveals felsenmeer, a mantle of frost-fractured rock (Fig. 20). Colluvial veneers that thicken downslope into aprons of organic debris, reworked loess, bedrock fragments and fine-grained slope wash cover slopes. Permafrost is prevalent in the apron deposits and

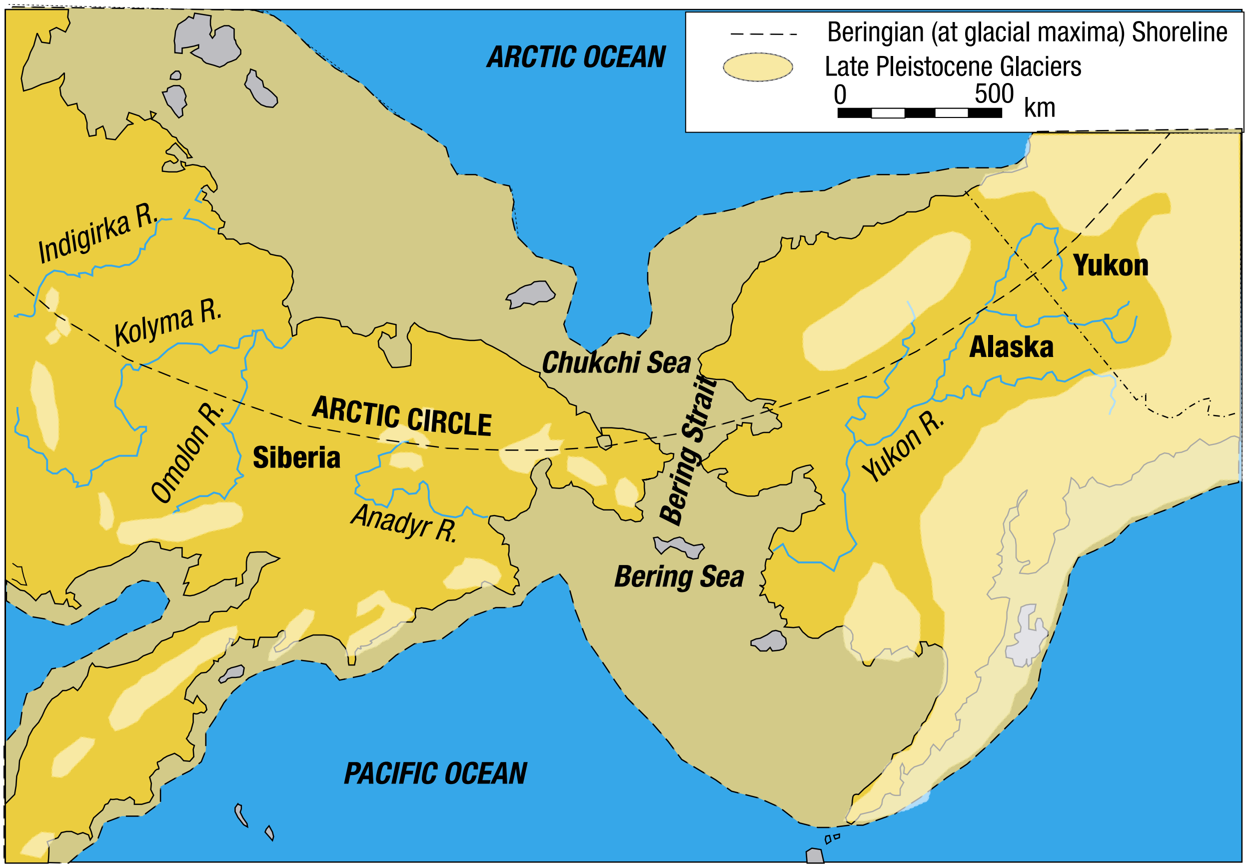

Figure 17. Beringia (dark yellow and dotted shading) at the height of the last glaciation. Adapted from Hopkins *et al.*, 1982.

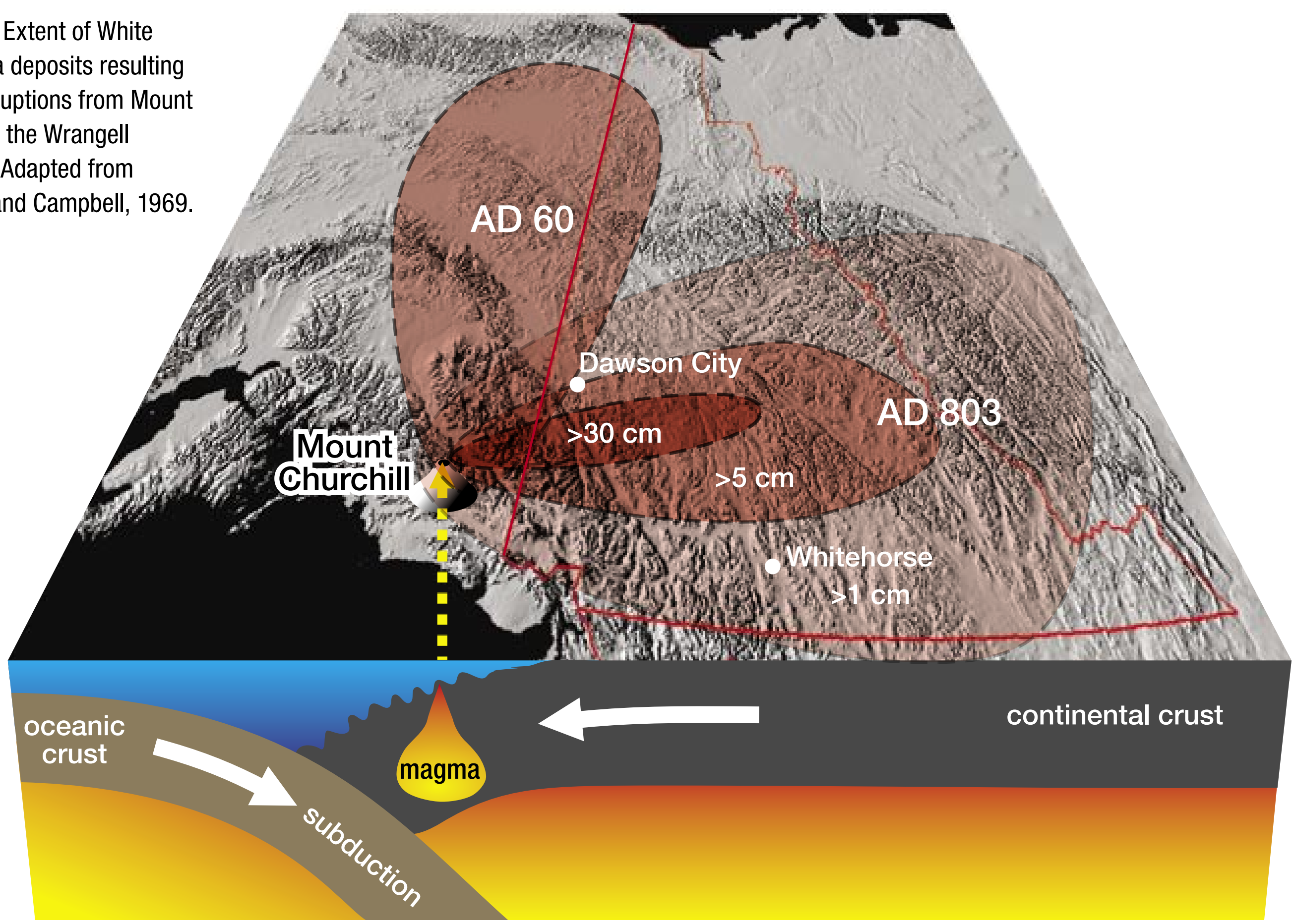

Figure 18. Extent of White River tephra deposits resulting from two eruptions from Mount Churchill, in the Wrangell Mountains. Adapted from Lerbekmo and Campbell, 1969.

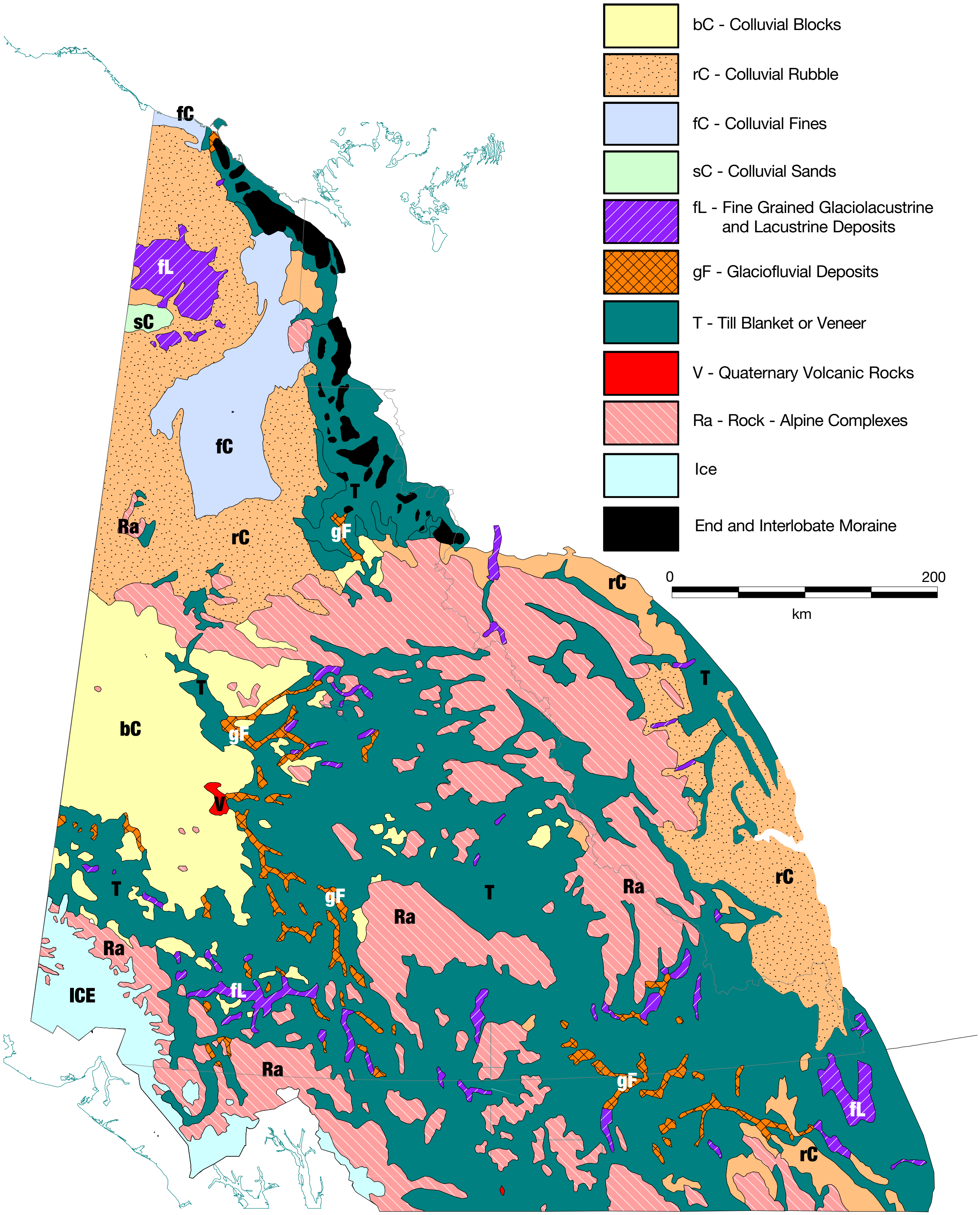

Figure 19. Distribution of surficial geologic material. Source: Fulton (1995).

on north-facing slopes where solifluction, the slow sliding of soil over the permafrost table, churns rock fragments and surface organic layers. Alluvial deposits are restricted to active stream channels and to sporadic alluvial terraces. The areas adjacent to the Pleistocene glaciers received loess, silt blown by katabatic winds from broad outwash plains.

The northern Yukon, specifically the Eagle Plains, Old Crow Basin and Old Crow Flats ecoregions, forms a subdued landscape. A veneer of fractured bedrock covers the rolling weathered surface of the Eagle Plains Ecoregion. A pediment surface, consisting of a blanket of silty clay colluvium and finely fractured bedrock, extends from the west flank of the Richardson Mountains. Alluvial deposits line active stream channels. Bedrock exposures are common along streams and rivers. Streams within the Old Crow Flats Ecoregion are entrenched into the thick glacial lake sediments. Beach deposits, marking the former glacial lake shoreline, fringe low-lying hills in the Old Crow Basin Ecoregion.

Formerly glaciated areas

The landforms and surficial materials of the east–central and southern Yukon reflect sculpting by Pleistocene glaciers and their retreat between 10 ka and 15 ka years ago.

In general, valleys have steep sides with bottoms filled with silt, sand and gravel. Alpine areas have abundant exposed bedrock with active talus aprons, nivation cirques and rock glaciers. Summits that were overtopped by the ice sheet have exposed, and sometimes polished, bedrock with interspersed pockets of glacial till. Coalescing valley glaciers formed regional ice lobes that merged in the low-lying inter-range terrain of the central Yukon. The maximum heights of these ice lobes decreased westward and are clearly marked on slopes in the Dawson Range (Klondike Plateau Ecoregion) and near Mayo (Yukon Plateau–North Ecoregion). Above the ice limit are bedrock tors; scattered below the ice limit are glacial erratics — boulders transported

C. Kennedy, Yukon Government

Figure 20. Tors are bedrock knobs that project along ridgelines. They are the product of millions of years of gradual erosion (weathering) in areas either above (as shown here) or beyond the limit of scouring glacier ice during the Pleistocene epoch.

by the ice — and lateral moraines. At the height of the ice along some slopes, lateral moraines or eskers form sand and gravel benches. The meltwater streams that flowed along glacier margins occasionally had sufficient volume and velocity to carve bedrock channels and small canyons, which are now perched high above the valleys and often cut across drainage divides. Kame terraces are common in mountainous regions where meltwater collected against the ice. Drainage diversions and sediment-clogged valleys are also a common feature in glaciated terrain. Underfit drainages and chains of wetlands lining broad mountain valleys often result.

The Tintina Trench funnelled ice westward from both the Selwyn and Pelly mountains. The converging ice lobes sculpted the hills along the Tintina Trench. Drumlins, crag and tail glacial features, and aligned bedrock ridges are common. Depressions are often blanketed with tens of metres of till, but hill summits may have only a thin till cover or bedrock may be exposed completely.

The lowlands of the Liard Basin Ecoregion are underlain by Tertiary fluvial gravel and sand with minor basalt flows (200 ka to 800 ka), capped by glacial till. A proglacial lake left lacustrine beds in the upper Frances, Hyland, Coal and Rock river drainages. Part of the Hyland Highland Ecoregion may have been ice-free during the most recent glaciation, as indicated by its more dissected landforms and the presence of probable Beringian flora.

As the glaciers melted, they left hummocky moraine, glaciolacustrine and glaciofluvial plains and esker complexes in valley bottoms (Fig. 14). A disordered terrain of sand and gravel ridges, pockmarked by kettle lakes and hollows, marks areas where stagnant glacier ice melted.

Some valleys were filled by meltwater when drainage outlets remained blocked by ice. A large glacial lake filled the entire Old Crow Flats Ecoregion and lower elevations of the Old Crow Basin Ecoregion. Glacial Lake Champagne filled many of the valleys of the Yukon–Southern Lakes Ecoregion. Fluctuating lake levels (lake outlets were ice-dammed) left numerous shoreline terraces and beachridges. Silt deposited on the bottom of glacial Lake Champagne underlies much of the cultivated land in southern Yukon, and is exposed as the "clay cliffs" in the City of Whitehorse. These lakes were ephemeral and were drained abruptly when the ice dams were breached. Ensuing floods scoured narrow valleys downstream and, in wider places, left sheets of gravel outwash, including longitudinal fluvial dunes created by the turbulence.

Ongoing erosion by glaciers and high-gradient streams is keeping pace with uplift in the Icefield Ranges Ecoregion. As a result, the rivers flowing from these ranges are loaded with sediment and extensively braided. Advances of the Lowell and other glaciers have blocked the Alsek River several times, impounding "Glacial Lake Alsek." The most recent impoundment, during the "Little Ice Age" (AD 1450–1850), inundated the present site of Haines Junction. Catastrophic draining of the lake is recorded in the lore of the Southern Tutchone people, and by large longitudinal dunes in the lower Alsek valley. Since that time, glaciers have generally retreated leaving lateral- and end-moraine complexes and stagnant ground ice features.

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■ PERMAFROST

by Chris Burn

Permafrost is ground that remains at or below 0°C for two or more years. Permafrost occurs in all of the Yukon's ecoregions, but its thickness and the proportion of ground it underlies increases northwards (Fig. 21). All terrain, except rivers and lakes, is underlain by perennially frozen ground in the northern Yukon, but the scattered permafrost of the southern Yukon is found under less than 25% of the ground surface. Permafrost terrain comprises a seasonally thawed active layer, underlain by perennially frozen ground. The active layer is the layer of ground above the permafrost that thaws in the summer and freezes in the winter.

Throughout the Yukon, except in the mountains south of Carcross where snow is deep, ground ice and permafrost present hazards to municipal and highway construction. Ground ice is most often found beneath organic soil, and is impressively preserved in the Klondike "mucks." Except to the north, permafrost problems have commonly been managed by attempted obliteration of ground ice. For projects of relatively short duration, such as in mining, this approach has often been adequate. In the long run, however, more imaginative arrangements have proved necessary. For instance, at Tatchun Creek, in the Yukon Plateau–Central Ecoregion, ground ice melting has caused repeated failure of the Klondike Highway roadbed and extensive remedial measures have been necessary.

THICKNESS

Four ground temperature profiles (Fig. 22) shown on Figure 21 indicate the variation in permafrost conditions across the Yukon. The profile from Blow River represents deep permafrost with a base at 238 m depth, characteristic of glaciated environments on the Yukon Coastal Plain. Permafrost may be well over 300 m thick in more westerly, unglaciated portions of this ecoregion, but it thins rapidly to the south, for it was absent beneath glacial ice and lakes; it is only 63 m thick at Old Crow. The high geothermal flux in cordilleran terranes of the central and southern Yukon help to raise the permafrost base to 89 m at the North Cath drill site in the Eagle Plains Ecoregion, and to 135 m in the mountains of the Yukon Plateau–North Ecoregion. In areas underlain by coarse glacial deposits, convective heat from groundwater circulation may also raise the base of permafrost locally. Thicknesses between 20 and 60 m have been reported from valley-bottom sites in the Klondike Plateau Ecoregion near Dawson, and between 25 and 40 m near Mayo, in the Yukon Plateau–North Ecoregion. Drilling in the Takhini Valley, in the Yukon Southern Lakes Ecoregion, has revealed 16 m of frozen sediments, while municipal excavations near Teslin encountered only 2 m. In the Yukon, annual mean temperatures at the top of permafrost decline northward with a steep drop across the treeline, varying from –0.8°C in the Takhini Valley to –2.8°C at Eagle Plains.

Very thin permafrost may degrade or be established in years or decades, but the time scale for thicknesses of over 15 m is in the order of centuries. Permafrost in the Yukon Coastal Plain has formed over millennia. Thus, permafrost zones are temporal, as well as spatial, units.

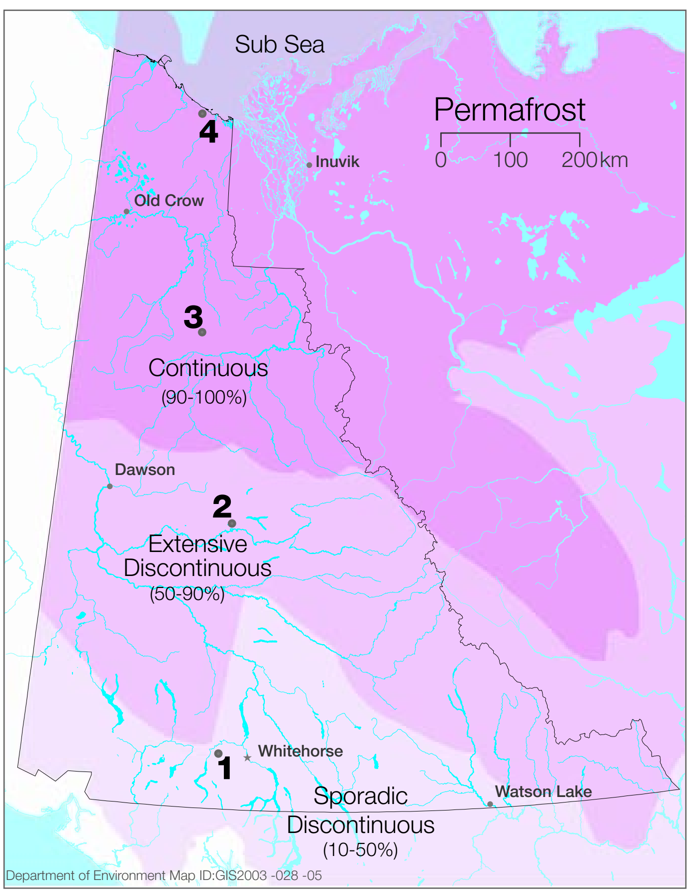


Figure 21. Permafrost zones, indicating locations of ground temperature profiles, as shown in Figure 22.

DISTRIBUTION

Annual mean near-surface ground temperatures below 0°C lead to permafrost growth. At the macro scale, these are a function of air temperature, modified by the insulation of snow. In the Yukon, physiographic factors are responsible for the presence of permafrost, particularly the blocking of maritime air by the Boundary and Icefield ranges, and topographic enhancement of winter inversions within dissected plateaus.

Snow cover affects local permafrost variations by insulating against extreme temperatures. For example, a heavy snowfall in early fall may delay or reduce frost penetration. Permafrost in uplands of the central and southern Yukon is a result of short, cool summers, for in winter the ground is protected by a thick snow cover. In valleys, summer is commonly hot, but the winter may be extremely cold.

Within the boreal forest, the snowpack is usually uniform with little drifting, because of interception of snow by the canopy and reduced wind speeds. Above and north of treeline, local conditions of snow cover are more variable and directly impact permafrost distribution, even leading to the absence of permafrost. For example, in the Mackenzie Delta, thick accumulations of snow in willow thickets around lakes and rivers may lead to eradication of permafrost.

Within the discontinuous permafrost zone, the specific location of frozen ground depends mainly on the thickness of the surface organic horizon, which insulates the ground from higher summer temperatures, and on the moisture content of the active layer. A high rate of evapotranspiration will dissipate solar energy that would otherwise warm up the soil and melt permafrost.

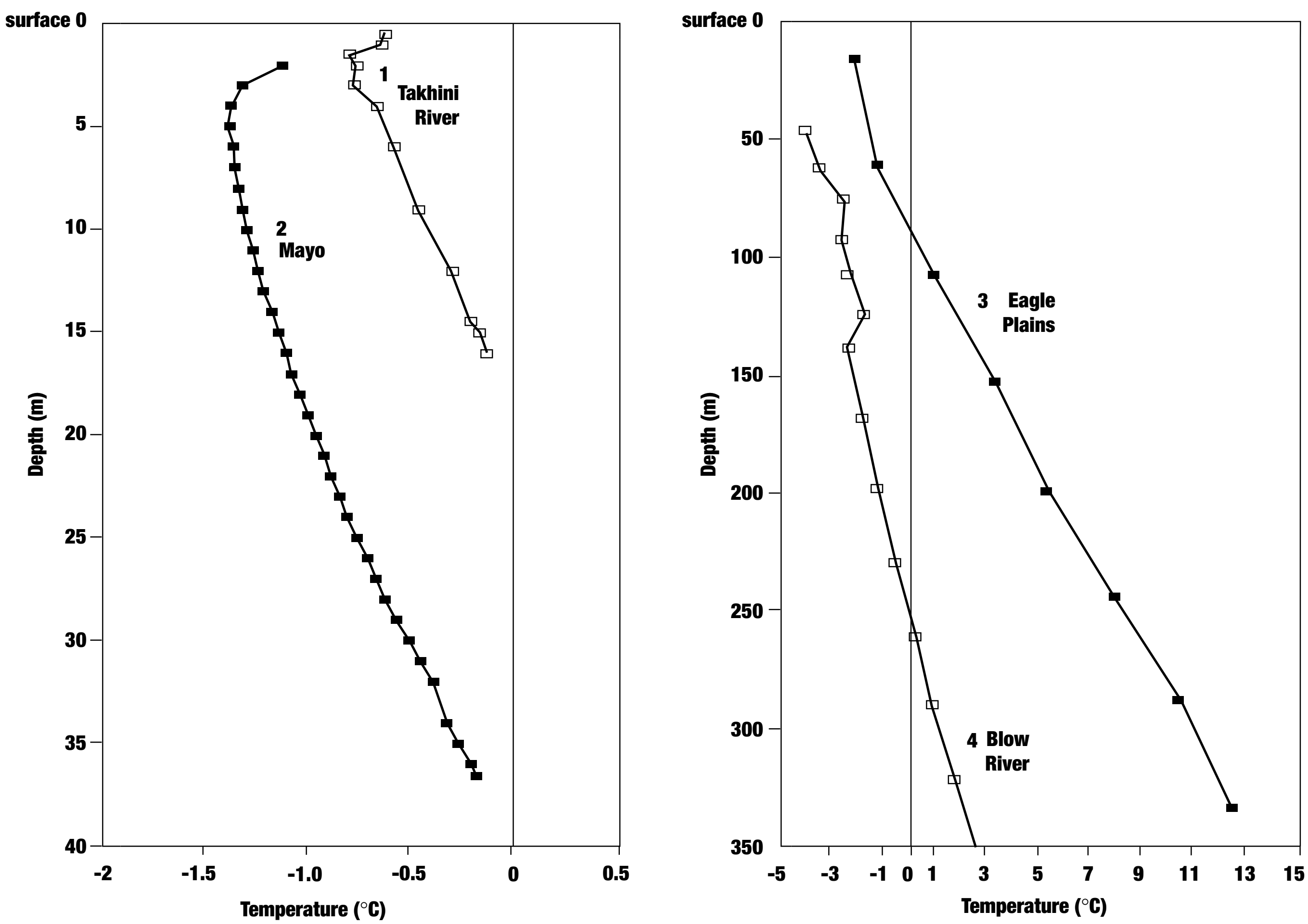


Figure 22. Equilibrium ground temperature profiles from: (1) glaciolacustrine sediments in the Takhini River valley (Yukon Southern Lakes Ecoregion; from Burn [1998]); (2) glaciolacustrine sediments near Mayo (Yukon Plateau North Ecoregion, from Burn [2000]); (3) North Cath B-62 drill hole (Eagle Plains Ecoregion; data from Taylor and Judge, [1974]); and (4) Imperial Oil Limited Blow River well (Yukon Coastal Plain Ecoregion; data from Burgess *et al.* [1982]). Plots have different vertical and horizontal scales.

The combinations of factors at various scales that lead to permafrost imply that its response to climate change is complex. Changes in surface conditions, such as those caused by forest fire, often alter the ground thermal regime more rapidly than fluctuations in climate, and are, for example, currently causing permafrost degradation in the Takhini Valley. However, climate change over decades may also warm permafrost, particularly if it alters snow accumulation.

GROUND ICE

The practical significance of permafrost largely relates to the growth and decay of ground ice. There is usually an ice-rich zone at the base of the active layer, which forms by ice segregation during downward migration of water into permafrost at the end of summer. Water may also be injected into near-surface permafrost in autumn. The growth of ice wedges by snow melt infiltrating winter thermal contraction cracks, also contributes to high ice contents in the uppermost 10 m of the ground. Ice wedge polygons are well developed in lowlands of the northern Yukon, but individual wedges have been reported further south.

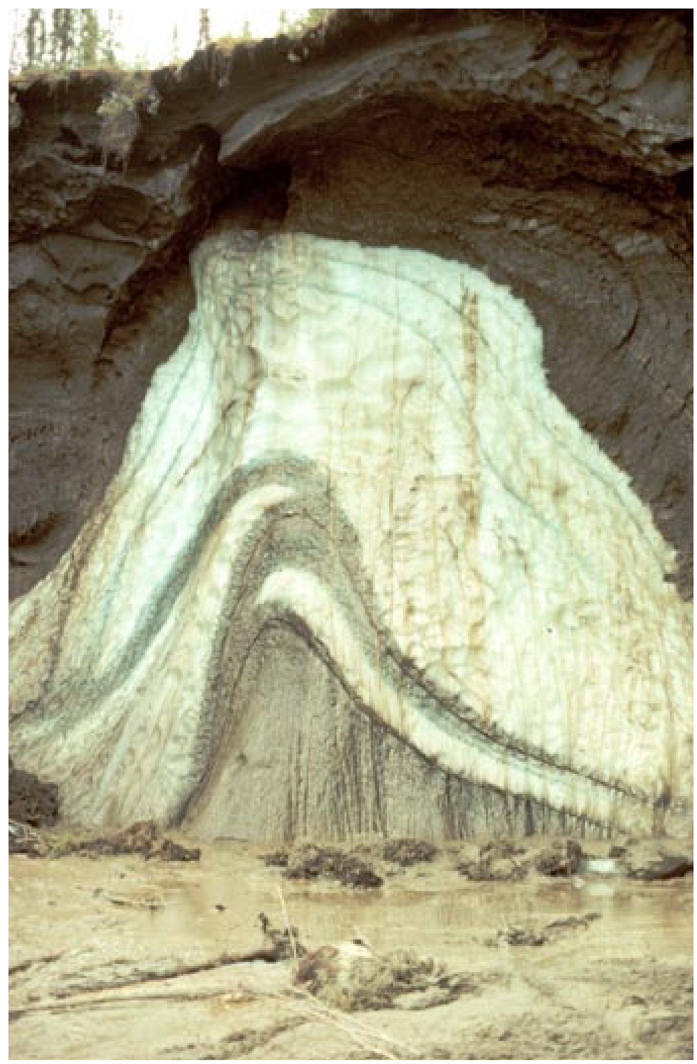
Accumulation of ground ice leads to heaving of the ground surface. Thick, laterally extensive bodies of massive, near-surface ice, probably formed by ice segregation during permafrost growth, are found in the northern Yukon (Fig. 23) and in the Klondike Plateau Ecoregion. Glaciolacustrine sediments in the central and southern Yukon often contain beds of segregated ice, which may comprise over 80% ice by volume in the upper 10 m of the ground. Over 400 open-system pingos have been identified in the central Yukon, mostly in unglaciated valleys where coarse materials do not impede groundwater movement downslope. Numerous palsas — peat mounds with a core of segregated ice — have been identified in wetlands. Buried glacier ice is abundant near the termini of glaciers throughout the southern Yukon, and at higher elevations, as a relict from the Little Ice Age. Rock glaciers are also widespread in the alpine zone.

THERMOKARST

Ground subsidence occurs during thawing of ice-rich terrain with water pooling in enclosed depressions to form thermokarst lakes. Thermokarst lakes are currently widespread and actively developing in glaciolacustrine sediments deposited during the McConnell glaciation. Retrogressive thaw slumps may be observed in riverbanks where active erosion has exposed ice-rich soil, and at other sites, including road cuts.

DRAINAGE AND VEGETATION COVER

Permafrost derives its ecological significance from cold ground temperatures within the active layer, and the influence of a relatively impermeable frost table on drainage. Moisture- and frost-tolerant species, such as black spruce and mosses, are often associated with permafrost, while deciduous forests usually grow in drier, permafrost-free soil. The relations between vegetation and permafrost



A. Duk-Rodkin, Geological Survey of Canada

Figure 23. Deformed ground ice at least 20 m thick in glaciolacustrine sediments, Bonnet Plume Basin (Peel Plateau Ecoregion). The ice is exposed in a cutbank.

are illustrated by the sequence of vegetation succession that commonly follows forest fire. Ground warming and thickening of the active layer in years shortly after fire improves drainage and allows the establishment of species suited to dry soils, especially pine. However, as a surface organic horizon redevelops, the active layer thins, segregated ice persists at the base of the active layer, and drainage is impeded, leading to replacement of this vegetation by moisture-tolerant species, such as spruce.

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■ SOILS

by Scott Smith

Soils form at the earth's surface as the result of interactions between climate, geologic parent material, time, relief and living organisms. Soils in the Yukon have formed under a cold, semi-arid to moist subarctic climate on a range of geologic materials. The result is that most Yukon soils are only mildly chemically weathered, and many contain near-surface permafrost. Because much, but not all, of the territory has been glaciated in the past, some soils have formed directly over local bedrock, whereas others have formed in glacial debris of mixed lithology. In mountainous terrain, soils form on a range of slope debris, called colluvium, and are subject to ongoing mass wasting and erosion.

Within the Canadian System of Soil Classification, the most common soil orders in the Yukon are the Brunisols — mildly weathered forest soils, the Regosols — unweathered alluvial and slope deposits, and the Cryosols — soils underlain by near-surface permafrost. Each of these "soil orders" is associated with a specific environment created by the soil-forming factors. A brief description of each soil order is given in Table 3 and its distribution shown in Figure 24.

Those ecoregions in the southern Yukon that lie in the rain shadow of the St. Elias Mountains, such as the Ruby Ranges, Yukon Southern Lakes and Yukon Plateau–Central, are dominated by soils formed under a semi-arid climate on calcareous glacial parent materials. These soils tend to be alkaline and belong to the Eutric Brunisol great group of soils. They support mixed forests of aspen, pine and spruce, while grassland ecosystems appear on south-facing slopes. Milder summer temperatures, higher precipitation and finer-textured parent materials in the valleys and basins of the Liard Basin and Hyland Highland ecoregions of the southeast Yukon result in soils containing subsurface clay accumulations. These belong to the Grey Luvisol great group of soils. Where parent materials are coarse textured, Eutric Brunisols are formed.

In the main ranges of the Selwyn Mountains Ecoregion along the Northwest Territories border, and at higher elevations of the Pelly Mountains Ecoregion along the British Columbia border, high precipitation causes strong leaching of the soil. This results in the formation of Dystric Brunisols, (i.e. forested soils with acidic soil horizons). These soils support extensive conifer forests composed of subalpine fir, spruce and pine. Occasionally, in very coarse-textured parent materials without any calcareous mineralogy, Humo–Ferric Podzols may form. These have been reported in the Mackenzie Mountains and Selwyn Mountains ecoregions under subalpine forest conditions. They may also occur sporadically in alpine environments in the Yukon Stikine Highlands Ecoregion immediately adjacent to the Yukon–British Columbia border.

Permafrost is widespread and discontinuous throughout the Yukon Plateau–Central, Yukon Plateau North ecoregions. While many well-drained upland soils are free of permafrost and classify as mildly weathered Eutric Brunisols, poorly drained areas and north-facing slopes are usually underlain by near-surface (i.e. active layer less than 2 m depth) permafrost. These often show evidence of frost churning in the upper soil horizons. These soils are classified as Turbic Cryosols. Open forests of paper birch and black spruce are associated with Cryosols in these ecoregions. The Mackenzie, Selwyn and British–Richardson Mountains ecoregions are characterized by rugged landscapes of colluvium and bedrock outcrops dissected by major valley systems. Here the upper slopes are composed of rubble, scree and bedrock. In unglaciated valleys, lower pediment slopes are composed of fine-textured silt and clay and almost always underlain by permafrost. These soils are Orthic or Gleysolic Turbic Cryosols depending on the degree of saturation.

In northern ecoregions, the alluvial parent materials deposited on river floodplains are often braided and may be scoured by the formation of aufeis. There is generally little soil formation or permafrost on these active floodplains throughout the territory. The soils are usually classified as Orthic Regosols, or if there is evidence of multiple deposits and buried vegetative debris as Cummulic Regosols.

Many valleys have higher-level glaciofluvial terraces. Terrace surfaces are not subject to the erosion and depositional forces like those on active floodplains and soil development usually produces Brunisolic soils. In the Yukon Plateau–Central and Klondike Plateau ecoregions, glaciofluvial terraces formed during early pre-Reid glaciations, some dating back to over 2.5 million years. Some of these glaciofluvial surfaces have been subjected to weathering throughout most of the Pleistocene and the resultant soils are termed paleosols or "relict soils." The soils do not fit the Canadian soil classification system for modern soils very well but have been termed paleo-Luvisols because of the clayey nature of the subsurface horizons.

Table 3. Simplified descriptions of major soil orders and subgroups in the Yukon. For more detailed definitions of these soils, see Soil Classification Working Group (1998).

Soil order	Occurrence	Description
Brunisol	Very common in Boreal Cordilleran Ecozone	Mildly weathered mineral soil, commonly forms under forest cover and grasslands in southwest and central Yukon. The most common subgroup of Brunisol in the Yukon is the Eutric Brunisol, which has a pH in the surface soil of >5.5. Dystric Brunisols are less common acidic subalpine and alpine soils with pH <5.5.
Cryosol	Very common in all northern ecozones	Permafrost-affected soils, may be associated with wetlands, tundra, or taiga forest conditions. Turbic Cryosols are mineral soils strongly affected by frost churning, which generates various forms of patterned ground. Static Cryosols lack this frost-churning process. Organic Cryosols are the soils of peatlands underlain by permafrost.
Regosol	Scattered throughout all ecozones	Regosols are soils that have not been weathered and are associated with active landforms such as floodplains, colluvial slopes, dunes, thaw slumps and debris flows. The soils do not exhibit horizon formation typical of other soils.
Luvisol	Restricted to ecoregions in southeastern Yukon	Luvisols are the soils associated with fine-textured soils under boreal and temperate forests throughout Canada. In the Yukon, they only develop at lower elevations on clay-rich glacial deposits under relatively mild and wet conditions such as are found in the Liard Basin, Hyland Highland and Muskwa Plateau ecoregions.
Organic	Scattered wetland soils of Boreal Cordilleran Ecozone	In soil taxonomic terms, Organic refers to soils that are formed of decomposed vegetation (peat) rather than sand, silt and clay. Organics are associated with fen wetlands that are not underlain by permafrost.
Podzol	Rare	Podzols are associated with temperate, high rainfall forested areas. In the Yukon, they are occasionally found in Selwyn Mountains and Yukon Stikine Highlands ecoregions. All Podzols identified in the Yukon have been classified as Humo-Ferric Podzols (i.e. those with enriched iron concentrations in the subsoil).

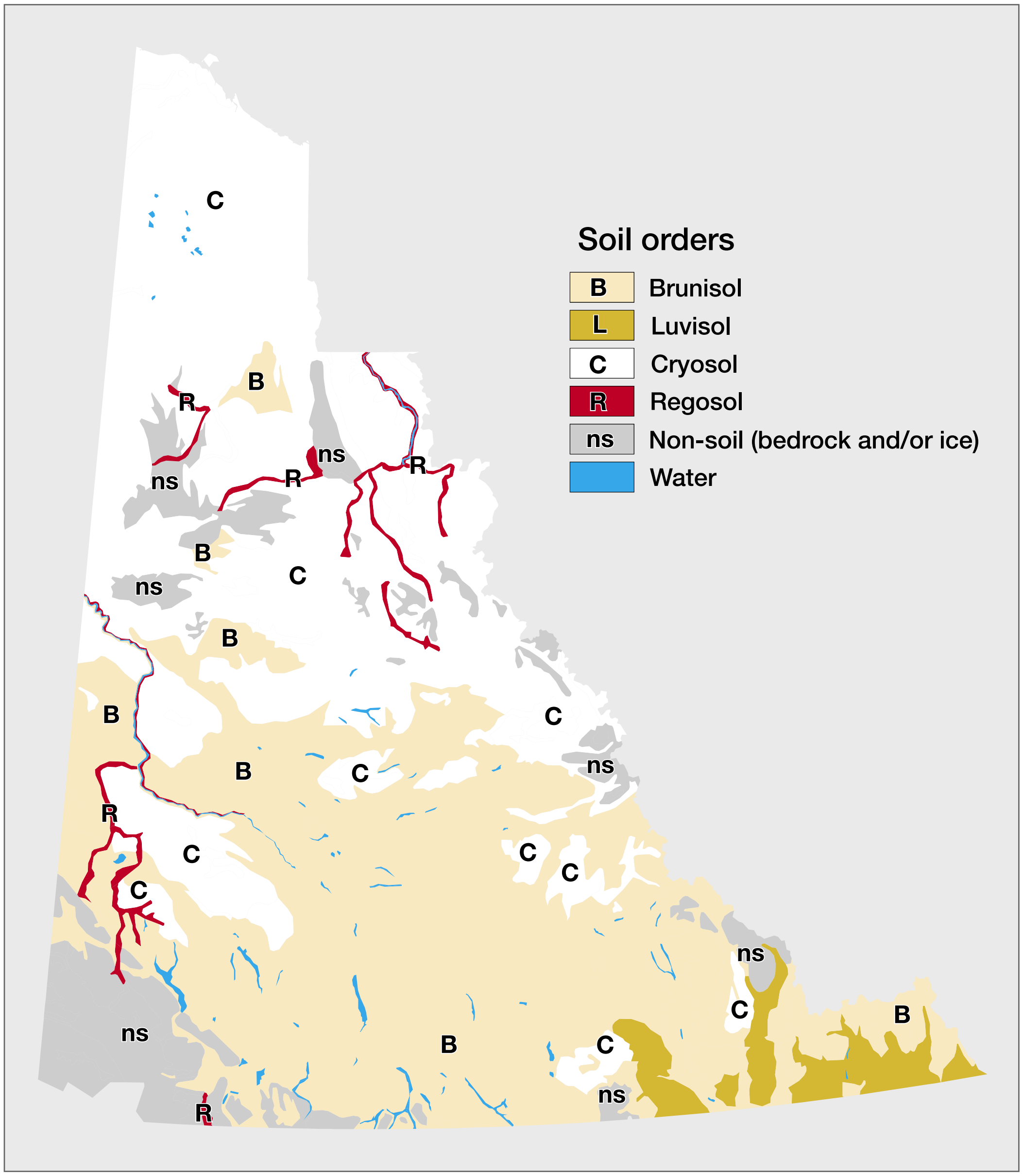

Figure 24. Distribution of major soil types (orders) in the Yukon. Adapted from White *et al.* (1992).

A predominant soil feature observable along the roadcuts of the Klondike Highway between Braeburn and Pelly Crossing is the thick surface deposit of White River tephra. This tephra was deposited by the younger easterly trending lobe of tephra from Mount Churchill in the Wrangell Mountains of eastern Alaska (Fig. 18). Although the tephra was deposited some 1,200 years ago, it remains largely unweathered and, in places, the original buried forest floor materials are well preserved (Fig. 25). The tephra is relatively inert, being composed mainly of fine particles of glass (amorphous silica), 0.05 to 1 mm in diameter. Closer to the source, large particles of pumice from 2 to >50 mm can be found in this surface deposit. Natural vegetation communities have re-established seemingly without effect on the ash deposits. Where tephra-rich soils have been used for agriculture, suitable production can occur with ample additions of nutrients and water.

The ecoregions that cover the large plateaus and plains of the northern Yukon are underlain by continuous permafrost and dominated by Cryosols. The unglaciated Old Crow Basin, Old Crow Flats and Eagle Plains ecoregions have extensive permafrost with open stands of black spruce, birch and occasional larch. Turbic Cryosols dominate the pediment and lacustrine parent materials. Peat deposits underlain by permafrost, called Organic Cryosols, are common in the Old Crow Flats Ecoregion. The Peel Plateau Ecoregion has been glaciated, but the soil formation (Cryosolic) and vegetation cover are similar to adjacent unglaciated ecoregions.

The Yukon Coastal Plain is the only ecoregion in the Yukon to lie within the Southern Arctic Ecozone. Arctic tundra landscapes exhibiting extensive patterned ground characterize this ecoregion. The soils all belong to the Cryosolic Order. Where surfaces show evidence of frost churning, soils are classified as Turbic Cryosols. On recently disturbed surfaces, such as alluvium, thaw slumps, or dunes, where no churning is evident, soils are classified as Static Cryosols. Soils of lowland polygons may be underlain by perennially frozen peat and are classified as Organic Cryosols. In the western portion of this ecoregion, the unglaciated plain includes large fluvial fan formations composed of sandy soils that have active layers too thick to allow these soils to be classified as Cryosols. In these cases, the soils are classified as Regosols.

The Mount Logan and St. Elias Mountains ecoregions contain vast areas without soil formation or vegetation cover. Here high-elevation icefields and rock summits dominate the landscape. They are classified as non-soil areas on Figure 23.

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S. Smith, Agriculture and Agri-Food Canada

Figure 25. Deposit of greater than 30 cm of volcanic tephra found along the Nansen Creek Road in the Yukon Plateau–Central Ecoregion. Original forest floor is visible in the road cut just to the left of the knee of the surveyor. The tephra below this forest floor layer has fallen from the upper part of the road cut over the underlying soil parent materials.

VEGETATION

by Karen McKenna, Scott Smith and Bruce Bennett

The *Flora of the Yukon* by William Cody (1996) lists over 1,100 vascular plant species identified in the Yukon. Although the Yukon has low plant diversity relative to other parts of Canada, its overlapping range of circumpolar and Beringian flora is in many ways unique.

Beringia is the name of a subcontinent that extended periodically from the Lena River in Siberia to the Mackenzie River in the Northwest Territories during the Pleistocene (Fig. 17). The enormous continental ice sheets that covered much of the Northern Hemisphere isolated Beringia from the rest of North America and Asia. The Swedish botanist Dr. Eric Hultén first used the word Beringia in 1937 to describe the distribution of plants that surround the Bering Strait and adjacent areas but are unknown elsewhere. He concluded that when large ice sheets covered much of Europe and North America, the shallow strait was exposed as a plain of 1.5 million square kilometres, an area roughly three times the size of the Yukon. He termed it the Bering Land Bridge.

J. Meikle, Yukon Government

Figure 26. A number of plants associated with Beringia reach their southern and eastern extents in the Yukon. An example is bearflower *(Boykinia richardsonii)* photographed near the eastern limit of its range near the Snake River in the Mackenzie Mountains Ecoregion.

The tundra landscape of Beringia was different than the wet, tussock tundra and stunted forests of the region today as it was drier and dominated by grasses. Remnants of this steppe grasslands are thought to exist on many south-facing slopes in the central Yukon and interior Alaska and in extensive areas of central Asia. Many of the plants continue to grow here (Fig. 26). The existence of the plant species that composed the Beringian flora are indicated by seeds, pollen or plant fragments preserved in lake or river sediments and even in the stomachs of mammals mummified by permafrost.

Today, trees cover most of the plateaus and valleys in the southern Yukon and form closed or open canopies, depending on site conditions. The southeastern part of the territory has the greatest proportion of closed-canopy forests and the greatest number of tree species. The major tree species in the Yukon include white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, larch *(Larix laricina)*, subalpine fir *(Abies lasiocarpa)*, lodgepole pine *(Pinus contorta)*, aspen *(Populus tremuloides)*, balsam poplar *(Populus balsamifera)* and paper birch *(Betula papyrifera)*. To the west and north, stands of these species are more open and discontinuous. Larch, subalpine fir, and lodgepole pine are generally absent in the western part of the Yukon, but larch occurs north of the Selwyn Mountains Ecoregion, and subalpine fir occurs to a limited extent in the northwest Klondike Plateau Ecoregion.

In the south-central and eastern Yukon ecoregions, white spruce and black spruce are the climax tree species on moderately to well-drained sites. As a result of fire, however, current stands contain lodgepole pine, and to a much lesser extent, aspen (Fig. 27). Black spruce predominates in poorly drained areas.

In much of the southern Yukon, mature forests of black spruce or mixed black spruce and white spruce exist in association with permafrost that persists under these stands. Currently, stands consist of black and white spruce, aspen, balsam poplar and paper birch, in pure stands or mixed in various proportions. Succession after fire usually starts with willow, aspen and balsam poplar, although black spruce and paper birch are the initial invaders in some places.

Subalpine fir is the primary alpine timberline species throughout the south-central and eastern Yukon ecoregions, but white spruce replaces it westward and northward. The treeline species of white and black spruce are the most prevalent. White spruce and balsam poplar thrive in protected alluvial environments almost to the Arctic Ocean.

Shrub-dominated communities occur on recent alluvial sites, disturbed areas, and wetlands, and near treeline in the southern Yukon, where they occur under a very open forest canopy. Their abundance increases northward, especially on higher plateaus and protected slopes of mountains. Willows, shrub birch, soapberry and alder are the most prevalent species on better-drained sites; ericaceous shrubs, frequently with willows and shrubby cinquefoil, occur on poorly drained sites.

Wet tundra, composed of sedge and cottongrass tussocks, occurs in the southern Yukon, but is more common northward and forms the predominant vegetation of the Arctic tundra. Tussocky tundra occurs on imperfectly drained sites where seasonal frost lasts for a significant portion of the year, or where near-surface permafrost is present. A high water table supported by permafrost may permit tussock development on gentle slopes. In the northern Yukon, trees (particularly black spruce and larch) with ericaceous shrubs and willows, locally occur in tussock fields with forbs, lichens and mosses usually present.

Alpine tundra is formed by several communities, ranging from sedge meadows or tussock fields to pioneer colonization of lichens on rocks. The wetter areas, common on gently sloping terrain and depressions with an accumulation of organic matter, possess vegetation similar to that described for tussock fields. The mesic alpine vegetation is characterized by a combination of prostrate shrubs, mainly ericads and willows, grass, sedge, forbs, lichens, and *Sphagnum* and other mosses. Mineral soils are usually stony, and permafrost is either deep or absent. The soils are well drained and tend to dry out during summer if the snow-free period is sufficiently long. Rock fields may have only crustose or fruticose lichens growing on the rock, with members of the mesic alpine vegetation community growing in interstices between rocks.

Grasslands are restricted to steep, dry, south-facing slopes along the Yukon and Pelly rivers on moraine, colluvium, and glaciofluvial material. Shrubs, such as sagewort and rose, and several forbs occur in the grasslands. The two dominant grasses are purple reedgrass *(Calamagrostis purpurascens)* and glaucous bluegrass *(Poa glauca)*. These areas are very dry during the summer and, because of their position on steep slopes, are susceptible to erosion.

The Yukon does not possess extensive wetlands relative to most other areas of northern Canada (Fig. 28). Wetlands cover less than 5% of the territory. Wetlands are critical landscape components for hydrologic storage and filtering, as well as important wildlife habitat. Most wetlands exist in complexes with upland ecosystems. The nature of wetlands varies within the territory. Shallow open water is often a major component of the wetland complexes

J. Meikle, Yukon Government

Figure 27. The forest cover in most of the Yukon is a mosaic resulting from successive forest fires. This area of the Liard Basin Ecoregion shows the small, patchy nature of some burns. Photo taken west of Coal River.

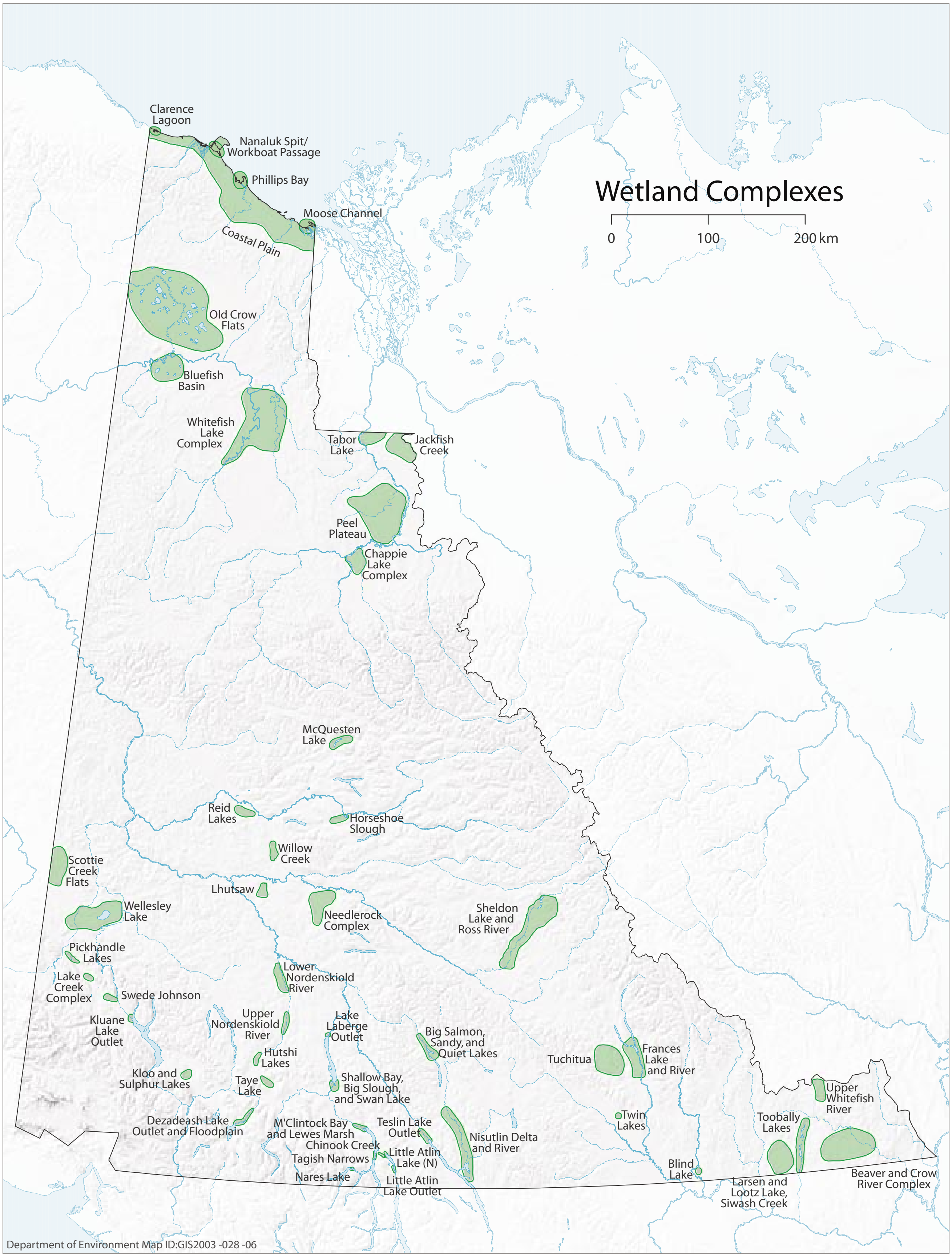

Figure 28. Distribution of major wetland complexes in the Yukon. Compared with other subarctic regions of Canada, the area of wetlands, particularly extensive peatlands, is relatively small owing to the mountainous nature of the terrain and the semi-arid climate. Map source: Yukon Wetlands Technical Committee (1998).

in all regions. This is particularly the case in hummocky terrain such as the Needlerock Wetland complex in Yukon Plateau–Central Ecoregion and the thermokarst-induced lakes in the Old Crow Flats Ecoregion. Tall willow and alder are common in swamps and along creeks throughout much of the territory.

Within the Boreal Cordillera Ecozone in the southwestern Yukon, wetlands are relatively small and scattered, with the exception of a few large marshes associated with active deltas. In the calcareous soils of the Whitehorse area, wetlands tend to be largely without peat formation and are often characterized by marl and fen development with shrub–graminoid vegetation. In central and southeastern Yukon, wetlands are usually a complex of fen and plateau bog, where the bog portion of the wetland is underlain by permafrost. The vegetation of the fens is usually graminoid while sparse stunted black spruce, lichen, ericaceous shrubs and *Sphagnum* characterize the bogs. In the Taiga Cordilleran Ecozone of northern Yukon permafrost is continuous so that plateau bogs and collapse scar fens are the most common wetland forms. These bogs are recognized by sparse stunted black spruce with the characteristic *Cladina* lichen groundcover. Where winters are cold enough to cause contraction cracking of the peat, polygonal peat plateaus form. Circular collapse scar fens (resulting from thermokarst) are typically dominated by various species of *Sphagnum* moss.

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■ WILDLIFE

MAMMALS

by Mark O'Donoghue and Jennifer Staniforth

The Yukon Territory still retains extensive near-natural ecosystems; the present suite of wildlife is similar to what existed over a thousand years ago. Many mammals are of Beringian origin, but the present fauna includes a few colonizing species from the south, as well as some introduced species that have become established. The low number of species present, relative to more southern areas, reflects the harshness of the seasonal extremes to which animals must adapt, and the low productivity of arctic and northern boreal vegetation. The mountainous terrain of the Yukon, stretching from the British-Richardson Mountains Ecoregion in the north to the towering peaks and icefields of the St. Elias Mountains Ecoregion in the south, creates a wide variety of habitats for wildlife. A list of all mammals known to occur in the Yukon and their distribution by ecoregion is given in Table 4.

The Southern Arctic Ecozone, represented by the Yukon Coastal Plain Ecoregion, is home to true arctic species such as Arctic foxes, collared lemmings, and a small number of muskoxen, which are expanding their range from Alaska. Offshore, polar bears, four species of seals, and walruses can be spotted on the ice flows, and migrations of beluga and bowhead whales happen each summer. Barren-ground caribou from the Porcupine Herd, especially bulls and younger animals, spend much of their summer along the northern coast of the Yukon, where harassment from insects is reduced by the cool winds off the water and mountains. During fall, these caribou migrate south of the treeline to overwinter in the taiga forest. Further south, smaller herds of woodland caribou move shorter distances between seasonal ranges (Fig. 29, 30a).

The Boreal and Taiga Cordillera ecozones of the Yukon encompass some of the last extensive boreal, subarctic and alpine habitats in North America for natural populations of wolves, wolverines and grizzly bears. Likewise, black bears, red foxes, least and short-tailed weasels, Arctic ground squirrel, moose (Fig. 31), and a variety of voles and shrews make their homes in all but the most inhospitable areas. The mountains and cliffs are occupied by thinhorn sheep (Fig. 30b) and in the south, mountain goats

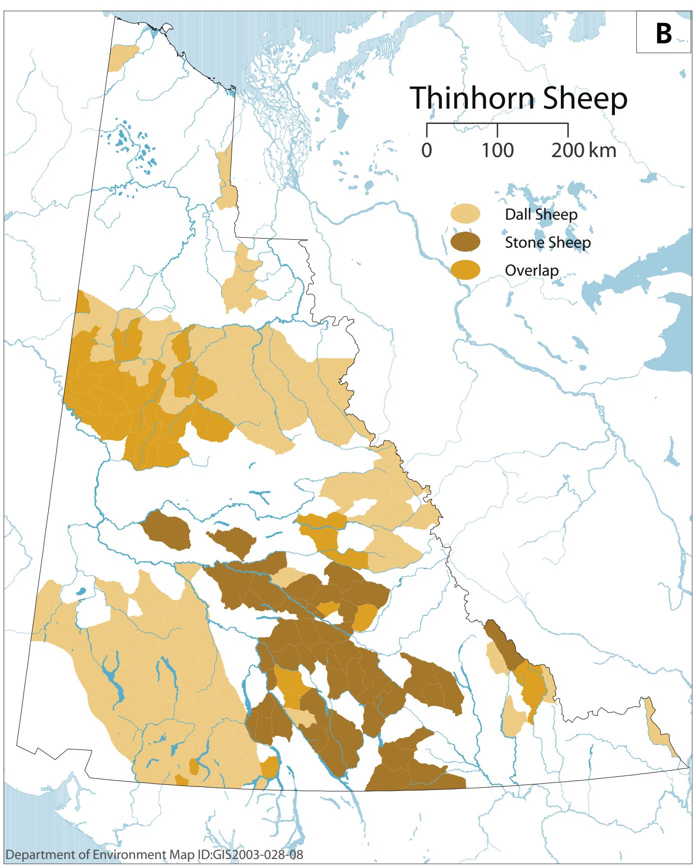
Table 4. Terrestrial mammalian species known to occur in the Yukon and their known or expected distribution by ecoregion.

SPECIES	ECOREGIONS																					
INSECTIVORES	**32**	**51**	**53**	**66**	**165**	**166**	**167**	**168**	**169**	**170**	**171**	**172**	**173**	**174**	**175**	**176**	**177**	**178**	**179**	**180**	**181**	**182**	**184**
Black-backed shrew				x						x	x				x	x	x	x		x	x	x	
Common shrew		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Pygmy shrew		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Dusky shrew		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Water shrew				x							x	x	x	x	x	x	x	x	x	x	x	x	
Tundra shrew	x	x	x		x	x	x	x	x	x		x							x				
Barren-ground shrew	x				x	x																	
BATS																							
Little Brown Myotis				x							x	x	x	x	x	x	x	x	x	x	x	x	
LAGOMORPHS																							
Snowshoe hare		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Collared pika		x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
RODENTS																							
Northern red-backed vole	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Brown lemming	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Long-tailed vole		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Singing vole		x			x			x		x	x	x	x	x		x			x				x
Tundra vole	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Meadow vole		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Chestnut-cheeked vole	x	x	x	x	x	x	x	x	x	x	x	x			x	x							
Muskrat	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Heather vole				x							x			x	x	x	x	x	x	x	x	x	
Northern bog lemming		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Ogilvie Mountains lemming								x		x													
Collared lemming	x				x	x	x																
Beaver		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Bushy-tailed woodrat				x							x	x	x	x	x	x	x	x	x	x	x	x	
Deer mouse				x						x	x	x	x	x	x	x	x	x	x	x	x	x	
Porcupine	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
House mouse												x					x						
Northern flying squirrel				x							x	x	x	x	x	x	x	x	x	x	x	x	
Hoary marmot								x		x	x	x	x	x	x	x	x	x	x	x	x	x	
Woodchuck				x								x	x	x	x	x	x	x	x	x	x	x	
Arctic ground squirrel	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Least chipmunk				x						x	x	x	x	x	x	x	x	x	x	x	x	x	
Red squirrel		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Meadow jumping mouse				x							x	x	x	x	x	x	x	x	x	x	x	x	
Western jumping mouse																	x						
CARNIVORES																							
Coyote				x								x	x	x	x	x	x	x	x	x	x		
Wolf	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Arctic fox	x																						
Red fox	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Cougar				x								x	x	x	x	x	x	x	x	x	x		
Lynx		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Wolverine	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
River otter	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Marten		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Fisher				x													x	x		x	x	x	
Ermine (short-tailed weasel)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Least weasel	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Mink	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Black bear	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Grizzly bear	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Polar bear	x				x																		
UNGULATES																							
Wood bison				x										x			x						
Mountain goat											x		x				x	x	x	x		x	x
Dall sheep					x			x		x	x	x	x	x	x	x	x		x			x	
Stone sheep								x							x	x	x	x					
Moose	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Elk															x		x						
Mule deer				x								x		x	x	x	x	x		x	x		
White-tailed deer																					x		
Woodland caribou								x		x	x	x	x	x	x	x	x	x	x	x	x	x	
Barren-ground caribou	x	x	x		x	x	x	x	x	x													
Muskox	x																						

C.F. Roots, Geological Survey of Canada

Figure 29. In summer, caribou graze in alpine environments. They commonly rest on snow patches to reduce irritation by mosquitos (Yukon Plateau–North Ecoregion).

Figure 30. Distribution of large ungulates in Yukon Territory. (a) Barren-ground and Woodland caribou herds; (b) Thinhorn sheep; (c) mountain goats. Maps courtesy of Fish and Wildlife Branch, Department of Environment, Government of the Yukon.



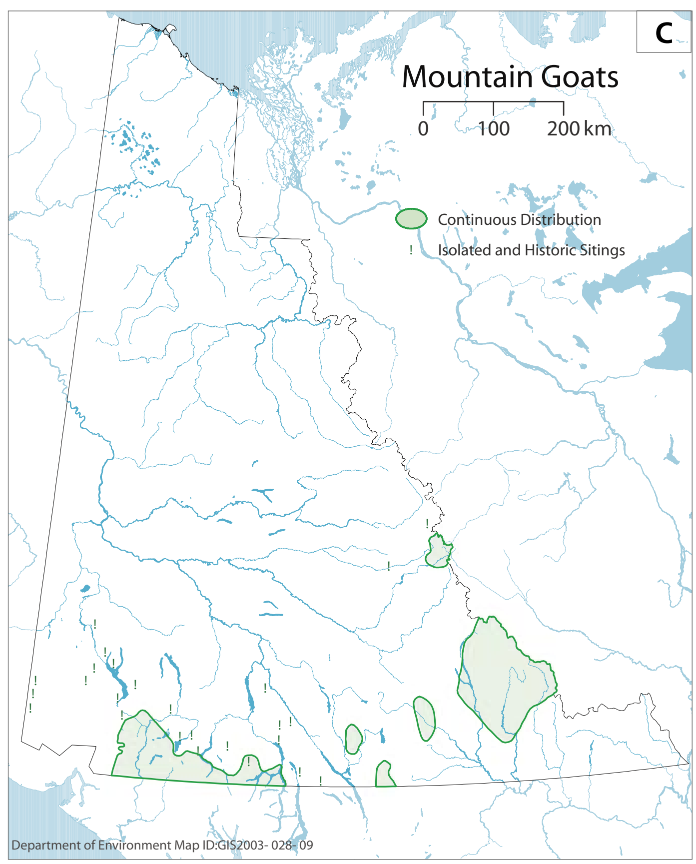


Figure 31. A bull moose (*Alces alces*) during the fall rutting period in the Yukon Plateau–Central Ecoregion. Moose, which weigh up to 1,000 kg, are found in all ecoregions with the exception of the St. Elias Mountain Ecoregion in the extreme southwestern part of the territory.

Figure 32. Snowshoe hare (*Lepus americanus*) thrive in the woodlands of the Boreal and Taiga ecozones. Local populations typically fluctuate on 10-year cycles.

(Fig. 30c). Pikas and hoary marmots hide in the talus slopes. Beavers, muskrats, mink and otters ply the territory's streams and ponds.

The populations of many species including lynx, coyotes, marten, and porcupines, as well as many birds of prey, are mostly restricted to the forested areas and follow the cyclic fluctuations in abundance of snowshoe hares (Fig. 32). About every 10 years, numbers of hares peak up to 300 times those at cyclic lows. Their importance to survival for many other northern animals is such that snowshoe hares are often called a "keystone species." Red squirrels, flying squirrels, least chipmunks, and several other small mammals round out the mammals of the boreal forest.

Finally, there have been several new additions to the Yukon fauna in recent years. Mule deer, white-tailed deer, and cougar have naturally expanded their ranges north from British Columbia. Wood bison have been reintroduced, and elk were introduced into the area northwest of Whitehorse during the past 40 years. Elk have also been seen in small numbers north of the Yukon–British Columbia border in the Beaver River watershed in the far southeast Yukon. Groups of a bison herd that mostly ranges near Fort Liard in the Northwest Territories, have been seen in the lower La Biche watershed in the extreme southeast corner of the Yukon.

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BIRDS

by Dave Mossop and Pam Sinclair

The Yukon's bird habitat is primarily mountainous, with major valleys, wetlands, boreal and taiga forests and an Arctic marine coastline providing good variety. Most of the bird species supported by boreal forest and tundra are well dispersed. The spectacular concentrations that do occur are migration events. These include the movement of thousands of Sandhill Cranes through the Tintina Trench; the spring staging of waterfowl such as Tundra and Trumpeter Swans in the Yukon Southern Lakes Ecoregion; the concentrations of diving ducks and other waterbirds that gather on the Old Crow Flats Ecoregion in late summer; and the Snow Geese that gather in huge flocks in early fall to feed on the Yukon Coastal Plain before heading south along the Mackenzie River Valley. The Yukon is renowned for its birds of prey. Peregrine Falcon, Gyrfalcon and Golden Eagle rule the open skies. The territory also has many species of hawks, falcons and owls.

As of the fall of 2002, 288 bird species had been recorded in the Yukon, with 223 occurring regularly. This compared with over 450 species in Alaska, 400 in British Columbia and 312 species confirmed in the Northwest Territories.

Of the bird species occurring, many have a large proportion of their Canadian population in the Yukon. Examples of significant occurrences are impressive numbers of nesting anatum Peregrine Falcons, which are endangered in Canada; Canada's only nesting Surfbirds; and healthy numbers of breeding Trumpeter Swans and Great Grey Owls, which are both listed as vulnerable in Canada. In addition, several species strictly associated with arctic tundra elsewhere in Canada are found breeding in the Yukon's alpine tundra, far south of the Arctic.

About 36 bird species regularly spend the entire year in the Yukon. However, most Yukon birds come to the territory seasonally to breed or pass through to breeding grounds in Alaska.

With spring come flocks of migratory birds, and the Yukon comes alive with spring calls and displays. The many species of warblers, flycatchers, sparrows and thrushes join year-round residents of the forests like the chickadee, Spruce Grouse, and ever-present raven, the Yukon's territorial bird. As the ice thaws, the wetland birds arrive in droves for the short breeding season. These include shorebirds, ducks, geese, cranes (Fig. 33) and swans. Shortly afterward, the tundra fills with local ptarmigan, longspurs, plovers and sparrows.

Several contrasting migration strategies bring birds from very different sources. For birds wintering in North and South America, there is a major overland flyway from southwestern North America, an overland route from eastern and central North

C.D. Eckert

Figure 33. Sandhill Cranes feed during late June in the Jackfish Wetland complex in the Fort McPherson Plain Ecoregion. This region is nesting habitat to species, including the Sandhill Crane, that are part of the Mackenzie Valley flyway and are less common in central Yukon.

America, and a route direct from the Gulf of Alaska. There is also a far-eastern route across the Bering Strait from Asia.

This diversity is reflected in Yukon breeding populations of very different geographic origins. Five species have the bulk of their populations in Eurasia, and in the Yukon three of these are confined to the extreme north. Ten species are predominantly found in eastern North America, and in the Yukon most of these are confined to the southeast. Many species are predominantly found in western North America and, in the Yukon, some of these are confined to the southwest of the territory.

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AMPHIBIANS

by Brian G. Slough and Lee Mennell

The status of amphibian populations in the Yukon Territory is largely unknown; little is known about their abundance, habitat requirements, or life history patterns. Recent field surveys and sightings have greatly increased our knowledge of their distribution in the Yukon. Four species of anurans are known to occur in the territory, three of which have very restricted ranges.

The wood frog (*Rana sylvatica*) is common throughout the Yukon in a diversity of habitats that provide shallow ponds for breeding (Fig. 34). It has been found as far north as the Old Crow Flats Ecoregion and may occur north of treeline, as it does in the Brooks Range of Alaska. It has been found further north than any other amphibian in North America. The wood frog's success is due to cold tolerance and accelerated development. They can withstand temporary freezing to –6°C. One should expect to find them in all ecoregions except Mount Logan. Wood Frogs have yet to be reported in the British-Richardson Mountains and the Yukon Coastal Plain ecoregions.

The Columbia Spotted Frog (*Rana luteiventris*) was first reported in the Yukon in 1993 at two locations. Its range extends from northwestern British Columbia into the Yukon along the West Arm of Bennett Lake in the Yukon–Stikine Highlands Ecoregion. This is their known northern limit in North America. The Columbia Spotted Frog appears to be limited by snowfall in this region, which must be adequate to insulate shallow ponds from freezing to the bottom during the period of underwater hibernation. The populations and meta-population

J. Meikle, Yukon Government

Figure 34. The wood frog is common throughout the Yukon, occurring farther north than any other amphibian in North America. They are reported as far north as the Old Crow Flats and Peel River Plateau ecoregions. This photo is from the Russell Range (Yukon Plateau–North Ecoregion) near the boreal–subalpine break. This wood frog is a distinct bluish-grey colour, one of many colour and pattern phases exhibited by the species in the Yukon.

here are isolated from others to the south and may be highly vulnerable to extinction.

The boreal chorus frog (*Pseudacris triseriata*) was first reported in the Yukon in 1995, near the La Biche River in the southeast Yukon. It is widespread east of the Rocky Mountains in North America but appears to exist here only in the Muskwa Plateau Ecoregion.

The boreal toad (*Bufo boreas*), common throughout northern British Columbia, enters the Yukon only in the southeast. It is most common in the Liard Basin and Hyland Highland ecoregions and it likely occurs in the Muskwa Plateau Ecoregion. Its most northerly location in the Yukon is North Toobally Lake. It occurs at several geothermal springs in the region, including Coal River Springs and springs on the Meister River in the Pelly Mountains Ecoregion, some 400 km north of their continuous range (National Museum of Canada-Amphibian Records). The boreal toad is restricted to areas of high snowfall and geothermal activity where ground freezing is limited and they are able to burrow below the frost line.

A specimen of western toad (*Bufo* sp.) was collected at Whitehorse in 1948 and deposited in the American Museum of Natural History. Likely an accidental occurrence, it was 100 km north of its known range.

Further monitoring efforts are required to confirm the ranges of these species, thus it is likely that more range extensions will be documented. Salamanders and newts (*Caudata* sp.), snakes and other reptiles are not known from the Yukon, but some species, such as the long-toed salamander (*Ambystoma macrodactylum*) found near the Yukon border, may yet be discovered here.

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FISH

by Al von Finster

Most of the Yukon Territory is drained through three major drainage basins: the Yukon, the Mackenzie (via the Peel and Liard rivers), and the Alsek (see Fig. 7). The Yukon Coastal Plain Ecoregion is drained by a series of small, northward-flowing coastal rivers directly into the Beaufort Sea. Some fish species range widely and are found in all Yukon drainage basins. Other species are much more restricted in their range, and have been found in only small portions of a single drainage basin (Table 5). Reasons for this differential distribution include postglacial redistribution, the life histories of the fish species concerned, natural boundaries to upstream migration, and the introduction of exotic species. There is a relative lack of knowledge concerning distribution of non-economic fish species and stocks.

Fish habitat is both defined and maintained by the waters in which fish live, by the surrounding terrestrial environments that influence the nature of those waters, and by the overriding climate that affects both the terrestrial and aquatic environments. Stocks using different waters, or parts of the same waters separated by geography or altitude, may exhibit markedly different behaviour to successfully maintain essential life processes such as feeding, reproduction and overwintering. The physical fish habitats that exist in each of the drainage basins defined for the Yukon Territory are briefly described below.

YUKON RIVER DRAINAGE BASIN

The basin is comprised of a number of sub-basins. The headwaters of most sub-basins are in mountains that were ice-covered in the last glacial period. Moraine-dammed lakes are common. The middle and lower reaches of most rivers flow through glaciofluvial or glaciolacustrine deposits. Lakes, deposits of colluvium in the upper sub-basins, and glacial deposits throughout the drainage basin all provide storage for water. These stored waters provide critical overwintering habitat for fish.

Much of the central Yukon and most of the Porcupine drainage were not subject to continental glaciation. Surface and subsurface storage of water is very limited in these areas. As a consequence, there is less overwintering habitat for fish.

Table 5. Fish species that may be found in the principal drainage basins of the Yukon. Anadromous species are shown in bold text.

Species: N = native, I = introduced, A = anecdotal

Drainage basin	Yukon River	Mackenzie River		Alsek River
		Peel River	Liard River	
Chinook salmon *(Onchorynchus tshawytcha)*	N			N
Chum salmon *(Onchorynchus keta)*	N	N	N	A
Coho salmon *(Onchorynchus kisutch)*	N			N
Sockeye (kokanee) salmon *(Onchorynchus nerka)*				N
Pink salmon *(Onchorynchus gorbuscha)*				A
Steelhead salmon/Rainbow trout *(Onchorynchus mykiss)*	I			N
Cutthroat trout *(Salmo clarki)*				N
Lake trout *(Salvelinus namaycush)*	N	N	N	N
Arctic char *(Salvelinus alpinus)*	I	N		
Dolly Varden char *(Salvelinus malma)*	N	N	N	N
Bull trout *(Salvenlinus confluentus)*			N	
Round whitefish *(Prosopium cylindraceum)*	N	N	N	N
Mountain whitefish *(Prosopium williamsoni)*			N	
Pygmy whitefish *(Prosopium coulteri)*	N	N		N
Lake (humpback) whitefish *(Coregonus clupeaformis)*	N	N	N	N
Broad whitefish *(Coregonus nasus)*	N	N		
Arctic cisco *(Coregonus autumnalis)*	N	N	N	
Bering cisco *(Coregonus laurettae)*	N			
Least cisco *(Coregonus sardinella)*	N	N	N	
Inconnu *(Stenodus leucichthys)*	N	N	N	
Arctic grayling *(Thymallus arcticus)*	N	N	N	N
Burbot *(Lota lota)*	N	N	N	N
Northern pike *(Esox lucius)*	N	N	N	N
Longnose sucker *(Catostomus catostomus)*	N	N	N	N
White sucker *(Catostomus commersoni)*			N	
Slimy sculpin *(Cottus cognatus)*	N	N	N	N
Spoonhead sculpin *(Cottus ricei)*		N	N	
Walleye *(Stizostedion vitreum)*			N	
Goldeye *(Hiodon alasoides)*			N	
Lake chub *(Couesius plumbeus)*	N	N	N	
Flathead chub *(Platygobio gracilis)*		N	N	
Spottail shiner *(Notropis hudsonius)*			N	
Emerald shiner *(Notropis atherinoides)*			N	
Trout-perch *(Percopis omiscomaycus)*			N	
Threespine stickleback *(Gasterosteus aculeatus)*	I			
Ninespine stickleback *(Pungitius pungitius)*			N	
Longnosed dace *(Rhinicthys cataractae)*		N	N	
Arctic lamprey *(Lampetra japonica)*	N		N	

Non-anadromous fish are most numerous in the Yukon River basin. They comprise more species and a greater number of stocks and populations than the anadromous species. Those that are present in any given location and time have either adapted, or are adapting, to changes in the environments that they live in and are part of. Two or more stocks of a single species may use the same waters. There may be a wide range of densities, life history strategies, migratory patterns, and other behaviours within any given ecoregion.

MACKENZIE RIVER DRAINAGE BASIN

Portions of two primary sub-basins of the Mackenzie extend into the Yukon Territory. The Liard River is a headwater tributary of the Mackenzie River. It rises in the southeast Yukon and flows southeasterly into British Columbia. The Peel River is a lower-river tributary of the Mackenzie. It begins in the north-central Yukon Territory within 50 km of the Alaska border and flows east and then north to the Northwest Territories. The Liard and Peel river habitats are described separately below.

Peel River habitat

The lower section of the Peel River, including its tributaries, is accessible to fish moving upstream from the Mackenzie River. It is likely that additional species will be documented in this section of the river as more information is gathered and as species extend their ranges. The list in Table 5 must be considered to be provisional.

On the Peel River, Aberdeen Falls are a complete obstruction to the upstream migration of fish stocks. The species assemblage above the falls is correspondingly smaller than in the river below the falls. The principal tributaries into the Peel River generally consist of steep headwater streams, which are usually barren of fish, and low gradient, laterally stable upper stream reaches with local, very high fishery values. Lower portions of tributary streams are characterized by moderate gradient, laterally unstable mid-reaches and laterally stable, actively downcutting lower reaches extending to the Peel River. Maximum fishery values occur in valley wall, groundwater-fed channels within the middle and lower reaches.

Liard River habitat

Headwater lakes are present, though not as common or as extensive as in the Yukon River drainage basin. Principal tributaries tend to have rough, graded channels. There are deep and extensive deposits of glacial and reworked, unconsolidated materials in the basin. Observed winter flows are significant and open water areas are common, implying discharges from ground water stored in these deposits. The Liard River in the territory has a low to moderate gradient until immediately north of the British Columbia border, where it enters the first of a series of canyons.

Recolonization by fish after glaciation probably occurred from refugia both north and south of the basin. Movement of species into the watershed continues. As an example, chum salmon have been captured in the Liard River to a point near the Yukon border. Without artificial obstructions such as hydro-electrical dams, more fish species may be expected to move up the Liard River from the Mackenzie River proper. Tributaries that head in the Yukon Territory and enter the Liard River

J. Meikle, Yukon Government

Figure 35. Bull trout *(Salvenlinus confluentus)* in the Yukon are most abundant in the Liard River drainage, but are known to occur in the Yukon River drainage in the Lapie and Morley rivers. This species is a land-locked char, which ranges mostly on the eastern side of the Rocky Mountains from Wyoming to the Yukon. The species is experiencing population decline in southern areas from habitat alteration and overfishing but Liard River populations are stable. Photo from Beaver River.

downstream of the border, such as the Hyland and La Biche rivers, have been little studied (Fig. 35).

ALSEK RIVER BASIN

The Yukon portion of the Alsek River drainage basin has two distinct sub-basins. The Alsek sub-basin is above an almost total obstruction to upstream migration of anadromous fish, and encompasses the Dezadeash and Jarvis rivers drainages. The species assemblage is similar to that of the Yukon River basin, except that there are some stocks of indigenous rainbow trout, alpine dolly varden, and kokanee salmon. This sub-basin is generally subject to interior weather conditions, with limited precipitation and severe winter temperatures. This results in locally difficult overwintering conditions.

The Tatshenshini sub-basin is accessible to Pacific salmon. The species assemblage is a combination of coastal and interior (Yukon River) species. Graded rivers with steeper tributaries mark the sub-basin. Only one of these tributaries, the upper Takhanne River, has a relict interior species assemblage. The others have a coastal mountain species assemblage, with alpine Dolly Varden dominating the reaches that are above Pacific salmon utilization. Precipitation is greater than in the Alsek sub-basin, and temperatures are milder, resulting in more abundant overwintering habitat.

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INSECTS

(adapted from Danks et al. 1997)

The Yukon Territory provides a setting for its fauna that is of particular geological and ecological interest. Much of the Yukon was unglaciated in Pleistocene time as part of Beringia, a much larger ice-free but essentially treeless area extending through Alaska into eastern Siberia (Fig. 17). The Yukon today is a distinctly northern region dominated by arctic, alpine, subarctic and boreal terrain. Nevertheless, it is relatively benign for its latitude of 60 to 69°N, and habitat diversity here is enhanced by the local amelioration of temperature on south-facing slopes and in river valleys.

As a result of these past and current influences, the insect fauna of the Yukon is relatively rich and distinctive, reflecting the results of evolution on a variety of scales, and comprising distinctive assemblages of forest, grassland and tundra species (Fig. 36). The composition of the fauna reflects the current or past prevalence of particular habitats, such as boreal forest that supports many widely distributed North American species, shallow still waters that support many aquatic species, and dry grasslands on warm slopes that support many leafhoppers and heteropterans.

Arachnida and Insecta, the classes reported in Table 6, contain about one-third of the known arachnid fauna of Canada and more than half of Canada's insect fauna. In these groups are 297 species of spiders, 157 species of mites, and 2,711 species of insects (i.e. belonging to the Insecta family). About one-fifth of the Canadian species known in those groups are recorded in the Yukon. However, recorded species represent only part of the total number of species that actually occur. So while Table 6 lists some 2,397 recorded species of Insecta and 454 species of Arachnida for the Yukon, actual numbers of species are likely in the range of 6,000 and 900, respectively. The reliability and estimated values vary by order. For instance, orbatid mites have been more widely collected than the other orders listed.

Individual species, as well as different groups, differ widely in ecological and distribution features according to their particular life histories. However, the fauna, like the terrain, is distinctly northern; it is dominated by certain northern and widespread taxa, whereas other groups are represented by few species. The prevalence of northern groups tends to be correlated, though not exclusively, with their occupation of aquatic habitats, which are favourable in the north, and with general feeding habits, such as predation, that are advantageous where specific resources are more limited. Many adaptations of structure, behaviour and life cycle reflect the demands of cold and seasonal life.

The range of most Yukon insect species are restricted to the North American arctic and subarctic regions. A few northern groups of insects, as well as spiders and oribatid mites, have Holarctic distribution. Endemic species (i.e. those occurring only in the Yukon) make up a significant proportion of the recorded species of mites, mayflies, beetles and butterflies. Much taxonomic evidence, such as the occurrence of sister-species in the Yukon and in Asia, indicates past connections between North America and Eurasia that preceded the well-known Pleistocene connection.

About half of the Yukon fauna are widespread in North America, and one-third have strictly western distribution. These and other ranges suggest that species have come to occupy the Yukon by several different routes. For example, northern boreal ranges predominate among the Nearctic species (those restricted to North America). Therefore, many of them probably are postglacial invaders from the south and east. However, other widely distributed arctic and boreal species are known from Beringia as Pleistocene fossils, reflecting their presence there during glaciation. Several species appear to have survived the Pleistocene in both Beringian and southern refugia, because they have distinct or disjunct northern and southern populations. In several groups, substantial numbers of species occur only in the formerly glaciated southern parts of the Yukon and have not spread farther north; they are presumed to have entered the Yukon from the south after deglaciation. Also presumed to be invaders from the south after glaciation are species, especially from stream habitats, that range from southern Cordilleran ecozones into the Yukon but are restricted to the southern Yukon.

About one-tenth of the insect species in the Yukon are restricted to the northern unglaciated areas in North America (East Beringia), suggesting that these species survived the ice age in Beringia but have not subsequently spread beyond it. The Beringian portion of present-day Yukon includes the Klondike Plateau, Northern Ogilvie Mountains, Eagle

Table 6. The numbers of recorded Arachnida (spiders and mites) and Insecta (flies, hoppers, beetles and others) species in the Yukon and elsewhere. Adapted from Danks *et al.* (1997), Table 1, p. 972.

	Yukon		Canada	North America	Yukon species as % of Canadian species
Taxonomy	**Total**	**Endemic**	approximately	approximately	approximately
ARACHNIDA					
Spiders *(Araneae)*	297	17	1,400	3,800	20
Orbatid mites *(Oribatei)*	157	50	400	1,000	45
Total	**454**	**67**	**1,800**	**4,800**	**65**
INSECTA					
Mayflies *(Ephemeroptera)*	30	8	300	680	10
Dragon flies *(Odonata)*	33	5	200	450	15
Stoneflies *(Plecoptera)*	71	8	250	610	30
Grasshoppers *(Orthoptera)*	17	2	220	2,000	10
True Bugs *(Heteroptera)*	216	19	1,300	3,900	20
Leafhoppers and planthoppers *(Homoptera)*	unknown	–	2,000	7,000	–
Beetles *(Coleoptera)*	913	57	7,500	24,000	12
Black flies *(Diptera)*	unknown	–	7,000	20,000	–
Butterflies and moths *(Lepidoptera)*	518	24	4,700	11,500	10
Caddis flies *(Trichoptera)*	145	15	580	1,300	25
Wasps and ants *(Hymenoptera)*	unknown	–	6,000	17,500	–
Total Insecta, only groups with Yukon data, as listed above	**2,397**	**205**	**21,850**	**56,840**	**10**

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Figure 36. Tiger swallow tail *(Papilio glaucus)*. Easily identified by black and yellow stripes, along with a "tail" projecting from each hind wing. This common butterfly of the Yukon can often be seen congregating around mud puddles.

Plains and British-Richardson Mountains ecoregions (Fig. 17). These species occur across Beringia, in East Beringia only or across Eurasia, but not more widely in the Nearctic region. The habitat requirements of the species confined to Beringia indicate the existence there in the Pleistocene of dry grassland, tundra and other habitats.

Additional evidence, grounded in wider collecting and systematic study, is required to analyze the dynamics of colonization and faunal interactions in the Yukon, and to establish the reasons for the continuing limitation of some species to Beringia. Although some evidence suggests that the fauna is more or less integrated, it may not yet have reached full equilibrium with climatic and biotic influences following deglaciation. In any event, the taxonomic and ecological structure of the Yukon insect fauna continues to demonstrate the constraints of current environments and the repercussions of Beringian history.

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TRADITIONAL LAND USE

by Ruth Gotthardt

Human occupancy of the Yukon is, in a sense, as old as the landscape itself. At the end of the Pleistocene, the land was in effect newly created, emerging from the cover of massive ice sheets in the south and exposed as proglacial lakes drained in the north. The first North American populations left traces of their ancient camps dating back to perhaps 24,000 years ago at the Bluefish Caves in the unglaciated northern Yukon. In the southern Yukon, sites dating to 10,000 years ago indicate that human hunters moved into the region as the ice sheets were retreating.

The ancestors of Yukon First Nations people were among the earliest human populations to devise effective adaptations to arctic and subarctic environments. Principal among these were strategies for food preservation and storage for the seasons of resource scarcity, and strategies for dealing with periodically unpredictable resources and conflicting periods of resource abundance. Characteristically, solutions were achieved through a combination of technological ingenuity and human resource management.

Elements common to all boreal forest hunting technologies were the use of snares, deadfalls, surrounds and nets — all essentially "automated" hunting devices for taking the often scattered and unpredictable game of the northern forest. Regionally, the use of these technologies was implemented in response to the distribution and relative concentration of resource species. In the northern Yukon, for example, caribou surrounds were constructed on a near-monumental scale to exploit the seasonal migrations of thousands of caribou belonging to the Porcupine herd.

New insight into change in hunting technologies and strategies in the Yukon's prehistoric past has been a serendipitous byproduct of the recent discovery of significant reduction of alpine ice patches in the southwest Yukon (Fig. 37). Unprecedented examples of hunting technology are being recovered from the ice patches, including spears and bows and arrows, a number with hafting elements, feathers, and ochre decoration still preserved (Fig. 38). The evidence recovered to date suggests that a major shift in hunting strategies occurred about 1,300 years ago with the abandonment of throwing spears (Fig. 39) and the introduction of bows and arrows, possibly in combination with hunting blinds, for taking caribou on ice patches.

At the core of traditional social organization for most of Yukon's First Nations was the division of society into two complementary moieties, referred to commonly as "Crow" and "Wolf." Membership in a moiety — the term "clan" is used locally — is assigned through the maternal line and structures all aspects of an individual's relationships both within and outside of the community throughout their lifetime. Membership in the Crow or Wolf clan is the principal mechanism by which networks of trade and exchange were established between unrelated people from distant groups. These kinds of remote connections not only facilitated acquisition of valued trade items, but also provided a means by which people might call upon their ties to other groups to ensure survival in times of resource scarcity.

Adaptation to the northern forests has fostered a subsistence strategy characterized by a high degree of seasonal mobility designed to take advantage of certain periods and locales in which resources are both abundant and predictable. One of the most critical aspects of this pattern is the knowledge possessed by individuals and the group concerning the habitat, behaviour and movement of game and fish.

Non-biotic resources were factored into the seasonal round as well. Highly siliceous, cryptocrystalline stone such as agate, chalcedony and chert were the preferred materials for the manufacture of tools and implements. Traditionally, the most valued materials were obsidian and, within the past 1,500 years, native copper, which are concentrated in the St. Elias Mountains Ecoregion. Because these resources were unevenly distributed in the landscape, access was achieved by developing extensive networks of intergroup trade and exchange.

The geographic proximity of resource areas to each other is of key importance when considering the human use of the landscape. The exploitation along the interface of varying physiographic units or ecological zones is characteristic of human groups attempting to maximize access to a

J. Meikle, Yukon Government

Figure 37. Accelerated melting of snow patches in southern Yukon in the late 1990s revealed thick layers of caribou fecal material (dark band where snow patch has receded) accumulated over many thousands of years, where there are no caribou today. Searches during the brief midsummer when these deposits are exposed have led to better understanding of caribou diet and caribou hunting techniques.

Figure 38. Ice-patch investigators examine a complete arrow recently exposed by melting ice. The excellent preservation, including organic artefacts, in ancient ice has resulted in discoveries unique in North America. They have provided archeologists and First Nations researchers with an unparalleled window into the Yukon's past.

Heritage Branch, Yukon Government

variety of resources and to ensure survival should one resource fail. The traditional land use and archaeological records of the Yukon indicate that the preferred sites and areas of highest population density were located where at least two such zones converged.

The generalized seasonal migration saw gatherings in midsummer at chinook salmon fishing sites in sloughs on the major rivers and tributaries of the Yukon and Pacific drainages. Fishing technology made use of large conical fish traps, about 4 m in length constructed of willow or spruce poles, three or four of which were set in a weir across the shallow section of a creek or slough. Surpluses of salmon were dried and cached for use during winter. The principal salmon fishing camps were reused every season and were the "headquarters" by which local groups or bands identified themselves and their neighbours. Some of the names have persisted in translation. The Little Salmon and Carmacks First Nations, for example, had their major fish camps, respectively, at the mouth of the Little Salmon River and just above the mouth of the Nordenskiold River, the present site of the village of Carmacks in the Yukon Plateau–Central Ecoregion.

In early fall, extended family groups moved to treeline settings in the uplands to pursue moose and caribou, and where available, sheep and goats. At the same time, berries were ripening, and for some areas, the chum salmon run was of considerable economic importance. Other species running at this time were lake trout and inconnu, dolly varden in the southeastern Yukon, and least cisco, particularly in the Atlin, Teslin and Carcross areas. Local and regional factors from year to year determined whether groups aggregated or dispersed, where scheduling conflicted, to exploit resources.

Figure 39. Foreshaft of a throwing spear with stone point still attached with sinew. The artefact, obtained from the base of a melting snow patch, has been radiocarbon dated to about 4500 BP.

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In late fall, people gathered at whitefish spawning localities at the lake outlets where traps and short sinew nets were used again. Lakes where the population of winter fish was sufficient were used as the base for winter villages. These were located at the narrows of the lakes, or at lake outlets, which often remained open during the winter, and where the natural constriction permitted setting nets for schools of whitefish. In the southern and central Yukon, access to good winter fish lakes was the critical factor for survival during the times of scarcity in winter and complex socio-political negotiation was used in the control of this resource.

Winter was the period of highest mobility and smallest group size, often made up of single family units. Hunters set snares for moose and erected small surrounds in caribou winter ranges. Other smaller game was taken in deadfalls and snares. Knowledge of the location of good lingcod (burbot) and jackfish (northern pike) lakes was critical for survival in times of scarcity. In February, people often moved their camps to creek outlets on lakes to fish for spawning lingcod.

In early spring, beaver and muskrat were hunted and trapped on the lakes, and spawning grayling and jackfish were netted and trapped on the creeks. Later in the spring, migrating waterfowl were hunted. In June, spawning fish, including the longnose sucker, were netted from the creeks.

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Divergence from these generalized patterns is a response to broad regional differences in resource availability.

Kaska people inhabiting the lands within the Liard drainage in the southeastern Yukon lacked access to salmon. However, beaver populations were considerable and formed a correspondingly greater focus in their subsistence round. The archaeological record of this portion of the Yukon reveals a highly dispersed pattern of land use and generally small site size. The impression remains that overall population density was probably among the lowest in the Yukon. Relationships with groups who had access to the annual salmon run were emphasized as well, resulting in close ties with both Teslin and Upper Pelly River peoples. Links were also maintained with the Tahltan to the south who provided the Kaska with highly valued obsidian from sources in the Mount Edziza area in northern British Columbia, and which placed the Kaska in a favourable position to trade with their neighbours.

By comparison, the Southern Tutchone groups in the southwestern Yukon exploited a more varied resource base. Because they were close to Tlingit groups on the coast via the Chilkat Pass, they were able to obtain exotic resources of the coast in trade, particularly the dentalium shell. Groups resident at Klukshu and Shaw'she had access to the productive salmon run in the Alsek-Tatshenshini drainage (Fig. 40).

The Gwitch'in in the northern Yukon were caribou hunters. Their seasonal round focused on the interception of the Porcupine caribou herd in its spring and fall migration between their wintering grounds in the protected mountain valleys of northern Yukon, and calving grounds on the Yukon Coastal Plain Ecoregion. The caribou fences of the Gwitch'in in the British Richardson Mountains Ecoregion, some measuring more than 2 km in length, represent the most comprehensive expression of surround technology in the North American boreal and taiga forest regions. Successful hunts could sustain a large village through the winter to the early spring when the muskrat hunt began.

Figure 40. Fish weirs are traditionally used in the upper reaches of small streams to trap spawning chinook and sockeye salmon in midsummer. This one is at Klukshu village near the Haines Road on a tributary of the Alsek River.

Spring caribou interception localities traditionally were located at river crossings. Klo-kut and Rat Indian Creek are two such sites that attest to the size of the communities that could be supported by the hunt. The Gwitch'in also differed from other Yukon First Nations in their trading connections, although troubled at times, to the Inuvialuit of the Yukon North Coast and Herschel Island.

Inuvialuit populations adapted to the Arctic environments of the northern Yukon, north of the treeline. Ancestral Inuvialuit populations appeared in northwestern North America approximately 4,000 years ago. These early arrivals oriented toward caribou hunting and exploitation of coastal resources, principally seals, by hunting along the edge of open leads in the ice cover of the Beaufort Sea. However, by 1,000 years ago their descendants, known as the Thule, had refined techniques of open-water hunting for bowhead whale. With almost unprecedented rapidity, the Thule colonized the entire Arctic archipelago. In a few centuries, they established themselves as far east as Greenland, following the range expansion of the bowhead whale. The Qikiqtarukmuit were the Siglit, or Mackenzie Inuvialuit, subgroup occupying the Yukon north coast, the British and Barn Mountain foothills and Herschel Island where they had their village of Qikiqtaruk. The Siglit linked their Gwitch'in neighbours in the northern Yukon and the lower Mackenzie River to the far-flung Arctic and Siberian trade networks.

The interpretation of human history in the Yukon requires the reconstruction of adaptations to environmental change over time. Up to at least the mid-Holocene, bison were hunted routinely in parts of the Yukon. Recent dates on bison from the Whitehorse area indicate survival of this species within the past millennium. Ethnographic records report bison from the Carcross and Ross River areas as well. Muskoxen remains dated to about 3,000 years ago in the Dawson area suggest this species may have been a common element in the subsistence round of peoples of the northern Yukon in the early and mid-Holocene.

Catastrophic events relating to the regional geology factor into human history as well. One of the most powerful volcanic eruptions in recent global history occurred at the headwaters of the White River in Alaska, immediately adjacent to the southwest Yukon in AD 803. Twenty-five cubic kilometres of tephra blanketed the southern and central Yukon as a result of the eruption (see Fig. 18 and 25). The effect of the White River ash fall on human populations in the Yukon is not well understood. The appearance of Athapaskan-speaking Navaho and Apache peoples in the American Southwest is likely tied to this event. Nearly co-incident with the White River eruption is the sudden appearance in Alaska and the Yukon of such technological innovations as the bow and arrow and the knowledge of metal working by heating and folding, which used native copper nuggets found in stream beds in the White River drainage. The acceleration of coastal-interior trade, possibly based on copper, may be traced to this period, culminating in the highly organized and profitable trade witnessed by the first European fur traders to enter the country in the mid-19th century.

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PART 2

Ecozone and ecoregion descriptions

SOUTHERN ARCTIC ECOZONE

The Southern Arctic Ecozone covers northern mainland Canada from the coastal foothills of the Richardson Mountains in the Yukon to Ungava Bay in northern Quebec (Fig. 1). Over 80% of the land area in this ecozone lies west of Hudson Bay. Of the three arctic ecozones, this one has the most extensive vegetative cover and highest biodiversity. It is represented in the Yukon in only one ecoregion, the Yukon Coastal Plain.

Climate: This ecozone experiences long, cold winters, and short, cool summers. Mean annual temperature ranges from –11°C in the northwest (i.e. Yukon and Tuktoyaktuk Peninsula) to –7°C in northern Quebec. Mean summer temperature ranges from 4 to 6°C, producing a short growing season with up to 750 growing degree days, and enhanced by long periods of daylight. The mean winter temperature ranges from –28°C in the northwest to –17.5°C in Quebec. The mean annual precipitation in the northwestern portion of the ecozone is in the range of 200 to 250 mm.

Hydrology: The major controlling influence on hydrologic response is the presence of continuous permafrost underlying the landscape. Though the area receives relatively little precipitation, runoff is significant. Peak flows, which generally occur in June, exhibit very quick response times because of the shallow active layer. Because there is very little infiltration and evapotranspiration rates are low, snowmelt is quickly transported to the stream channel with little loss. Likewise, peak summer

J. Hawkings, Canadian Wildlife Service

Cotton grass *(Eriophorum vaginatum)* in flower on Herschel Island at Thetis Bay.

rain locally produces flash floods. Because of the relatively small streamflow generating areas, the largest streams in this part of the Yukon are relatively small compared with elsewhere in the ecozone. Many streams experience zero winter flow from November to April.

Landforms and soils: Most of the Southern Arctic Ecozone is underlain by Precambrian granitic bedrock, and the terrain consists largely of broadly rolling rocky uplands and intermittent lowlands. Much of it is mantled with discontinuous moraine, except in coastal areas and within much of the Yukon Coastal Plain Ecoregion, where fine-textured marine or glaciomarine sediments cover the surface. Thick glacial drift deposits characterize much of the westernmost section of the ecozone from Great Bear Lake to the Firth River on the Yukon coast. Strung out across the landscape are long, sinuous eskers, some reaching lengths of 100 km. A small part of the ecozone west of the Firth River is unglaciated. The undulating landscape is studded with innumerable lakes, ponds and wetlands. Cryosols, the dominant soils, are underlain by continuous permafrost with active layers that remain moist or wet throughout the summer.

Vegetation: This ecozone covers the major area of vegetation transition between the taiga forest to the south and the polar desert conditions of the Northern Arctic Ecozone. The vegetative cover is dominated by shrubs, which decrease in size to the north. Typical shrubs include dwarf birch, willow, and heath species; these are commonly mixed with various herbs, lichens and mosses. Major river valleys, such as the Babbage, support scattered clumps of stunted spruce trees. Wetlands are common in the low-lying coastal areas, and mainly support sedge moss vegetation.


J. Hawkings, Canadian Wildlife Service

White and intermediate phase snow geese photographed during late-summer staging along the Yukon Coastal Plain.


B. McLean

In this zone of continuous permafrost, the Arctic fox *(Alopex lagopus)* seeks out alluvial or well-drained sandy soils for den sites.

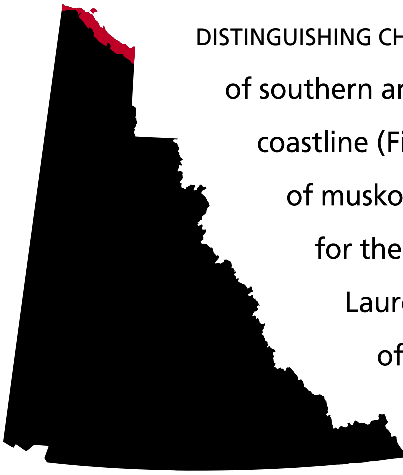
Wildlife: A wide variety of mammals live in this ecozone. It includes the major summer range and calving grounds for Canada's largest caribou herds, the barren-ground caribou in the west and the woodland caribou in the eastern portion of the ecozone. Other mammals include grizzly bear, black bear in northern Quebec, polar bear in coastal areas, wolf, moose, Arctic ground squirrel, and brown lemming. This ecozone is also a major breeding and nesting ground for a variety of migratory birds. Representative species include the Yellow-billed, Arctic, and Red-throated Loons; Tundra Swan; Snow Goose; Long-tailed Duck; Gyrfalcon; Willow and Rock Ptarmigan; Red Phalarope; Parasitic Jaeger; Snowy Owl; Hoary Redpoll; and Snow Bunting. Some typical marine species include walrus, seal, beluga whale, and narwhal.

Human activities: This ecozone is sparsely populated. The total population of approximately 10,300 is scattered in 17 communities, including Tuktoyaktuk, Paulatuk, and Coppermine in the west; Chesterfield Inlet, Rankin Inlet, and Eskimo Point on the coast of Hudson Bay; and Kangirsuk on Ungava Bay. Rankin Inlet is the largest centre with a population of 1,706. Much of the local economy is based on subsistence hunting, trapping, and fishing. Inuit and Inuvialuit form over 80% of the population. The mineral and hydrocarbon potential of the zone has also led to increased exploration and some extraction activity. Construction, some tourism, and government services are the other principal activities.

Yukon Coastal Plain

Southern Arctic Ecozone

ECOREGION 32



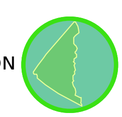
DISTINGUISHING CHARACTERISTICS: This is the only ecoregion in the Yukon representative of southern arctic ecosystems and the only ecoregion in the Yukon with a marine coastline (Fig. 32-1). The Yukon Coastal Plain Ecoregion is home to populations of muskoxen, polar bear and Arctic fox and provides important summer range for the Porcupine caribou herd. Much of the land surface was glaciated by Laurentide ice moving westward from the Mackenzie Valley; the area west of Firth River is unglaciated.

J. Hawkings, Canadian Wildlife Service

Figure 32-1. Driftwood, carried down river (principally the Mackenzie) from the Taiga and Boreal Cordillera ecozones, is strewn along the beaches of the Yukon Coastal Plain where no trees grow.

APPROXIMATE LAND COVER
tundra, 80%,
lakes and wetlands, 20%

TOTAL AREA OF ECOREGION IN CANADA
6,380 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
5,460 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
1% (includes coastal lagoons/shallow water)

Metres above sea level

ELEVATIONAL RANGE
0–585 m asl
mean elevation 82 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Northern portion of **Northern Mountains and Coastal Plain Ecoregion** (Oswald and Senyk, 1977) • Equivalent to **Northern Coastal Plain Ecoregion** (Wiken *et al.*, 1981) • Yukon portion of **Alaska Tundra Region** (CEC, 1997) • Yukon portion of **Arctic Coastal Tundra Ecoregion** (Ricketts *et al.*, 1999) • Contiguous with the **Beaufort Coastal Plain Ecoregion** of Alaska (Nowacki *et al.*, 2001)

PHYSIOGRAPHY

The Yukon Coastal Plain Ecoregion incorporates the Yukon Coastal Plain (Bostock, 1948; Hughes, 1987b) or Lowland (Mathews, 1986) physiographic unit (Fig. 2). The coastal plain is a band of land, north of the British, Barn and Richardson mountains, that slopes to the Beaufort Sea (Rampton, 1982). It extends inland along the Babbage and Blow rivers. The slope increases moving in a southerly direction away from the coast.

Much of the plain is an erosion surface, or pediment, where the gentle slope is a result of a long period of uninterrupted erosion. Ongoing erosion carries material across the surface by soil creep and sheetwash. The surface of the pediment often intersects different rock types and bedding planes in the underlying bedrock. Eastern portions of the ecoregion are mantled with glacial drift, which imparts a rolling or hummocky nature to the surface (Rampton, 1982).

Relief is generally less than 30 m. The elevation is generally less than 80 m asl in the west, except for Herschel Island with a maximum elevation of 185 m asl, and one of the Buckland Hills between the Firth and Malcolm rivers at 585 m asl is the highest point in the ecoregion. The elevation of the plain increases to the east where the surface lies between 150 and 300 m asl. Streams have cut into the surface of the plain, typically between 3 m in the west to more than 150 m in the east. A coastal scarp is prominent in the eastern portion of the ecoregion but largely absent adjacent to the Alaska border. The greater relief in the east reflects isostatic rebound following retreat of the Laurentide Ice Sheet. The uplift results in downcutting by postglacial streams (Fig. 32-2).

The Coastal Plain is incised with several large rivers, as well as smaller streams. From the west, they include the Malcolm, Firth, Babbage, Blow and Big Fish rivers. These rivers broaden into large alluvial fans where they meet the Beaufort Sea. Wetlands and small lakes are common along the Beaufort coast.

BEDROCK GEOLOGY

A veneer of glacial deposits, colluvium and alluvium covers most of this ecoregion, obscuring the bedrock, a pediment made of a Late Tertiary erosion surface. The distribution of underlying rock units is shown by Norris (1981a,b; 1985) and summarized in Lane and Dietrich (1996). The region is part of the Arctic Alaska Terrane, which comprised the Foreland during the Tertiary compression stages of the Cordilleran orogeny. Fold and thrust structures project from the northern Richardson and Barn mountains northward beneath the coastal plain to the offshore Beaufort Foldbelt (Lane and Dietrich, 1995). The Rapid Depression beneath the northwestern half of the ecoregion is a V-shaped, northward-plunging, fault-controlled trough containing more than 4,000 m of Lower Cretaceous sandstone and conglomerate.

The dominant rock types in this ecoregion are slates and shale of Paleozoic through Early Tertiary age; as a result exposures are few and crumbly, or have been reduced to fine-grained talus. Sandstone and minor chert produce blocky talus. The prominent rock pillar called Engigstciak is composed of early Ordovician chert. Mudstone and sandstone of the Upper Cretaceous Tent Island, and Lower Tertiary Moose Channel formations are exposed along the Big Fish River where it runs northeastward out of the Yukon Territory. Bluffs of dark-coloured shale and siltstone of the Jurassic Kingak Formation extend to the mouths of the Spring and Firth rivers, the latter exposing fine ammonite and crinoid fossils. In 1826, John Franklin noted lignite seams near the mouth of the Babbage River; these are within the Moose Channel Formation. The Reindeer Formation also contains bituminous coal: it has been mined near the mouth of Rapid Creek and at Shingle Point. Tertiary sandstone delta-fronts immediately offshore to the north have hydrocarbon potential, but these reservoir strata appear thinner and narrower than those in the Beaufort and Mackenzie Delta region to the east.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

The Yukon Coastal Plain can be subdivided into two main land units: the low relief, gently sloping coastal margin and the mountain fringe, which forms a narrow belt of land at the contact between the Richardson Mountains and the Coastal Plain itself (Rampton, 1982).

The entire area is underlain by permafrost, and the coastal area is modified by shoreline processes. Thermokarst lakes, retrogressive thaw flow slides, non-sorted polygons and stripes, pingos and other periglacial features are common. Organic deposits are found throughout the area, overlying most surficial geology units. Peat thickness ranges from 0.3 to 3.5 m, influencing the thermal and moisture balance of the surface. Disturbance of the organic layer can result in thermokarst, which can produce soil subsidence, slumps, slides and gullies where the slope is greater than 5 degrees.

Unglaciated terrain exists in the ecoregion west of Herschel Island. Surficial materials here consist of coalescent fluvial fans, terraces, sandy eolian deposits and fine-textured marine colluvial and lacustrine materials. Beaches, spits and bars are the common shoreline landforms through the extent of the Beaufort coastline.

The low relief portion of the Coastal Plain includes several large fluvial fans, at the mouths of Craig and Clarence creeks, and the Malcolm, Firth and Babbage rivers. The fans west of the Firth River are mainly coarse-grained and contain less ice than the finer-grained, organic-rich fan deposits of the Babbage and Firth rivers. The lower parts of these fans, as well as the floodplains of most streams in the area, are unvegetated and have shifting channels.

The easternmost boundary of the ecoregion includes a portion of the Mackenzie Delta. These deposits are fine-grained, organic and ice-rich, except for the talik zone under active channels.

Moraines left by glaciers are found east of the Firth River, generally at elevations lower than 300 m asl (Rampton, 1982). The moraines cover large surfaces and have been modified by thermokarst, retrogressive thaw slides and other periglacial processes, such as solifluction and soil creep. They generally present a rolling to hummocky surface. The moraines are fairly rich in silt and clay and contain high volumes (10 to 40%) of segregated ice, in the form of ice lenses and ice wedges. The first 3 m of the moraines are usually a mixture of mudflow deposits, lacustrine sediments, colluvial moraine and ice. Two large ice-push features, Herschel Island and the ridge east of the Babbage River's lowermost floodplain, are distinct from other glacial deposits of the area. They consist of unconsolidated sediments thrust by the front of overriding glaciers, now containing large bodies of ice-rich sediments and segregated ice.

Large outwash deposits or glaciofluvial sand and gravel deposits are southeast of the Firth River, on the north side of the Tugulak River floodplain and a narrow band between Deep Creek and Blow River. These larger deposits formed as meltwater streams flowed along the southwestern edge of the Buckland glaciers. They have a low gradient and poor drainage, and are often covered by thick ice-rich organic deposits and punctuated by numerous shallow thermokarst ponds. A large esker runs between the Blow and Running rivers. Small glaciofluvial deposits located at higher elevations are usually well drained and have low ice content.

Glacial lakes formed in several areas between the rising slope of the coastal and mountain fringe and the retreating glaciers. Ice-rafted boulders, beach lines and fine-grained sediments, ranging in thickness between 1.5 and 6 m, were left over older sediments. The glaciolacustrine deposits are usually poorly drained, low relief, ice-rich and often covered by peat. Thermokarst lakes, ice wedges and polygons are commonly seen in this kind of terrain.

Colluvial deposits are associated with foothills of the Richardson and other mountain ranges to the south of the ecoregion. The colluvium is derived from local bedrock and frost-shattered debris moved through soil creep or solifluction, sometimes mixed with alluvium at the base of the slopes. Colluvium composition ranges from coarse boulder fields to fine-grained organic and ice-rich debris.

GLACIAL HISTORY

The Yukon Coastal Plain includes both glaciated and unglaciated terrain. The boundary between these terrains is marked by the Late Wisconsinan absolute limit of the Laurentide Ice Sheet about 30,000 years ago (Hughes *et al.*, 1981; Lemmen *et al.*, 1994; Duk-Rodkin and Hughes, 1995). The limit follows the northeastern front of the Richardson, Barn and British mountains, descending westward towards Herschel Island (Fig. 15). The ice sheet advanced across extensive late Cenozoic pediments, surfaces that extend from the foothills to the coast, descending from approximately 850 m asl at the east end of the coastal plain to almost sea level at the border with Alaska (Rampton, 1982). In addition to the Laurentide glacial maximum, two other well-defined former ice margins occur in this ecoregion. The first is the Katherine Creek Phase (ca. 22 ka;

Duk-Rodkin and Hughes, 1991; Lemmen *et al.*, 1994), traceable from southern Mackenzie Mountain to Deep Creek, a tributary to the Babbage River (Fig. 32-2). The other is the Tutsieta Lake Phase (ca. 13 ka; Hughes, 1987a; Duk-Rodkin and Hughes, 1995) that follows the Peel River and the western edge of the Mackenzie Delta. The three former ice margins are considered correlative to the Buckland phase, Sabine phase (both from Rampton, 1982) and Late Wisconsinan limits of glaciation, respectively.

CLIMATE

This ecoregion has an arctic climate. Winters are prolonged, lasting from October through June. Summers are brief, with temperatures very dependent on whether the winds are onshore or offshore, with ice cover, even in summer, near the coast. Precipitation is light, but the winds are some of the strongest in the Yukon.

Mean annual temperatures are –10 to –12°C; February is the coldest month near –28°C, with the mean maximum near –24°C and the mean minimum near –32°C. Above freezing temperatures can occur during the winter but are accompanied by strong winds. Extreme minimums are only near –50°C due to some heat transfer from the Arctic Ocean through the ice cover. July is the warmest month with means ranging from 8 to 10°C. Temperatures near 30°C have occurred during June, July and August, but fairly heavy frosts can also occur in these months.

Annual precipitation is light, being between only 125 and 200 mm. June through August has the heaviest precipitation, 20 to 35 mm, in the form of rain, drizzle, and occasional snow. The months of October to May have mean monthly amounts of 3 to 5 cm of snow.

Winds are strong throughout the year with mean speeds near 20 km/hr. They are strongest from

C. Kennedy, Yukon Government

Figure 32-2. The Blow, Babbage (above), Firth and Malcolm rivers cut into the pedimont surface of the Yukon Coastal Plain, creating rare bedrock exposures. Deep Creek, a tributary to the Babbage River near this point, occupies a drainage channel, parallel to the coast, that formed along the front of the intermediate Laurentide glacial maximum, the Katherine Creek Phase.

October through May; sustained winds of 50 to 80 km/hr do occur. The prevailing direction is either from the west or from the east, although a southerly component can develop in the major valleys such as the Blow and Babbage rivers. These prevailing winds cause much redistribution of the light snow cover.

Detailed historic climatic data are available from Komakuk Beach, Stokes Point and Shingle Point. As these stations are on the coast, summer temperatures are frequently higher some 2 to 3 km inland than reported by these stations. Currently, a limited range of weather data is collected by automated weather stations at Komakuk Beach and Shingle Point only.

HYDROLOGY

The Yukon Coastal Plain Ecoregion is situated within the Arctic Hydrologic Region (Fig. 8). The major direction of drainage is to the north into the Beaufort Sea. The ecoregion drains the northern foothill slopes of the British–Richardson Mountains Ecoregion, the relatively flat coastal plain that includes Herschel Island, and the western Mackenzie Delta. Numerous larger streams within the ecoregion originate in the British and the Richardson mountains, with streamflow response that is not characteristic of the ecoregion. These include the lower reaches of the Blow, Firth and Malcolm rivers. Because the ecoregion is long and narrow, there are no representative intermediate or large streams within the ecoregion. Small representative streams include Deep and Poland creeks. While there are no intermediate- or large-sized lakes, the ecoregion contains numerous small pothole lakes and ponds. Lakes and wetlands are estimated to cover approximately 20% of the ecoregion.

There are no historical representative hydrometric stations within the Yukon portion of the ecoregion, but there is one representative Alaskan station, at Nunavak Creek near Barrow. The Babbage River and Kaparuk River near Deadhorse are somewhat representative transitional basins, useful in characterizing the hydrologic response. Annual streamflow has an increase in discharge in May due to snowmelt, rising to a peak in June within the majority of streams. Summer rain events will produce secondary, and occasionally the annual peak flows, on some streams. Fall (September) streamflows are often high. The mean annual runoff is estimated to be relatively low with an ecosystem average of 168 mm, while mean seasonal and summer flows are estimated to be at 14.4×10^{-3} and 6.9×10^{-3} $m^3/s/km^2$ respectively. The mean annual flood is estimated to be among the highest of all Yukon ecoregions (on a unit-area basis) with a value of 175×10^{-3} $m^3/s/km^2$. The mean maximum summer flow is estimated to have a value of 40×10^{-3} $m^3/s/km^2$. The minimum annual and summer flows are estimated at 0 and 0.6×10^{-3} $m^3/s/km^2$, respectively. Due to the dominant role of winter temperatures and permafrost on streamflow, all ecoregion streams experience no water flows from December to April.

PERMAFROST

Permafrost is continuous beneath the tundra of the Yukon Coastal Plain Ecoregion. Ground temperatures in an exploration well drilled by Imperial Oil near Blow River indicate the base of permafrost in eastern portions of the ecoregion is about 240 m deep (Fig. 21). Equilibrium near-surface temperatures at Blow River are calculated to be about –5.5°C (Burgess *et al.*, 1982; their Figure 16). At the coast, ground temperatures may be lower, with –9°C recorded in a suite of holes drilled near Kay Point. In unglaciated portions of the North Slope of Alaska, permafrost is up to 700 m thick (Lachenbruch and Marshall, 1986), and the same may be expected in contiguous portions of the Yukon Coastal Plain west of the glacial limit.

The near-surface layers of permafrost are often ice-rich (Mackay, 1983), and large masses of ground ice are regularly exposed in thaw slumps along the coast (Pollard and Dallimore, 1988). Some of these icy beds likely formed during regional permafrost aggradation following deglaciation (Mackay and Dallimore, 1992). Coastal recession is about 10 m/yr at many points due to these highly erodable sediments (Mackay, 1963). Storms in September, when wave fetch is greatest, are the major erosion events (Dallimore *et al.*, 1996).

Ice wedges are ever-present features of the terrain. A warmer, regional, early-Holocene climate has been inferred from truncated ice wedges exposed at coastal sites (Harry *et al.*, 1988; Burn, 1997). Occasionally, large icy bodies form when snowbanks accumulate at the foot of coastal bluffs and are covered by falling debris (Pollard and Dallimore, 1988). Ground ice found within the glacial limit is thought to be generally formed after glaciation, but deformation of icy beds on Herschel Island may have occurred approximately 30 ka ago during their excavation by glacier ice from Herschel Basin, a depression almost equal in volume to the island, currently submerged between the island and the mainland (Mackay, 1959).

As on the north coast of Alaska, the summer climate is warmer inland than at the coast (Romanovsky and Osterkamp, 1995; Burn, 1997), leading to an increase in active layer depth with distance inland. The active layer depth also varies with surficial materials, so that it is 30 to 40 cm in fine-grained sediments, but over 1 m thick in gravels or sands (Rampton, 1982). Much of the terrain surface is hummocky (Mackay *et al.*, 1961), due to cryoturbation and soil movement during thawing in the active layer (Mackay, 1980). The terrain contains some thermokarst lakes, though not to the proportion found in the Tuktoyaktuk Coastlands east of the ecoregion (Rampton, 1988).

SOILS

Soils in the eastern and central portions of the ecoregion are formed on glacial materials. In the extreme western portion of the ecoregion, soils are found on unglaciated pediments or on vast alluvial fans of the Firth, Malcolm and Clarence rivers. The soils of the Yukon Coastal Plain Ecoregion were described by Wiken *et al.* (1984) and in part by Welch and Smith (1990). Tarnocai (1986) mapped soils in the Firth River as well, and Smith *et al.* (1989) conducted a detailed soil and vegetation survey of Herschel Island.

On the undulating glacial moraine that covers much of the ecoregion, shrub vegetation is associated with well-drained landscapes. Soils have active layers greater than 50 cm and show evidence of mild cryoturbation. These soils are classified as Orthic Turbic Cryosols. Closer to the coastal fringe, much of the low-lying landscape is characterized by brackish wetlands dominated by small waterbodies. There is minor peat accumulation in these wetlands, usually less than 40 cm, and soils are most often classified as Gleysolic Turbic Cryosols. There is evidence in eroding headwalls along the coast that 3 to 4 m of peat formed in the past, but peat does not seem to be accumulating to the same extent in modern soils of the ecoregion; lowland polygonal wetlands seldom contain more than 50 cm of peat over perennially frozen mineral soils.

On the unglaciated portion of the ecoregion, pediment surfaces tend to be composed of long gentle slopes at less than 10% grade with rather uniform tussock tundra and shrub tundra vegetation cover. These soils are for the most part Orthic Turbic Cryosols with active layers less than 50 cm. The large active fans provide fresh alluvial materials to the landscapes. Older terraces have permafrost established within them, yet there has been little soil formation and weathering. These soils are Regosolic Static Cryosols. The more active floodplains, and localized dune fields adjacent to the coast, do not have permafrost within 1 m of the surface and are classified as Orthic Regosols. These coarse-textured regosolic soils are relatively rare in the ecoregion but are important denning sites for foxes and wolves (Smith *et al.*, 1988; 1991)

Glacial ice-thrust marine sediments occur near King Point and form Herschel Island. Orthic Turbic Cryosols and associated patterned ground are the most common soils associated with the upland of the island (Fig. 32-3). Abundant thermokarst activity creates large fresh surfaces for renewed soil development. These scar areas are widespread on Herschel Island and Regosolic Static Cryosols are most commonly associated with them (Smith *et al.*, 1989).

VEGETATION

The vegetation of the Yukon Coastal Plain Ecoregion reflects its major physiographic features, including the marine coastline, low-lying polygonal wetlands, tussock tundra, broad alluvial fans and deltas, and rolling hills flanking the Richardson Mountains (Fig. 32-4).

The coastal areas support early-succession vegetation on beaches and spits, and littoral graminoid communities on estuaries and the shores of brackish lagoons. Development of salt marshes is inhibited compared with lower latitudes, due to sea ice abrasion, low tidal amplitudes and erosion. Massive thaw slumps, which build at the foot of the melting faces of cliffs of frozen sediments, are colonized by dense stands of mastodon flower (Smith *et al.*, 1989).

Figure 32-3. Frost action in the active layer of the fine-textured Cryosolic soils on Herschel Island and elsewhere in the ecoregion produces patterned ground. Patches of bare ground are set within a matrix of tundra vegetation.

The low inland terrain is covered by extensive wetlands and cottongrass tussock tundra (Hawkings 1999). Freestanding sedges, marsh grass and willows have colonized wet sites, such as low centre polygons, the margins of ponds and thermokarst lakes, beaded drainages and ice wedge channels. Tussocks of cotton grass, growing in association with various ericaceous shrubs, lichens and forbs, dominate well-drained sites, such as high-centre polygons or pediments.

Major drainages flowing from the mountains dissect the coastal plain in a north–south direction. The massive active alluvial fans of rivers like the Malcolm and Firth, with their constantly changing network of channels, exhibit various stages of succession. The active channels remain scoured and unvegetated, while stabilized gravel bars and fluvial terraces are gradually vegetated by bear root, lupine, dryas and willow.

In contrast, the floodplains of other major but less active drainages, like the Babbage River, support well-established vegetation, such as sedges, willows, alders and, in the Mackenzie Delta, trees.

In the foothills of the northern mountains rising above the coastal plain, site drainage is improved; gentle slopes are vegetated with shrub birch and willow, dryas, lichen and prostrate willows.

WILDLIFE

Mammals

The Yukon Coastal Plain is the only ecoregion in the Yukon normally inhabited by Arctic fox, barren-ground shrew, polar bear and muskoxen, although these species are occasionally seen further south (Jingfors, 1989). Arctic fox winter on offshore ice; however, they whelp and raise their young on land using traditional den sites. Summer fox activity is most prevalent on Herschel Island (Smits and Slough, 1993). The winter Arctic fox coat is white; the blue phase is not found here. Muskoxen, native to the arctic west of the Mackenzie River until extirpation by hunters in the 19th century, have immigrated to the Yukon Coastal Plain from a herd reintroduced to the coastal plain in Alaska between 1967 and 1970 (Alaska Geographic Society,

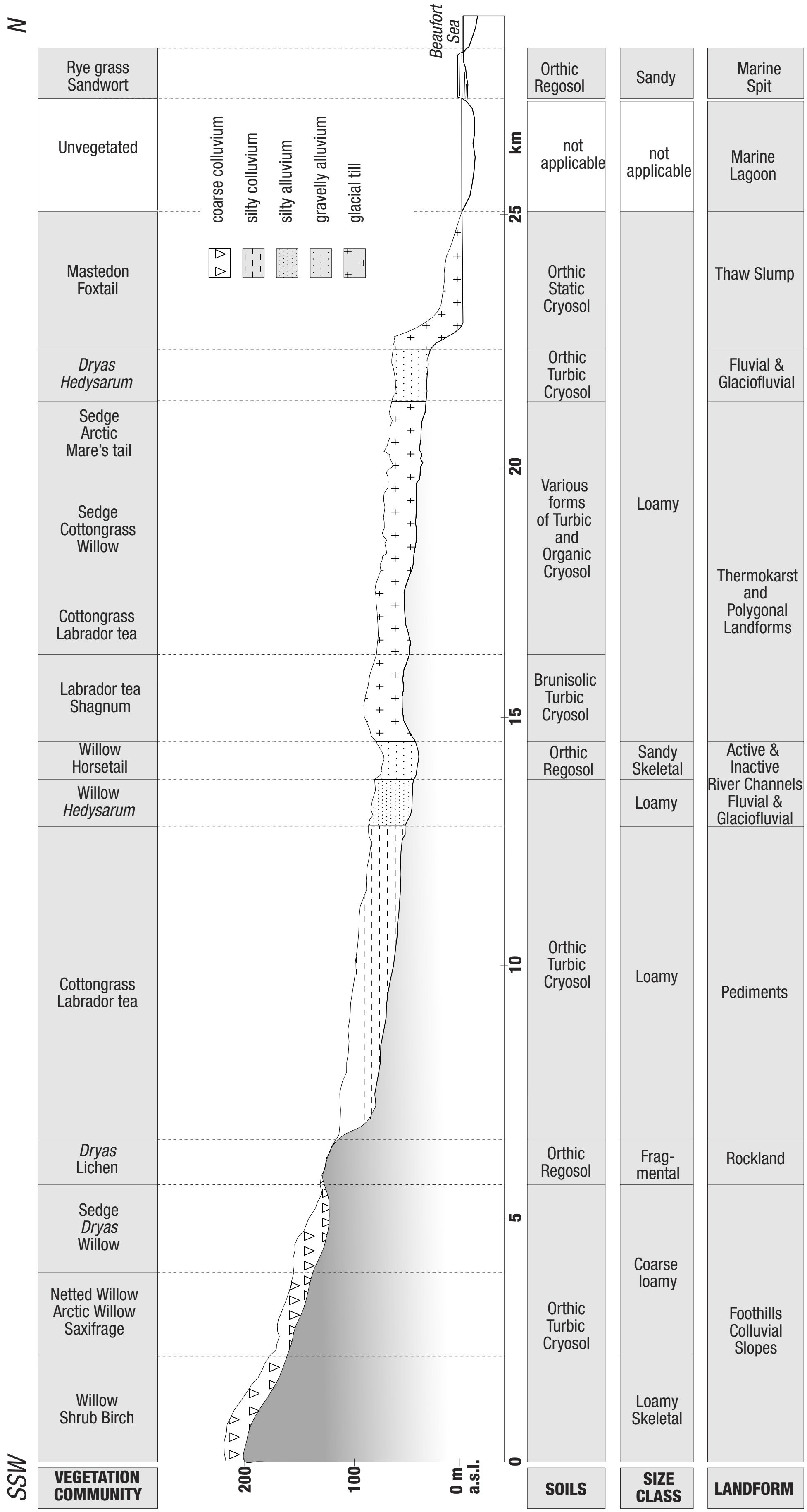


Figure 32-4. Schematic profile of soil and vegetation patterns across the Yukon Coastal Plain Ecoregion between the foothills of the Richardson Mountains and the Beaufort Sea coast. Stippled portion shows approximate thickness and extent of soil parent materials over bedrock. Note exaggerated vertical scale.

1981). The Yukon herd in 1995 numbered about 120 individuals, with another 30 or so roaming the region alone or in small groups (Fig. 32-5).

The Porcupine barren-ground caribou herd was estimated at 160,000 individuals in 1995 and 123,000 in 2001. During spring, the herd migrates north from their wintering grounds to the coastal plain in Alaska and the Yukon (Fancy *et al.*, 1994). Calving is concentrated in the foothills of the British Mountains, but extends to the coast (Fig. 32-6). Pre- and post-calving aggregations of both sexes use the area. A fall migration returns the herd to winter range in Alaska, the Northwest Territories, and the Yukon, south to the Ogilvie and Mackenzie mountains.

The ranges of several mammal species that occupy forested or alpine habitats extend to the coastal plain, including those of the meadow vole, northern vole, red-backed vole, wolverine, short-tailed weasel, wolf, red fox, grizzly bear, and moose (Youngman, 1975). Grizzly bears are not as abundant as they are in the British–Richardson Mountains Ecoregion (Nagy, 1990). Moose are restricted to riparian habitats and are not abundant (Smits, 1991).

Muskrat occupy the lowland lakes of the Mackenzie Delta. Typical small mammals include the collared lemming, brown lemming, and tundra vole. Although populations of these rodents are cyclic elsewhere in the arctic, these species do not appear to fluctuate greatly in the Yukon. The Arctic fox and avian predator populations cycle every three to five years, but this is most likely due to waves of

B. McLean

Figure 32-5. Muskoxen *(Ovibos moschatus)* were extirpated from the Yukon Coastal Plain by hunters in the 19th century. Individuals have immigrated to the area from a herd reintroduced to the Alaskan Coastal Plain between 1967 and 1970.

J. Hawkings, Canadian Wildlife Service

Figure 32-6. Caribou grazing on the sedge tundra of the Yukon Coastal Plain Ecoregion near the mouth of the Firth River in late summer. The abrupt change in topography in the background marks the boundary with the adjacent British–Richardson Mountains Ecoregion.

immigrants from adjacent cyclic populations. Tundra hares, arctic residents of Alaska and the Northwest Territories, are absent from the Yukon.

The overall mammalian diversity of the ecoregion is very low due to low productivity, a harsh environment, and a similarly low diversity of habitats. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Birds

Unlike the suitability for mammals, the Yukon Coastal Plain is one of the richest areas in the territory for birds. The avian community here is unique in the Yukon, featuring many species that do not nest elsewhere in the territory. As well, some of the highest nesting densities for many other Yukon species occur in this ecoregion.

From early June to mid-August, lowland tundra, sedge marshes, and small river deltas along the coast provide breeding habitat for a number of species that do not nest elsewhere in the territory. These include Brant;, Parasitic Jaeger; Glaucous Gull; Semipalmated, Pectoral, and Buff-breasted Sandpipers; Long-billed Dowitcher; Red Phalarope; and Lapland Longspur. Other species which commonly nest along coastal fringes of the ecoregion are Red-throated and Pacific Loons, Tundra Swan, Greater White-fronted Goose, Greater and Lesser Scaup, Red-breasted Merganser, Long-tailed Duck, American Widgeon, Mallard, Northern Shoveler, Northern Pintail, Green-winged Teal, Sandhill Crane, Common Snipe, Red-necked Phalarope, Long-tailed Jaeger, and Arctic Tern (Salter *et al.*, 1980; Sinclair *et al.* [editors], 2003).

Gravel beds of creeks and rivers provide nest sites for Semipalmated Plover and Spotted Sandpiper. Driftwood-strewn beaches along the Beaufort Sea are nesting areas for Common Eider and Glaucous Gull, which breed in the Yukon only in this ecoregion, as well as Snow Bunting. Mud banks of larger creeks and rivers house small colonies of Bank Swallow.

The upland tundra most prevalent on Herschel Island and the western portion of the ecoregion supports breeding species such as Rock Ptarmigan, American Golden-Plover, Baird's Sandpiper, Ruddy Turnstone, Horned Lark, American Pipit, and occasionally Snowy Owl and Smith's Longspur. Remarkably high densities of Rough-legged Hawk nest on ledges and pinnacles of coastal bluffs and inland ravines on Herschel Island (Ward and Mossop, 1985); this is the only Yukon ecoregion where the tundra race of Peregrine Falcon nests.

On Herschel Island, abandoned buildings at Pauline Cove are occupied by one of only six breeding colonies of Black Guillemot in the western Arctic (Ward and Mossop, 1985).

Shrubby habitats on the tundra and along some lakes, ponds, draws, and creeks support breeding Willow Ptarmigan, Common and Hoary Redpolls, Savannah, American Tree, and White-crowned Sparrows. Taller shrubs along larger creeks and rivers of the eastern half of the Coastal Plain support Northern Shrike, Gray-cheeked Thrush, American Robin, Yellow Warbler, and Fox Sparrow (Salter *et al.*, 1980). Two other species found in shrubby habitats, Bluethroat and Yellow Wagtail, are predominantly Eurasian in their distribution and do not occur elsewhere in Canada (Black, 1972; Taylor and Judge, 1974; Eckert, 1995b).

While spring migration along the coast is unremarkable, some spectacular staging and migration events occur in late summer and fall. Thousands of Snow Geese feed on the coastal plain from late August through mid-September (Hawkings, 1987) and thousands of Red-necked and hundreds of Red Phalarope stage along the coast in August (Ealey *et al.*, 1988). Also notable are thousands of moulting sea ducks, mostly Long-tailed Duck and Surf Scoter, which gather in Workboat Passage, between the mainland and Herschel Island, in July and August. Migration along the coast is both eastward toward the Mackenzie River delta and westward toward the Alaskan coast, depending on the species. Small river deltas, spits, and lagoons along the coast are used for resting and feeding by many waterfowl and shorebird species (Eckert, 1997b, 1998b).

While data are limited, the only species known to occur in winter are Gyrfalcon, Willow and Rock Ptarmigans, Snowy Owl, and Common Raven (Salter *et al.*, 1980).

TAIGA PLAIN ECOZONE

The Taiga Plain Ecozone is located mainly in the Mackenzie Valley of the Northwest Territories, northeastern British Columbia, and northern Alberta (Fig. 1). "Taiga" is a Russian word that is synonomous with subarctic and refers to the northern fringe of the boreal coniferous forest — the land of "little sticks" — that stretches from northern Labrador to Alaska and beyond to Siberia and Scandinavia. The Mackenzie River system and its many tributaries dominate the ecozone. The ecozone is represented in the Yukon by portions of three ecoregions, the Muskwa Plateau Ecoregion in the extreme southeast of Yukon and the Peel River Plateau and Fort McPherson Plain ecoregions in the northeast. Both of these areas essentially lie east of the main ranges of the Western Cordilleran and have climatic and physiographic conditions that are distinctly different from the rest of the Yukon.

Climate: The climate is marked by short, cool summers and long, cold winters. Cold arctic air influences the area for most of the year. The mean annual temperature ranges between –10°C in the Mackenzie Delta to –1°C in Alberta and British Columbia. From north to south, the mean summer temperature ranges from 6.5 to 14°C. The mean winter temperature ranges from –26°C in the north to –15°C in the south of the ecozone. Snow and freshwater ice persist for six to eight months of the year. The mean annual precipitation is low, ranging between 250 and 500 mm.

Hydrology: The northern and southern portions of this ecozone exhibit significantly differing hydrologic

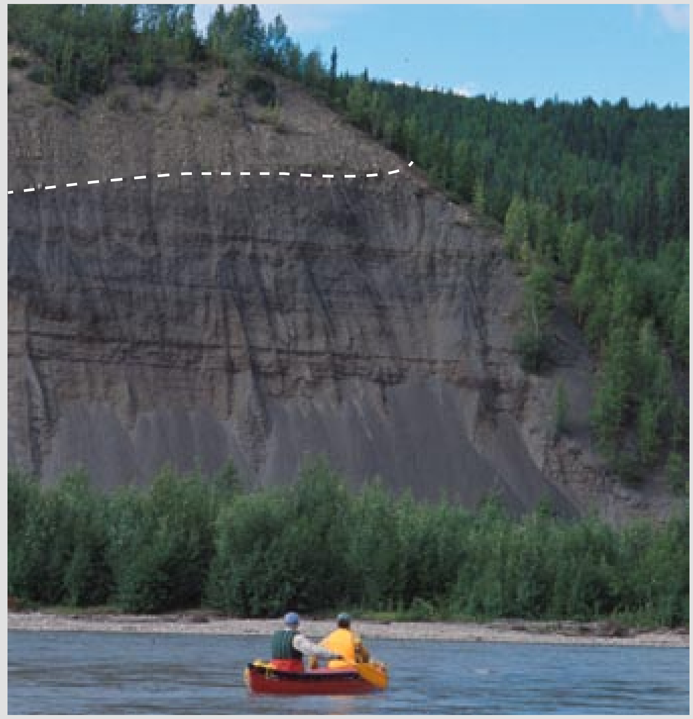
J. Meikle, Yukon Government

The northward flowing (left to right) Peel River near its confluence with the Caribou River. The river forms the boundary between the Peel River Plateau Ecoregion (foreground) and the Fort McPherson Plain Ecoregion in the distance.

response. Northern portions of the ecozone exhibit a similar streamflow response to that elsewhere in the Taiga Cordillera Ecozone to the west. Here, runoff volume is relatively large in comparison with more southern areas because of the underlying permafrost and lesser rates of evapotranspiration. Peak flows, which generally occur in June, are likewise greater relative to areas with less permafrost. Minimum flows throughout the ecozone generally occur in March and tend to be lower than the southern ecozones because of the effect of lower winter temperatures on groundwater flow. Small streams frequently experience zero flows, while some intermediate-sized streams may occasionally experience zero winter flows. Low flows within the Muskwa Plateau Ecoregion in the southern portion of the ecozone are slightly greater than those in the rest of the ecozone.

Vegetation: An open, generally slow-growing, conifer-dominated forest of predominantly black spruce characterizes the ecozone. The shrub component is usually well developed and includes dwarf birch, Labrador tea, and willow. Bearberry, mosses, and sedges are dominant understory species. Upland and foothill areas and southerly locales tend to have better drained and warmer soil, and may support mixed forests characterized by white and black spruce, lodgepole pine, tamarack, paper birch, trembling aspen, and balsam poplar. Along the nutrient-rich alluvial flats of the larger rivers, white spruce and balsam poplar grow to sizes comparable with those in the Boreal Plains Ecozone to the south.

Landforms and soils: The ecozone represents the northern extension of the Interior Plains of North America and lies contiguously with the Prairie and Boreal Plains Ecozones to the south. The subdued topography consists of broad lowlands and occasional plateaus, the largest having relief differences of several hundred metres. Underlain by sedimentary rock — limestone, shale and sandstone — the nearly level to gently rolling plain is covered with organic deposits and, to a lesser degree, moraine and lacustrine deposits. Alluvial deposits are common as terraces and braided floodplains along the major river systems of the ecozone. Wetlands (primarily peatlands) are a common feature and cover an estimated 25 to 50% of the ecozone. Most of the ecozone is underlain by permafrost, which acts to perch the surface water table and promote a regional overland seepage system. When combined with low-angle slopes, this creates a landscape dominated by soils that are seasonally waterlogged over large areas. Patterned ground features are common. The region's widespread permafrost and poor drainage create favourable conditions for Cryosolic, Gleysolic, and Organic soils.



J. Meikle, Yukon Government

The lowermost Snake River occupies the pre-Laurentide Peel River Channel. Above the bedrock surface (dashed line) is a blanket of glacial drift.

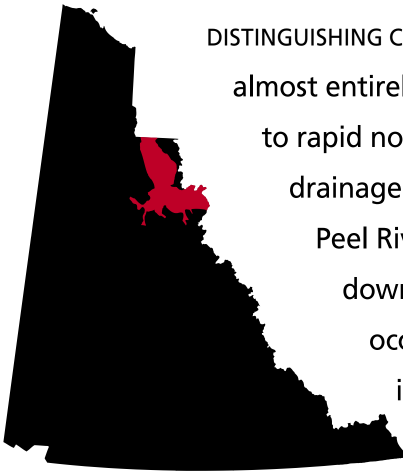
Wildlife: Characteristic mammals include moose, woodland caribou, wood bison, wolf, black bear, marten, lynx, and arctic ground squirrel. Barren-ground caribou overwinter in the northwest corner of the ecozone. Common bird species include Common Redpoll, Gray Jay, Common Raven, Red-throated Loon, Northern Shrike, Sharp-tailed Grouse, and Fox Sparrow. Fish-eating raptors include Bald Eagle and Osprey. The Mackenzie Valley forms one of North America's most traveled migratory corridors for waterfowl — ducks, geese, and swans — breeding along the Arctic coast.

Human activities: The population of 21,400 is approximately 60% aboriginal. The major communities include Fort Nelson, Inuvik, Hay River, Fort Smith and Fort Simpson. There are no communities within the Yukon portion of this ecozone but hunting, trapping, and fishing are the primary activities in the local economy. Mining, oil and gas extraction, and some forestry and eco-tourism are the main industrial activities in the ecozone.

Peel River Plateau

Taiga Plain Ecozone

ECOREGION 51



DISTINGUISHING CHARACTERISTICS: This is the only ecoregion in the Yukon with landscapes almost entirely shaped as the result of Laurentide glaciation. Several canyons testify to rapid northward draining of pro-glacial lakes about 10,500 years ago. Regional drainage was rerouted northward by Laurentide Ice, in response to which Peel River tributaries, such as the Snake, Caribou, Trail and Road rivers have downcut into the plateau (Fig 51-1). Most species of large Yukon mammals occur, but only the polar representatives of most small mammal genera inhabit the ecoregion. The extensive wetlands and the broad Peel River valley support considerable bird life.

J. Meikle, Yukon Government

Figure 51-1. The northern portion of the ecoregion is deeply incised by the Caribou, Trail, Road (above; entering the Peel) and Vittrekwa rivers, which flow eastward from the Richardson Mountains (background). Numerous wetland complexes are perched on the plateau.

APPROXIMATE LAND COVER
subarctic coniferous and mixed forest, 75%
forest–tundra transition, 10%
alpine tundra, 10%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
59,970 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
14,810 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
3%

ELEVATIONAL RANGE
45–1,470 m asl
mean elevation 455 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Largely equivalent to **Peel River Ecoregion** (Oswald and Senyk, 1977) • Portion of **Taiga Plains Region** (CEC, 1997) • Portion of the **Northwest Territories Taiga Ecoregion** (Ricketts *et al.*, 1999)

PHYSIOGRAPHY

The Peel River Plateau Ecoregion is very large, and stretches from the Beaufort Sea, along the eastern foothills of the Richardson, Mackenzie and Franklin mountains, almost to the Nahanni River (Fig. 2). A relatively small portion of it is in the Yukon.

The Yukon portion of this ecoregion incorporates the Peel Plateau and the Bonnet Plume Depression physiographic units (Mathews, 1986; Hughes, 1987b). The Peel Plateau lies between the Richardson Mountains to the west and the Wernecke Mountains to the south. It is bounded to the east by a scarp descending to the Mackenzie River valley bottom. The Bonnet Plume Depression, a lowland in the southwest corner of the ecoregion, was included in the Porcupine Plateau by Bostock (1948).

The lowest elevations in the ecoregion — less than 100 m asl — fall within the physiographic unit of the Bonnet Plume Depression, whereas higher elevations in the ecoregion are associated with the Peel Plateau, which covers the foothills and eastern flanks of the Richardson Mountains. Several ridges extend into the ecoregion northward from the Wernecke Mountains. Ridges and hills are commonly 760 m asl, but along the edge of the Wernecke Mountains elevations reach between 1,000 and 1,400 m asl. The plateau surface and higher terrace levels described by Bostock (1948) are probably evidence of Late Tertiary easterly drainage at much higher elevations than the present drainage (Mathews, 1991). Numerous small lakes are scattered over the plateau.

BEDROCK GEOLOGY

This ecoregion has little rock exposed, except for sandstone in the valleys of the Bonnet Plume and Snake rivers, and the Trevor Range. The regional bedrock distribution, largely covered by surficial deposits, is shown by Norris (1981g,h; 1982c), and the lithostratigraphy is described by Morrow (1999). The youngest rocks are Cretaceous, described by Norris and Hopkins (1977) and Yorath and Cook (1981).

The eastern part of the ecoregion is part of the Northern Interior Platform which consists of Proterozoic sedimentary rocks unconformably overlain by a Devonian to Carboniferous succession 1,900 m thick, in turn unconformably overlain by the Cretaceous strata. The Trevor Fault bisects the ecoregion from north to south. On the east, the uppermost rock is the Cretaceous Arctic Red Formation consisting of concretionary marine shale, siltstone, and lesser sandstone with small, convoluted bedding and vertical burrows. In a few places it is overlain by the Martin House Formation of glauconitic siltstone and shale.

The western side of Trevor Fault has been uplifted, likely in Middle Tertiary time. Lower Carboniferous dark grey shale, silty conglomerate, Mississippian light grey sandstone and dark grey shale are exposed in Noisy Creek and around the Trevor Range, a pop-up anticline whose core exposes the lower Paleozoic Bouvette Formation dolostone. The Cretaceous Trevor Formation consists of horizontal, broken-surface sandstone that tends to form plateaus, and locally contains beds of clay ironstone. The southwestern corner of the ecoregion is a complex of vertical and strike-slip faults of the Knorr–Richardson array; this low-lying area preserved the Cretaceous through Tertiary Bonnet Plume Formation consisting of non-marine conglomerate, sandstone and shale, with lignite seams.

Martin House Formation locally contains concretions in which ammonites may be found, as well as pale-green to pale-yellow bentonite clay seams several centimetres thick. Coal exploration leases cover the Bonnet Plume Basin, and lignite float is reported along the Peel River at 66°28'N 133°59'W. Devonian sandstone incised by the Snake River near the southern edge of the ecoregion may contain fish fossils (S. Cumba and J. Storer, pers. comm., 1997).

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

Surficial deposits within this ecoregion are 80% glacial in origin — moraine, glaciolacustrine and glaciofluvial. Moraine derived from the Laurentide Ice Sheet blankets most valleys and subdued uplands. Postglacial colluvium and alluvium comprise the remaining deposits (Duk-Rodkin and Hughes, 1992a,b). Glaciofluvial terraces extend along the main rivers, except for the Peel River within the Bonnet Plume Depression, which is incised in bedrock. Colluvial deposits occupy foothills, slopes and valley sides, usually in conjunction with patches of exposed bedrock.

Alluvial plains are present along major streams (Fig. 51-2).

Modern processes are dominantly related to permafrost. Thermokarst and periglacial landforms, including occasional open system pingo development, are common in the lower Bonnet Plume and Wind rivers. On slopes, active mass wasting features include rotational slides, debris flows and retrogressive thaw flow slides along the sides of deeply incised tributaries to the Peel River. Slope instability is related to postglacial downcutting, which has been as much as 400 m in parts of the lower Peel River. Retrogressive thaw flow slides are common where ground ice has been exposed in glaciolacustrine deposits by forest fire, debris flows and regressive erosion. Thermokarst processes are widespread on these silty and clayey glaciolacustrine landforms.

J. Meikle, Yukon Government

Figure 51-2. The Wind, Bonnet Plume (above) and Snake rivers begin in the Mackenzie Mountains. The Bonnet Plume and Wind rivers have extremely braided channels across the Bonnet Plume Basin. The lower Snake, by contrast, is incised deeply in the Plateau. It was diverted by Laurentide glaciation and subsequently captured by the Peel River.

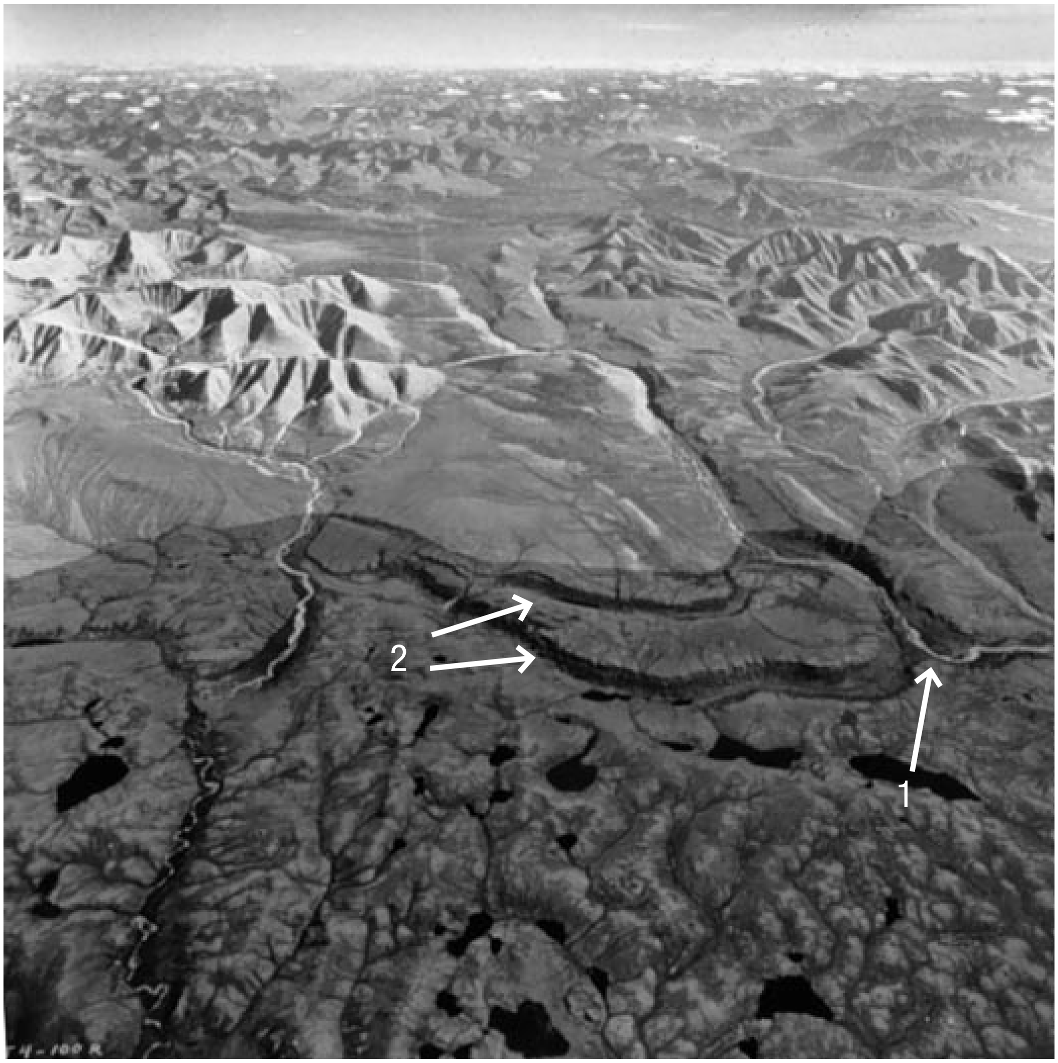
Sloping terrain has the characteristic runnel drainage pattern — fine, feather-like and parallel — that is common in high latitude frozen mineral soils. Terracing, solifluction and earth stripes are common on moderate slopes at upper elevations. On gently sloped upland surfaces, sorted circles, stone nets, or polygons are often present.

GLACIAL HISTORY

This ecoregion was affected by the Late Wisconsinan Laurentide Ice Sheet in the southern Bonnet Plume Depression, and by two glaciers in the Wind and Bonnet Plume valleys. There are three well-defined Laurentide glacial limits within this ecoregion: the maximum (ca. 30 ka; Hughes *et al.*, 1981; Schweger and Matthews, 1991); the Katherine Creek Phase (ca. 22 ka; Duk-Rodkin and Hughes, 1991; 1995); and the Tutsieta Lake Phase (ca. 13 ka; Hughes, 1987a). At its maximum, the ice sheet bordered the west, south and east edge of Bonnet Plume Depression (Fig. 51-3). Drainages exiting the mountains — the Snake River, Arctic Red River, and their tributaries — were diverted through Rapitan Creek-Bonnet Plume Valley, and other minor meltwater channels and valleys that drained into the depression. Damming of the Bonnet Plume, Wind and tributary rivers in the southern Bonnet Plume Depression directed drainage westward along Hungry Creek and the lower Hart River into pro-glacial Lake Hughes (Fig. 15), which formed on the middle Peel River Valley (Duk-Rodkin and Hughes, 1995). The main outlet of Lake Hughes was the Eagle River discharge channel, which today is occupied by Canyon Creek and the headwaters of Eagle River.

During the maximum extent of the Laurentide Ice Sheet, all drainage from the Mackenzie and Wernecke mountains exited via the Eagle River discharge channel into Lake Old Crow the proglacial lake occupying the Bell–Old Crow–Bluefish Basin (Fig. 16). During the Katherine Creek Phase, the ice sheet re-advanced to a position marked by a discontinuous meltwater channel along the middle reaches of Caribou, Trail, Road and Vittrekwa rivers; Stony Creek and Barrier River; and extending north along Peel Plateau. The Katherine Creek Phase reached Bonnet Plume Basin about 35 km west of the confluence of the Peel and Snake rivers

Figure 51-3. This oblique aerial photograph over the Bonnet Plume Basin, with a view southward into the Wernecke Mountains, has been shaded to show the extent of Laurentide glaciation (foreground). Noisy Creek (centre of photo) has been diverted westward where it flows out of the Knorr Range (1). Note the abandoned meltwater channels formed parallel to the glacial front (2).



A. Duk-Rodkin, Geological Survey of Canada

and extended eastward, parallel to the mountain front a few kilometres south of the Snake River. At this time, meltwater drained into the Arctic Ocean through a system of interconnected channels via Bonnet Plume Depression. The next eastward position of the Laurentide Ice Sheet, the Tutsieta Lake Phase, impinged on the eastern edge of the ecoregion, as marked by a meltwater channel occupied by the Peel River.

CLIMATE

From within the ecoregion, little or no climate data are available. The ecoregion is east of the continental divide and, therefore, climatic controls are different from those for the rest of the Yukon. Winters are relatively long, October to late May, with frequent intrusions of Arctic air into the Mackenzie Valley. Summers are short but fairly warm, in part due to the influence of continental air masses from the interior plains to the south. Precipitation is light to moderate, enhanced by the redevelopment of Pacific storms in the Mackenzie Valley.

Mean annual temperatures are near –8°C. Average February temperatures range from –25 to –30°C. Extreme minimum temperatures are near –55°C, somewhat less cold than the interior of the Yukon. Although not common, above freezing temperatures can occur in any winter month. May temperatures are variable, ranging from –25 to 30°C. July is the warmest month, with mean temperatures near 15°C, mean minimums near 10°C, and mean maximums near 20 to 25°C. Frost can be expected at any time, however, even during summer.

Precipitation is light to moderate with annual amounts near 300 mm. July and August are the wettest months, with mean monthly amounts near 40 mm, although over 100 mm can occur in these months. The driest period is November through May, but generally 15 to 20 cm of snow can be expected each month. Winds are expected to be light to moderate at 10 to 15 km/hr with prevailing directions probably from the northwest and south.

No climate stations occur within the ecoregion but relevant data from Fort McPherson, Fort Good Hope and Norman Wells can be used to characterize the climate of the ecoregion. The most applicable data to infer Yukon conditions is from the Fort McPherson station.

HYDROLOGY

Encompassing the eastern slopes of the Richardson and Mackenzie mountains, the drainage from this ecoregion is diverse. It extends from the Mackenzie Delta in the north, through the Peel River basin, to tributaries that feed directly into the Mackenzie River. The Peel River lies near the eastern boundary of the Yukon portion of the ecoregion. This lower reach of the Peel River is unique in that it flows parallel to the Richardson Mountains, having been formed along the front of the receding Laurentide Ice Sheet (Duk-Rodkin and Hughes, 1995). The Peel River has cut a deep canyon more than 30 m below the plateau surface downstream from the mouth of the Wind River. Tributaries include the eastern flowing Vittrekwa, Road, Trail and Caribou rivers, with these largely representative of ecoregion streamflow response.

There are no large lakes within the ecoregion, while most intermediate-sized lakes are associated with wetland complexes (Chappie Lake complex, see Fig. 28). These include Hungry, Margaret, Turner, Hogan and Chappie lakes, while Lusk Lake is a higher elevation subalpine lake. Wetlands and lakes are estimated to cover about 5% of the Yukon portion of the ecoregion. The most significant wetlands are the Turner and Hogan Lakes complexes, which are on the plateau adjacent the Peel River. Smaller complexes are located in the Bonnet Plume and Vittrekwa River valleys.

There are no representative hydrometric station records for the ecoregion. Selected hydrometric stations with similar topography from nearby ecoregions were chosen to represent Peel River Plateau streamflow characteristics. Because of the relatively low relief, runoff is relatively low. Annual streamflow is characterized by an increase in discharge in early May due to snowmelt, rising to a peak later in the month within most ecosystem streams. Summer rain events do produce secondary peaks, and sometimes the annual stream flow peak, in July or August. Smaller streams are known to experience peak rainfall events more frequently than larger ones. The mean annual runoff is estimated to be 192 mm, while mean seasonal and summer flows are estimated to be 12.6×10^{-3} and 9.4×10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are estimated to be 108×10^{-3} and 36×10^{-3} $m^3/s/km^2$, respectively. The minimum annual and summer flows are estimated to be 0.11×10^{-3} and $1.6. \times 10^{-3}$ $m^3/s/km^2$ respectively. Minimum streamflow generally occurs during March or earlier, with the magnitude among the lowest of all Yukon ecoregions, due to the increasing role of winter temperatures and permafrost on streamflow. The majority of small and some intermediate streams experience zero winter flows relatively frequently.

PERMAFROST

The continuous permafrost zone underlies the Peel River Plateau Ecoregion. Permafrost thickness of up to 625 m has been inferred from geophysical data collected near the Yukon–Northwest Territories border, but at lower elevations the depth to the base of ice-bearing permafrost appears closer to 300 m (Geological Survey of Canada, unpubl. data).

Ice-rich zones in the near-surface layers of permafrost are common; the uppermost 18.3 m of permafrost was delineated as such during geotechnical drilling at Midway Lake in a contiguous part of the ecoregion across the territorial border (EBA, 1990a). Ice wedges and lenses are regularly reported in the pediment slope grading down from the Richardson Mountains (Geocon, 1986; EBA, 1987a). On the pediment slope, these are developed into polygons, but the networks are not as extensive in glaciated terrain. About 75% of the area may be underlain by ice-rich ground (Geocon, 1986).

SOILS

Much of the ecoregion was subjected to Laurentide glaciation which produced a variety of soil parent materials derived both from local rock and from shield bedrock to the east. There have been few regional studies of the soils in the Yukon portion of this ecoregion. Sites along the Dempster Highway in the Northwest Territories portion of the ecoregion have been described by Tarnocai *et al.* (1993).

Most of the ecoregion is covered by open forests of black spruce and larch, or by extensive shrublands. Earth hummocks are associated with this forest cover and are considered to be the product of intense frost churning in these soils (Zoltai and Tarnocai, 1975). The resultant soils are classified as either Orthic or Brunisolic Turbic Cryosols. Soils derived from moraine are generally gravelly sandy-loam texture. Finer glaciolacustrine parent materials exist in association with former glacial lakes (Fig. 51-4) in the Bonnet Plume Depression. These soils tend to be wetter, support shrub or tussock vegetation along with black spruce, and have Gleysolic or Orthic Turbic Cryosol development.

Soils on the gravelly glaciofluvial deposits of the major rivers of the ecoregion tend not to contain permafrost, and support Orthic Eutric Brunisols formed under closed white spruce forest. On active, braided floodplains under shrub vegetation (Fig. 51-2), soils are typically Orthic Regosols and may be sandy, silty or gravelly in texture. Wetland soils are common in the Bonnet Plume Depression and scattered elsewhere in the ecoregion. Fibric Organic Cryosols are commonly associated with peat plateau and palsa landforms where peat accumulation of 2 to 3 m in thickness is typical (Zoltai *et al.*, 1988).

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Figure 51-4. Typical of the region is a retrogressive thaw slump on glaciolacustrine parent material. Thaw slumps are triggered by a disturbance of ice-rich sediments which then melt and produce an arcuate scar as shown in the foreground. With the exception of the small stand of spruce along the lakeshore (centre, foreground), the entire area was recently burned by a forest fire, the probable trigger of the slump.

VEGETATION

The vegetation of the Peel River Plateau Ecoregion is dominated by open stands of stunted black spruce and larch. Shrub-dominated communities occur at higher elevations. Much of the area has been burned, resulting in many mixed and deciduous communities. White spruce forests are restricted to fluvial terraces and some slopes along the major rivers.

The black spruce and black spruce–larch communities that dominate the Peel Plateau are underlain by medium to fine-textured Turbic Cryosolic soils, often gleyed, and derived from glacial parent materials. Labrador tea, shrub birch, ground shrubs such as lowbush cranberry and cloudberry, and mosses and lichens dominate the understory (LGL, 1981). Their micro-distribution is determined by earth hummocks (Zoltai and Pettapiece, 1973; Stanek *et al.*, 1981). Ericaceous shrubs dominate the tops and sphagnum mosses the inter-hummock troughs. Trees usually grow on, and often lean away from, the sides of the hummocks.

On shallow, poorly drained slopes, sedge tussocks and low ericaceous shrubs provide groundcover (Hettinger *et al.*, 1973; Stanek *et al.*, 1981; MacHutcheon, 1997). Tree density appears to be related to the time interval since the area was burned (Hettinger *et al.*, 1973). Initially, after a fire the tree density increases, but gradually the canopy thins out.

In old burns on drier sites, mixed forests of balsam poplar, paper birch, white spruce, green alder and willow have an understory of Labrador tea, lowbush cranberry and cloudberry (Hettinger *et al.*, 1973; Kennedy, 1992; MacHutcheon, 1997).

Along the lower portions of the Peel and Wind rivers, closed white spruce alluvial forests are found on well to imperfectly drained Eutric Brunisols. These sites typically host a shrub understory of mountain alder, willow and rose with a groundcover of horsetail, mustard and moss. On less stable sites along major rivers, mixed balsam poplar floodplain communities are more common. These are successional to the white spruce communities and dominated by balsam poplar, white spruce, mountain alder, and horsetail.

Numerous wetland complexes, dominated by small lakes and peat plateau bogs, are scattered on the plateau surface (Fig. 51-5). Sparse stunted black

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Figure 51-5. View westward toward the Richardson Mountains. Wetlands, including peat plateau bogs, fens and shallow water, occur throughout the ecoregion.

spruce with *Cladinia* lichen understory, shrubs, lichen, and moss dominate veneer bogs, common in the Bonnet Plume Basin (LGL, 1981).

Because this ecoregion is in the continuous permafrost zone, sparse black spruce and larch bogs dominate even alluvial terraces, such as are found along the Bonnet Plume River. Understory vegetation consists of shrub birch, willow, Labrador tea and other ericaceous shrubs (Hettinger, 1973; Stanek *et al.*, 1981; C.E Kennedy, writ. comm., 1992). Sites subject to frequent flooding have become tall willow or willow–alder swamps. Floodplain marshes along riverbanks are colonized by horsetail. Fens are dominated by *Carex aquatilis*.

Shrub-dominated communities are common at higher elevations on gently sloping south and southwest facing slopes. These low shrub communities with scattered alder clumps, shrub birch, Labrador tea, cloudberry, alpine blueberry, lowbush cranberry, and sedges, mosses and lichen, are associated with earth hummocks and Turbic Cryosols (Stanek *et al.*, 1981).

WILDLIFE

Mammals

Many of the taiga and alpine mammals of the Yukon occur in the Peel River Plateau including grizzly bears, wolves and wolverines. The ranges of two small populations of Dall sheep, occurring in the Richardson Mountains, extend into the Peel River Plateau at key mineral licks (Barichello *et al.*, 1987). Barren-ground caribou from the Porcupine herd occasionally winter here, east of the principal winter range (Fancy *et al.*, 1994). Moose occupy suitable habitats along river drainages.

Collared pika, arctic ground squirrel, singing vole and chestnut-cheeked vole are common. A list of mammal species known or expected to occur in this ecoregion is given in Table 4. Many of the rodent and ungulate species found in the southern Yukon are absent, resulting in relatively low diversity. There is little known of the small mammal populations of the area.

Birds

There is limited documented information on the bird life of the Yukon portion of the Peel River Plateau (Dennington, 1985; Frisch, 1987). There is speculation that Harris's Sparrow, a species not yet documented in the Yukon, may occur, along with Gray-headed Chickadee, which has not been confirmed breeding in the territory.

The wetlands of Chappie Lakes are used by staging Sandhill Crane, and staging and nesting Tundra Swan, Greater and Lesser Scaups, Surf Scoter, Red-necked Grebe, and Canada Goose (Dennington, 1985; Hawkings, 1994). Another wetland complex of potential importance is Hungry Lake, found in the extreme western portion of this ecoregion, where Tundra Swan and Bald Eagle occur in summer (Frisch, 1975; Peepre and Associates, 1993). Sandhill Cranes nest in the Northwest Territories portion of this ecoregion (Frisch, 1987), and Lesser Yellowlegs, Solitary and Upland Sandpipers, and Common Snipe occur in wetlands and open areas (Frisch, 1987).

The Peel River itself supports breeding Common Merganser, Canada Goose, Semipalmated Plover, Spotted Sandpiper, Herring Gull, and Belted Kingfisher. The Peel River, lower Wind River and their tributaries also support nesting Peregrine Falcon, Gyrfalcon, Bald Eagle, and a few Osprey (Yukon Wildlife Branch, 1977; Peepre and Associates, 1993).

Forested areas of the Northwest Territories section of this ecoregion are known to provide breeding habitat for Red-tailed Hawk, Merlin, American Kestrel, Olive-sided Flycatcher, Gray-cheeked and Varied Thrushes, Yellow, Yellow-rumped, Blackpoll, and Wilson's Warblers, Dark-eyed Junco, Chipping Sparrow, Rusty Blackbird, Pine Grosbeak, and Common Redpoll (Frisch, 1987). Year-round forest residents probably include Gray Jay, Common Raven, and Boreal Chickadee (Frisch, 1987).

Shrubby tundra areas near treeline support Northern Shrike, American Robin and American Tree and Savannah Sparrows (Frisch, 1987). Willow Ptarmigan inhabit this shrub tundra zone and adjacent subalpine forests throughout the year (Brown, 1979; Frisch, 1987).

Fort McPherson Plain

Taiga Plain Ecozone

ECOREGION 53

DISTINGUISHING CHARACTERISTICS: Only a small portion of this low relief, low elevation ecoregion occurs within the Yukon Territory. It includes the only part of the territory that lies on the floor of the Mackenzie Valley. Perennially frozen peatlands are extensive, covering over 25% of the ecoregion. The mean annual runoff is extremely low because of the very low relief (Fig. 53-1). The mean seasonal and summer stream flows of rivers are the lowest per unit area among all the Yukon ecoregions.

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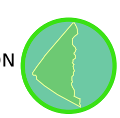
Figure 53-1. A view of the nearly level topography of the Fort McPherson Plain. The light coloured areas are covered in lichens that grow on the relatively dry surface of elevated peatlands called peat plateaus.

APPROXIMATE LAND COVER
subarctic coniferous and mixed forest, 85%
small lakes and non-treed wetlands, 15%

TOTAL AREA OF ECOREGION IN CANADA
30,180 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
2,840 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
1%

ELEVATIONAL RANGE
35–440 m asl
mean elevation 150 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Northwestern portion of **Peel River Ecoregion** (Oswald and Senyk, 1977) • Portion of **Taiga Plains Region** (CEC, 1997) • Portion of the **Northwest Territories Taiga Ecoregion** (Ricketts *et al.*, 1999)

PHYSIOGRAPHY

The northern half of the Fort McPherson Plain Ecoregion corresponds to the Peel Plain physiographic unit though the ecoregion also includes part of the Peel Plateau (Mathews, 1986; Hughes, 1987b; Bostock, 1948) (Fig. 2). The plain is an extensive level surface with little or no exposed rock. The ecoregion begins on the east bank of the Peel River and extends to the east and southeast into the Northwest Territories along the Mackenzie River Valley. Only the western margin of the ecoregion lies within the Yukon Territory.

The ecoregion slopes generally in a northeasterly fashion from an elevation of just over 440 m asl in the south to approximately 35 m asl in the north along the Peel River.

BEDROCK GEOLOGY

This area lacks exposed bedrock, but is part of the Northern Interior Platform succession (Norris, 1981h; Morrow, in press). Beneath the veneer of surficial deposits is the horizontal Cretaceous Arctic Red Formation of shale and sandstone, which is 350 to 400 m thick (Dixon, 1992). An unconformity separates the Cretaceous rock from underlying Devonian to Carboniferous sandstone and shale. Several exploratory gas wells have been drilled along the lower Trail River.

SURFICIAL GEOLOGY

Surficial deposits are dominantly moraine with small patches of discontinuous glaciolacustrine sediments (Duk-Rodkin and Hughes, 1992b,c). The remaining 10% of the area is comprised of colluvium, alluvium and organic deposits. Peatlands are most commonly developed on lacustrine deposits and moraine (Fig. 53-2).

Modern processes include rotational slides, debris flows, mudflows and retrogressive thaw flow slides along valley sides due to slope instability related to postglacial downcutting. Retrogressive thaw flow slides are also common where ground ice has been exposed by forest fire, debris flows and regressive erosion. Debris flows are most commonly triggered

C.D. Eckert, Yukon Government

Figure 53-2. Wetland complexes composed of shallow water, basin fens and peat plateau bogs occur throughout the ecoregion. During dry summers, the taiga forest and shrublands can become dry enough to support forest fires. The resultant burns (dark area surrounding the light-coloured fen) can be extensive.

by summer storms that expose the active layer and eventually develop into retrogressive thaw flow slides. Thermokarst processes are widespread on glacial lacustrine and morainel pediments.

GLACIAL HISTORY

The ecoregion was completely covered by the Late Wisconsinan Laurentide Ice Sheet, which blocked drainage and formed temporary lakes between glacier ice and mountain slopes. The rivers that border this ecoregion to the south and west formed part of a meltwater system that marked the western margin of the Tutsieta Lake Phase of the Laurentide Ice Sheet (ca. 13 ka; Hughes, 1987a; Duk-Rodkin and Hughes, 1995). At this time, the Mackenzie and Wernecke Mountain drainages and meltwater flowed to the Arctic Ocean via the Peel River. This flow established the present courses of the Snake and Peel rivers. The Cranswick and Arctic Red rivers were established following continued eastward retreat of the ice margin about 12,000 years ago. When the margin of the Laurentide Ice Sheet retreated from the uplands in the southern Anderson Plains east of the Mackenzie Valley, forming a large glacial lake. The outlet of this lake was west into the Mackenzie Delta area (Duk-Rodkin and Hughes, 1995), which is thought to have established the Mackenzie River in its present location.

CLIMATE

Little or no climate data are available from within the ecoregion. This ecoregion is east of the continental divide and, therefore, climatic controls are different from those for the rest of the Yukon. Winters are relatively long, October to late May, with frequent intrusions of arctic air up the Mackenzie Valley. Summers are short but fairly warm, in part due to the influence of continental air masses from interior plains to the south. Precipitation is light to moderate, enhanced by the redevelopment of Pacific storms in the Mackenzie Valley.

Mean annual temperatures are near –8°C. Average February temperatures range from –25 to –30°C. Extreme minimum temperatures are near –55°C, somewhat less cold than the interior of the Yukon. Although not common, above freezing temperatures can occur in any winter month. May temperatures are variable, ranging from –25 to 30°C. July is the warmest month with mean temperatures near 15°C, mean minimums near 10°C and mean maximums near 20 to 25°C. Frost can be expected at any time, however, even during summer.

Precipitation is light to moderate with annual amounts near 300 mm. July and August are the wettest months with mean monthly amounts near 40 mm, although over 100 mm in these months can occur. The driest period is November through May, but generally 15 to 20 cm of snow can be expected each month. Winds are expected to be light to moderate with mean values from 10 to 15 km/hr, with prevailing directions probably from the northwest and south.

No climate stations occur within the Yukon portion of this ecoregion but relevant data from Fort McPherson, Northwest Territories characterize the climate of this part of the Mackenzie Valley.

HYDROLOGY

Drainage from this very flat, low-lying ecoregion is into the Peel River. On the eastern side, the low divide between the Peel and Arctic Red River drainage basins makes up the political boundary with the Northwest Territories. Other than the Peel River, which forms the western boundary of the ecoregion, there are no large or intermediate-sized streams within the Yukon portion of the ecoregion. Smaller representative streams include the Satah River and Brown Bear and Georges creeks, all flowing into the Peel River. While there are no intermediate or large lakes, the ecoregion contains numerous small pothole lakes and ponds. The largest lakes are the Tabor Lakes, and the Seguin and Chi Itree complex.

Two historical representative hydrometric stations, Weldon and Jackfish Creek, are both within the Northwest Territories portion of the ecoregion. Monitored streams with similar characteristics were selected from adjacent ecoregions to supplement the available data to characterize the hydrologic response. Annual streamflow has an increase in discharge in May due to snowmelt, rising to a peak towards the latter part of the month. Summer rain events will occasionally produce secondary peaks on some streams, and infrequently the annual stream flow peak. Fall (September) streamflow is often higher than post-freshet summer levels. Because of the very low relief, mean annual runoff is extremely low with an estimated ecoregion average of 99 mm, while mean seasonal and summer flows are the lowest of all ecoregions (on a unit-area basis) with values of 5 X 10^{-3} and 2.7 X 10^{-3} $m^3/s/km^2$. The mean annual flood is moderately high, while the mean maximum summer flow is extremely low with values of 73 X 10^{-3} and 9.2 X 10^{-3} $m^3/s/km^2$, respectively. The minimum annual and summer flows are near 0, and 0.28 X 10^{-3} $m^3/s/km^2$, respectively. Due to the dominant role of winter temperatures and permafrost on streamflow, all ecoregion streams experience zero winter flows from December to April most years.

PERMAFROST

The Fort McPherson Plain Ecoregion is in the continuous permafrost zone. Geophysical data indicate the permafrost thickness may be up to 320 m, although temperature records from near Fort McPherson suggest the base of permafrost lies between 90 and 150 m from the surface (Geological Survey of Canada, unpubl. data).

Ground ice is found in all terrain units within the ecoregion, but ice wedges and thick accumulations of ice lenses are especially frequent in the moraine that blankets parts of the ecoregion (Geocon, 1986). There are numerous thermokarst lakes in these deposits (Harris *et al.*, 1983a). The ground surface in such terrain is usually hummocky and underlain by aggradational ice lenses (see Mackay, 1983).

SOILS

The soils of this ecoregion have formed on level to gently undulating topography composed of various glacial and organic parent materials. This is the only ecoregion in the territory that lies completely outside of the Cordilleran environment. As the ecoregion is within the zone of continuous permafrost, Cryosols dominate the landscape. Upland soils typically show earth hummock formations that underlie open forests of black spruce. These soils are classified as either Orthic or Brunisolic Turbic Cryosols (Pettapiece *et al.*, 1978). A surface of mossy peat up to 40 cm thick may be present. The permafrost table undulates beneath the surface producing an active layer 30 to 80 cm thick. The mossy forest floor materials tend to be acidic. Well-drained upland soils, particularly coarse-textured soils and shallow soils associated with bedrock outcrops, may be without near-surface permafrost, and are classified as Eutric Brunisols. Forest fires affect the thickness of the active layer and may result in a temporary drop of the permafrost table to a depth below 2 m, in which case the soils are classified as Brunisols rather than Cryosols.

Organic soils developed on peat materials are common in the Mackenzie Valley (Zoltai and Tarnocai, 1975) and particularly so in this ecoregion. For the most part these are Fibric Organic Cryosols that are associated with peat plateaus and palsa peatlands. These features develop mainly from moderately decomposed woody, sphagnum or sedge peat (Tarnocai *et al.*, 1993). It is estimated that a quarter of the ecoregion has a veneer of peat less than 1 m thick, most of which has some open subarctic forest cover.

VEGETATION

Open black spruce–lichen forests growing on imperfectly drained Turbic Cryosols, developed on earth hummocks, dominate the Fort McPherson Plain Ecoregion. Tamarack frequently accompanies the black spruce. Trees are usually less than 10 m tall (Zoltai and Pettapiece, 1973). Common shrubs include blueberry, Labrador tea, and lingonberry Reid and Calder, 1977; (Ritchie, 1984). The plain is dissected by drainages dominated by shallow open water and sedge fens. Stunted tamarack is sometimes associated with the fens.

Extensive areas of peat plateau bogs support stunted black spruce subarctic woodlands, where the tree height is usually 2 to 5 m. The understory is rich in shrubs including Labrador tea, shrub birch, blueberry, willow, lingonberry, cloudberry and bog cranberries, and in mosses dominated by *Aulacomnium* and *Sphagnum*, as well as *Cladina* lichens (Zoltai and Pettapiece, 1973; Reid and Calder, 1977; Ritchie, 1984).

String fens are also typical of the ecoregion and usually associated with Organic Mesisol or Fibrisol soils, though permafrost is present under the larger strings (Zoltai *et al.*, 1988). These fens are dominated by *Carex aquatilis*, often with willow and sparse tamaracks (Reid and Calder, 1977).

On the slightly better drained Peel Plateau portion of the ecoregion, white spruce and paper birch are probably mixed with the black spruce. The warmest sites may sustain some aspen and balsam poplar as well. The deciduous trees are likely successional post-fire or other disturbance species and will gradually be replaced by spruce in the canopy (Zoltai and Pettapiece, 1973; Ritchie, 1984).

WILDLIFE

Mammals

The Fort McPherson Plain contains essentially the same mammals as are found in the Peel River Plateau Ecoregion. Taiga forest dwellers such as lynx, marten, and wolverine are common. The only ungulate species represented are moose, wintering barren-ground caribou, and a small disparate year-round caribou population (Fig. 53-3).

A list of mammal species known or expected to occur in this ecoregion is given in Table 4. Many of the rodents and ungulates found in the southern Yukon are absent, resulting in a relatively low diversity. There is little known of the mammal populations of the area.

Birds

While the bird life of Fort McPherson Plain is poorly understood, initial investigations show that the area hosts unique and productive bird communities. Eckert *et al.* (2003) recorded a total of 66 species during surveys at Tabor Lakes and the headwaters of Jackfish Creek in late June and early July, 1999.

The most common and widely distributed passerines are American Tree Sparrow, Savannah Sparrow, Yellow-rumped Warbler, Dark-eyed Junco, and Rusty Blackbird. Less common but widely distributed species include Gray Jay, American Robin, Alder Flycatcher, Yellow Warbler, Blackpoll Warbler, Orange-crowned Warbler, White-crowned Sparrow, and Common Redpoll. Gray-cheeked Thrush and Lincoln's Sparrow are restricted in distribution but relatively common in suitable habitat.

C.D. Eckert, Yukon Government

Figure 53-3. The Fort McPherson Plain Ecoregion provides year-round habitat to a disparate caribou population. The range, population size and relationship to other caribou herds is poorly understood. This photo, taken in late June along a wetland margin, illustrates one of the recent burns in the region.

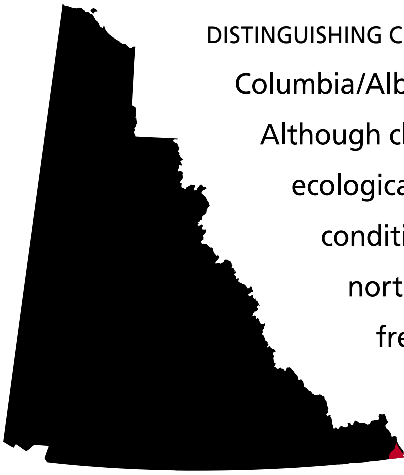
At Tabor Lakes, Swainson's Thrush inhabits the pockets of older white spruce, and Common Yellowthroat occurs at the very edge of its breeding range. Jackfish Creek headwaters hosts breeding Least Sandpipers, along with relatively high densities of Sandhill Cranes (Fig. 32). Open water habitats are productive throughout the region. At Jackfish Creek headwaters, Eckert *et al.* (2003) recorded 14 species of waterbirds (loons, grebes, and waterfowl), and two species of gulls; at Tabor Lakes, they recorded 17 species of waterbirds (loons, grebes, and waterfowl), and an amazing six species of gulls.

Other notable species in the area include both Trumpeter and Tundra swans, Peregrine Falcon, Sharp-tailed Grouse, Short-eared Owl, and the Yukon's first record of Palm Warbler at Tabor Lakes. Further, the Fort McPherson Plain appears to be an interesting place for vagrant birds; Eckert *et al.* (2003) recorded an impressive variety of rarities including Sabine's Gull, Glaucous-winged Gull, Glaucous Gull, Ring-billed Gull, and Eastern Kingbird.

Muskwa Plateau

Taiga Plain Ecozone

ECOREGION 66



DISTINGUISHING CHARACTERISTICS: This rolling plateau, centred in northern British Columbia/Alberta, extends into the extreme southeast corner of the Yukon. Although classified as part of the Taiga Plains Ecozone, the ecoregion is ecologically more representative of boreal rather than taiga (subarctic) conditions. The ecoregion is the only representation in the Yukon of northern boreal conditions east of the Cordillera (Fig. 66-1). A low frequency of forest fires results in a distinctive forest composition. This is augmented by the meeting of four major vegetation domains, resulting in a unique assemblage of plant species.

J. Meikle, Yukon Government

Figure 66-1. Closed stands of paper birch *(Betula papyrifera)*, balsam poplar *(Populus balsamifera)* and trembling aspen *(Populus tremuloides)* extend to the edge of the Beaver River. Coniferous forests in this ecoregion have a significant deciduous component (birch, aspen) and a tall shrub understory. There is little elevational stratification of forest communities or distinction between riparian and upland forests.

APPROXIMATE LAND COVER
boreal coniferous and mixedwood forest, 85%
boreal deciduous forest ,10%
lakes and non-treed wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
23,450 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
730 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
1%

ELEVATIONAL RANGE
255–1,115 m asl
mean elevation 570 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Southestern portion of **Beaver River Ecoregion** (Oswald and Senyk ,1977) • Portion of **Taiga Plains Region** (CEC, 1997) • Yukon portion of the **Muskwa/Slave Lake Forests Ecoregion** (Ricketts *et al.*, 1999)

PHYSIOGRAPHY

The Muskwa Plateau Ecoregion is represented in the Yukon as a small triangle of land lying north and west of the Liard River in the extreme southeast of the territory. This small southeast corner of the Yukon is part of a larger ecoregion that extends south into British Columbia. This ecoregion is part of the Alberta–Great Slave Plain Physiographic Region (Mathews, 1986) or Interior Plains region of Bostock (1948), which lies east of the Western Cordillera.

The subdued topography slopes south and east toward the Liard River. The elevation ranges from over 1,100 m asl on the ridge south of Mount Martin, a southern extension of the Kotaneelee Range south of the La Biche River, to below 300 m on the plain of the Liard River. Local relief is about 450 m.

The La Biche and Beaver rivers, and their tributaries, follow the northeast–southwest trend of the bedrock before cutting through the ridges in a more easterly direction (Fig. 66-2).

BEDROCK GEOLOGY

Bedrock exposure is limited to the Kotaneelee River west of Mount Martin and along the Beaver River at 60°N. The surficial sediments elsewhere contain abundant glacially transported debris so that the underlying shale and sandstone are unlikely to influence overlying soil and vegetative cover.

The regional geology is shown by Douglas (1976); structural and stratigraphic information has been acquired by companies with oil and gas leases in the region. Beneath the surficial material, sedimentary rocks form broad folds that are the easternmost expression of the northern Rocky Mountains. The northern edge of the ecoregion is traced around an anticline that forms the Kotaneelee Range, and most of the ecoregion is underlain by the adjacent La Biche syncline. Rusty-weathering, concretion-bearing shale, with lesser grey-green sandstone and siltstone, comprises the Lower Cretaceous Fort Saint John Group. The units beneath them, only exposed on the flank of the syncline along the northwest

J. Meikle, Yukon Government

Figure 66-2. The Labiche River cuts through the southernmost Kootanelee Range, having been diverted eastward by the most recent glaciation. Physiography and climate combine in this ecoregion to produce a fire cycle that is longer than in most of the boreal. Windthrow and insects are the more common agents of forest disturbance.

edge of the ecoregion, are grey-banded chert and sandstone of the Permian Fantasque Formation and grey siltstone, limestone, and shale of the Carboniferous-to-Permian Mattson Formation.

Within the Yukon portion of this ecoregion are two established petroleum fields and a sizeable region with high potential (National Energy Board, 1994). The Beaver River gas field, which straddles the British Columbia border, was discovered in 1957 and produced from 1969 to 1978 before being closed by water influx, although new techniques may allow further production. The Kotaneelee field, discovered in 1964, has been producing since 1993. However, most of the natural gas wells lie in the adjacent Northwest Territories, in the Liard and Pointed Mountain fields, and adjacent British Columbia. The principal reservoir is the Manetoe facies of Devonian limestone (Morrow *et al.*, 1990) that lies 2,500 to 3,500 m beneath the surface.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

The ecoregion was glaciated and glacial deposits are the dominant surficial unconsolidated material. Despite widespread evidence of pro-glacial lakes in the eastern valleys as the continental ice receded, the valleys have been largely swept clean of Quaternary fill by postglacial rivers. These rivers eroded a series of peneplains into bedrock, leaving bouldery lag deposits in valley bottoms. The modern rivers are underfit for the valleys they occupy.

Postglacial downcutting has affected areas of abundant glaciolacustrine sediments, resulting in extensive landslides throughout the valley bottoms. About 20% of the Yukon portion of the ecoregion has undergone mass movement, and some are kilometres in extent. The movement continues today and represents a significant hazard to existing and future development (I.R. Smith, pers. comm., 2000).

Failure of the Mattson Formation sandstone along steeply dipping bedding planes is commonly triggered by undercutting of slopes by rivers and streams. Block sliding, rotational slumps and soil creep are typical results. The overlying thick, clay-rich glaciolacustrine sediment and local till accumulations are also mobilized. Some of these flows extend several kilometres and can block local drainages, leading to later failures of these temporary dams.

GLACIAL HISTORY

Although the area is dominated by glacial features of the Cordilleran Ice Sheet that flowed across the area from the southwest to the northeast about 23,000 years ago, it was also affected by the Laurentide Ice Sheet a few thousand years earlier (30 ka; Duk-Rodkin and Hughes, 1995; Lemmen *et al.*, 1995; Duk-Rodkin *et al.*, 1986). The Laurentide Ice Sheet moved westward across the Kotaneelee Range as far west as the confluence of the Whitefish and Beaver rivers. Deglaciation eroded a series of meltwater channels. Meltwater from the continental ice flowed west and north across the La Biche Range, depositing an outwash delta there. Etanda Lakes are located at the apex of the delta. The middle and northern reaches of the La Biche Range supported small valley glaciers during the last glaciation in the area.

Drainage of the La Biche and Kotaneelee rivers was glacially altered. Before the last glaciation, the Kotaneelee River drained south between the La Biche and Kotaneelee ranges and was probably a tributary to the Beaver River. The Laurentide Ice Sheet eroded a channel oriented east-west across the Kotaneelee Range (Fig. 66-2) and deposited enough drift in the southern part of the valley that the direction of the river changed from south to east following glaciation. Later, when the Cordilleran Ice Sheet approached the ranges, it cut a northward channel across the drift barrier. This allowed meltwater to drain into the now east-flowing Kotaneelee River. The Cordilleran Ice Sheet also changed the drainage of the La Biche River by diverting it eastward across the La Biche Range, and later across the Kotaneelee Range, thereby creating the present zigzag pattern of the river.

CLIMATE

No climate data are available for this ecoregion. The description of climate given for the Hyland Highland Ecoregion would apply in a general way for this ecoregion. As elevations in the Muskwa Plateau ecoregion are generally less than 1000 m asl, station data from Fort Liard, Northwest Territories, would be most applicable to the area covered by this ecoregion.

HYDROLOGY

The Muskwa Plateau ecoregion is located in the very southeastern corner of the Yukon within the Interior Hydrologic region. Outside of the Yukon, this long and very narrow ecoregion drains the eastern foothills of the Rocky Mountains of Northern British Columbia. Within the Yukon, drainage is to the southeast from the La Biche Range of the eastern Mackenzie Mountains. Because of its small size, there are no representative large or intermediate-sized streams within the Yukon portion of the ecoregion. Though the La Biche River forms the eastern boundary of the ecoregion, and the Beaver River flows through the southwestern corner, these streams are not representative of the entire ecoregion. There are no large lakes within the ecoregion. There are scattered wetlands within the ecoregion; one notable complex exists within the Ottertail Creek valley between the Mount Martin and Mount Merrill ridges.

Hydrometric stations with similar topography to that of the Yukon portion of the Muskwa Plateau Ecoregion were chosen to represent streamflow characteristics. Because of lower relief within the small Yukon portion of the ecoregion, it is not truly representative of the remainder of the British Columbia portion. Also because of the relatively low relief, runoff and peak flow events are relatively low. Annual streamflow is characterized by an increase in discharge in early May due to snowmelt, rising to a peak later in the month within most ecosystem streams. Summer rain events do produce secondary peaks, and sometimes the annual peak, in July or August. Smaller streams are known to experience peak rainfall events more frequently than larger ones. Mean annual runoff is estimated to be 169 mm, while mean seasonal and mean summer flow are estimated to be moderate at $9.4 \text{ X } 10^{-3}$ and $8.7 \text{ X } 10^{-3}\ m^3/s/km^2$, respectively. The mean annual flood is estimated as relatively high at $131 \text{ X } 10^{-3}\ m^3/s/km^2$, while the mean maximum summer flow is estimated to be more moderate with a value of $46 \text{ X } 10^{-3}\ m^3/s/km^2$. The minimum annual and summer flows are estimated to be relatively low with values of $0.25 \text{ X } 10^{-3}$ and $0.51 \text{ X } 10^{-3}\ m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March or earlier. The majority of streams experience zero winter flows relatively frequently.

PERMAFROST

Muskwa Plateau is in the zone of sporadic discontinuous permafrost. The elevation is insufficient for alpine permafrost to form. Permafrost in the ecoregion is restricted to organic soils, and is likely less than 4 m thick. There are no published reports on permafrost from the Yukon portion of this ecoregion.

SOILS

Soils in this ecoregion have formed under a moist continental climate, somewhat milder and wetter than the adjacent Hyland Highland Ecoregion. Soil development reflects the mineralogy of the underlying Cretaceous calcareous shales and sandstones. Where soil parent materials are fine textured, such as clay loam moraine or glaciolacustrine materials, Brunisolic Gray Luvisols dominate the landscape. These Luvisols are highly productive forest soils found commonly throughout the Plains Ecozone. Eutric Brunisols are the common soils on coarse-textured, well-drained portions of the landscape (Zoladeski and Cowell, 1996). Orthic and Humic Gleysols occur in depressions on imperfectly and poorly drained mineral soils.

Wetlands are extensive, covering more than a quarter of the British Columbia part of this ecoregion, but are much less common in the Yukon portion. Organic Cryosols are common on peat plateau bogs and some veneer bogs (Zoltai *et al.*, 1988). Northern ribbed fens are common and lack permafrost. Fen soils are most commonly classified as Fibrisols or Mesosols.

VEGETATION

The vegetation cover is mixed boreal forest. The continental climate, with warmer, moister summers and relatively lower fire frequency than cordilleran ecoregions to the west, is reflected in the lush vegetation and high species diversity of this ecoregion. Fluvial sites in this area are the most productive in the Yukon. Trees on upland sites can reach more than 30 m in height (Applied Ecosystem Management, 1997b).

Though the region is dominated by northern boreal white and black spruce (Annas, 1977; Trowbridge *et al.*, 1983), occasional tall fern meadows and devil's club, typical of more southern forests, differentiate the Yukon part of this ecoregion from other parts of the Yukon and possibly other parts of the ecoregion. This area supports some plant species not found immediately south of the ecoregion.

As throughout the boreal forest, forest fires have a significant influence on forest composition. However, parts of this ecoregion show little evidence of fire over at least 250 years, the result in part of higher summer precipitation and a lower incidence of lightning. Forest composition and renewal on these sites appears to be controlled by the interactions between soil characteristics, insects and diseases. The resultant mixed forest canopy includes white spruce, black spruce, paper birch, trembling aspen and balsam poplar (Fig. 66-1).

White spruce–feathermoss forests form the dominant climax community found on moderately to rapidly drained fluvial deposits and moraine. Shrubs, such as highbush cranberry, rose, dwarf raspberry, red-osier dogwood, and green and gray alder, are common. Herbs include horsetail, bunchberry, mitrewort, bluebell and twinflower. As indicated above, ferns and devil's club are also present (Fig. 66-3).

Black spruce is more common on poorly drained sites usually with a Labrador tea and feathermoss understory. On moist and wet nutrient-rich sites, tamarack is occasionally found with black spruce. Subalpine fir is common at elevations over 750 m asl. Lodgepole pine does occur in one large burn in the Yukon portion of the ecoregion, but is not common elsewhere. Aspen also forms pure stands in this old burn.

Balsam poplar, paper birch and aspen frequently grow on disturbed sites, such as slumps found along the La Biche River. They are also found in mixed forest stands with white spruce. Graminoids with shrub birch and *Potentilla palustris* dominate the fens which border many of the lakes.

WILDLIFE

Mammals

Wood bison were historically present; the last one was shot in 1879 in British Columbia (Cowan *et al.*, 1973). A bison herd, re-established in British Columbia in the 1950s, occasionally ranges into the Yukon. Other species entering the Yukon near their northern limit of distribution here are mule deer and fisher. Black bears, moose and wolves are common.

Although this ecoregion is botanically productive, it does not provide suitable habitats for many of the rodent and ungulate species found in Boreal Cordillera ecoregions. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Several bat species, including the western long-eared myotis, northern long-eared myotis, long-legged myotis, big brown bat, and silver-haired bat, have recently been found in this ecoregion in British Columbia (Wilkinson *et al.*, 1995). Bats have

J. Meikle, Yukon Government

Figure 66-3. Devil's club *(Oplopanax horridus)* in the Lower Beaver River valley. The valley has a unique array of vascular plants derived from the overlap of Boreal Cordilleran, Boreal Plains and Beringian floral assemblages.

received little attention in the Yukon and additional species are expected to occur here.

Logging north and south of the 60th parallel may increase habitat suitability for ungulates well suited to early or mid-successional forests. Elk, mule deer, white-tailed deer and moose have all expanded their range and numbers following habitat change associated with development further south, and the same pattern may hold for the Muskwa Plateau. Climate warming may further increase the northward expansion of these species.

Birds

The Muskwa Plateau Ecoregion rivals the Yukon Coastal Plain for uniqueness within the Yukon, featuring many species that nest nowhere else in the territory or that reach their peak densities here. Remarkably, species that are at the edge of their range are abundant, such as Red-eyed Vireo at its northwestern limit and Hammond's Flycatcher at its northeastern limit.

Wetlands are not numerous, but support such rare Yukon species as Pied-billed Grebe, Marsh Wren, and Le Conte's Sparrow (Fig. 66-4), along with more widespread species such as Sora, American Coot, Solitary Sandpiper, Common Snipe, Alder Flycatcher, Common Yellowthroat, Lincoln's and Swamp Sparrows (Eckert *et al.*, 2003).

The rich and productive forests support an assemblage of forest birds that is unique in the Yukon. Philadelphia Vireo, and Black-and-white and Canada Warblers are found only in this ecoregion (Eckert *et al.*, 2003), while Ovenbird, Mourning Warbler, and Rose-breasted Grosbeak, which occur in low numbers in adjacent parts of the Hyland Highland Ecoregion, are common in the Muskwa Plateau (Eckert *et al.*, 2003). Cape May and Bay-breasted Warblers occur here and as far west as the edge of the Liard Basin Ecoregion (Sinclair, 1998). These, as well as a number of species that occur slightly farther west, reach their peak densities in this ecoregion, including Tennessee and Magnolia Warblers, Western Tanager, and White-throated Sparrow. Cedar Waxwing is most common in the Muskwa Plateau and Hyland Highland Ecoregions, although it occasionally occurs farther west in the Yukon (Eckert, 1995a; Eckert *et al.*, 2003). This is one of the few Yukon ecoregions where Pileated Woodpecker is known to occur.

C.D. Eckert

Figure 66-4. The Le Conte's Sparrow is only known in the Yukon from the extreme southeast in the Hyland Highland and Muskwa Plateau ecoregions. It inhabits grassy wetlands with scattered low shrubs.

Widespread forest bird species that are abundant in mixed forests include Yellow-bellied Sapsucker, Hammond's Flycatcher, Gray Jay, Swainson's Thrush, American Robin, Magnolia and Yellow-rumped Warblers, American Redstart, Chipping Sparrow, and Dark-eyed Junco (Eckert *et al.*, 2003). White spruce forests support an abundance of species, such as Three-toed and Black-backed Woodpeckers, Boreal Chickadee, Bay-breasted and Tennessee Warblers, Western Tanager, White-winged Crossbill and Evening Grosbeak. Red-eyed Vireos reach their peak densities in balsam poplar forests, while trembling aspen forests support high densities of Ruffed Grouse, Least Flycatcher, Warbling Vireo, and Ovenbird. Species occurring in riparian tall shrubs and young deciduous forests include Philadelphia Vireo, Alder Flycatcher, and Yellow Warbler. Eastern Phoebe is a specialty species that nests each year along the La Biche River (Eckert *et al.*, 2003).

The Yukon's only documented record for Broad-winged Hawk is from the lower La Biche River and, though its status is unclear, may be a rare breeder. Bald Eagles are seen along the La Biche and lower Beaver rivers, and may nest there, beside Spotted Sandpipers and Bank Swallows. Numerous owls inhabit the forests including Great Horned, Northern Hawk, Great Gray and Boreal Owls (Eckert *et al.*, 2003). Species known to occur in winter are Three-toed and Black-backed woodpeckers, Gray Jay, Common Raven, Boreal Chickadee, Red-breasted Nuthatch, and Common Redpoll (Sinclair *et al.* [editors], 2003).

Some species at the northern limits of their range now might well push farther north.

TAIGA CORDILLERA ECOZONE

This ecozone covers the subarctic regions of the Western Cordillera. It is located along the northernmost extent of the Rocky Mountain system and covers most of the northern half of the Yukon and southwest corner of the Northwest Territories. In this ecozone are found some of Canada's largest waterfalls, deepest canyons and wildest rivers.

Climate: Annual precipitation ranges from less than 300 mm in the north to over 700 mm in the Selwyn Mountains. Mean annual temperatures range from –10°C in the north to –4.5°C in the south. Average summer temperatures range from 6.5 to 10°C, modified by elevation and aspect. Summers are warm to cool with extended periods of daylight. Average winter temperatures range from –25°C in the north to –20°C in the south. Winters are long and cold with very short daylight hours, particularly in the northern portions of the ecozone. Weather systems moving inland from the Arctic coast have a marked influence on the climate of this ecozone.

Hydrology: The underlying permafrost, which is continuous north of the Ogilvie and Wernecke mountains, largely controls streamflow characteristics. Runoff is large relative to precipitation compared with more southern ecozones because of the underlying permafrost and low rates of evapotranspiration. Peak flows, which generally occur in June, are likewise greater relative to areas with less permafrost due to shorter pathways through the watershed, as a result of limited infiltration rates. Summer rain events can produce

J. Meikle, Yukon Government

East of the Snake River in the Wernecke Mountains (within the Mackenzie Mountains Ecoregion) is this glaciated U-shaped valley north of Mount McDonald, with walls 1,500 m high.

secondary peaks and sometimes annual peaks on smaller streams, especially in mountainous areas. Minimum flows generally occur in March and tend to be lower than the Pacific Maritime and Boreal Cordillera ecozones to the south, because of the effect of lower winter temperatures on groundwater flow. Small streams within this ecoregion frequently experience zero flows while some intermediate-sized streams may occasionally experience zero winter flows.

Vegetation: Vegetation cover ranges from tussock tundra composed of dwarf or low shrubs, mosses and lichens, and cottongrass at higher elevations in the northernmost portions of the ecozone, to taiga or open woodlands in the southern portions of the ecozone composed of white spruce and paper birch mixed with dwarf birch and willows, mosses, and lichens. Alpine tundra, composed of shrubs, lichens, saxifrages, and mountain avens, occur at higher elevations throughout the ecozone.

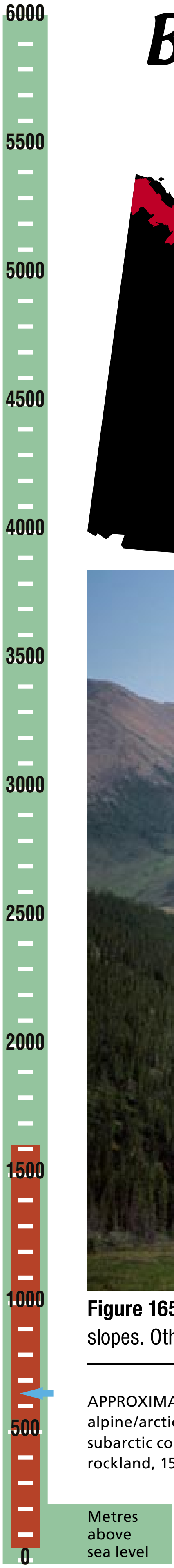
Landforms and soils: Mountainous topography, often consisting of semi-parallel ridges with deep intervening valleys, dominates the landscape of the ecozone. Foothills and intermontane basins are also present and common in the northern Yukon. Much of the surface is mantled with colluvium with frequent bedrock exposures and minor glacial deposits. The northwestern portion of this ecozone consists of unglaciated terrain. Cryosols, Brunisols and Regosols tend to be the predominant soils. Wetlands are extensive in some ecoregions. Permafrost features, such as earth hummocks, palsas, and peat plateaus, are common. The unglaciated portions of this ecozone commonly exhibit periglacial features, such as cryoplanation terraces and summits, and various forms of sorted and non-sorted patterned ground. Continuous permafrost underlies most of the ecozone.

Wildlife: Wildlife in the area is diverse. Characteristic mammals include Dall sheep, woodland and barren-ground caribou, moose, mountain goat, black and grizzly bear, wolf, lynx, Arctic ground squirrel, American pika, hoary marmot, and a concentration of wolverine. Important birds include Gyrfalcon, Willow and Rock Ptarmigans, and waterfowl. The Yukon's Old Crow Flats is a large wetland complex that has received international recognition for its value for the tens of thousands of swans, geese, and other waterfowl that nest or stage in this large intermontane basin each year.

J. Meikle, Yukon Government

Vegetation patterns repeat, controlled by permafrost, fire and low relief, near Shaefer Creek, Eagle Plains, with view northwest toward the David Lord Range.

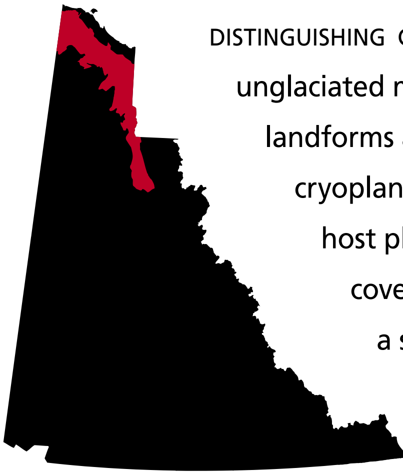
Human activities: Present activities include subsistence hunting, trapping and fishing; ecotourism; and outdoor recreation. During the 1960s and 1970s much exploration for hydrocarbons was undertaken in the major basins of the ecozone and pressure continues to explore these resources. In the Yukon, the ecozone is sparsely populated and home to the Vuntut Gwitch'in. The total population is roughly 350, most of whom reside in Old Crow, the Yukon's most northerly settlement.



British-Richardson Mountains

Taiga Cordillera Ecozone

ECOREGION 165



DISTINGUISHING CHARACTERISTICS: The ecoregion contains the largest extent of unglaciated mountain ranges in Canada. Some excellent examples of periglacial landforms are found within the ecoregion, including solifluction lobes and cryoplanation summits and terraces. The northernmost Richardson Mountains host phosphate minerals, including lazulite, the Yukon gemstone. Vegetation cover, strongly influenced by aspect and elevation (Fig. 165-1), produces a surprising diversity of ecosystems and habitats. This mountainous ecoregion contains the Yukon portion of calving habitat along with important migration routes of the Porcupine caribou herd.

J. Hawkings, Canadian Wildlife Service

Figure 165-1. View looking eastward in the Richardson Mountains showing spruce forest growing on lower elevation, south-facing slopes. Other slope aspects and elevations above 600 m asl support only shrub and/or tundra vegetation.

APPROXIMATE LAND COVER
alpine/arctic tundra, 65%
subarctic coniferous forest, 20%
rockland, 15%

TOTAL AREA OF ECOREGION IN CANADA
26,690km^2

TOTAL AREA OF ECOREGION IN THE YUKON
22,900 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
5%

ELEVATIONAL RANGE
40–1,610 m asl
mean elevation 640 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Mountainous portion of **Northern Mountains and Coastal Plain Ecoregion** (Oswald and Senyk, 1977) • Equivalent to **Northern Mountain Ecoregion** (Wiken et al., 1981) • Yukon portion of **Brooks Range Tundra Region** (CEC, 1997) • Yukon portion of **Brooks/ British Range Tundra Ecoregion** (Ricketts et al., 1999). Contiguous with the **Brooks Range Ecoregion of Alaska** (Nowacki *et al.*, 2001)

PHYSIOGRAPHY

The British, Barn and Richardson mountains and intervening valleys compose the British–Richardson Mountains Ecoregion (Rampton, 1982) (Fig. 2). They have been sometimes known collectively as the Arctic Mountains or Ranges (Bostock, 1948; Hughes, 1987b). The British Mountains comprise the eastern extension of the Alaskan Brooks Range, including the Buckland Hills and the northern foothills of the British Mountains (Rampton, 1982). The British and Barn mountains run parallel to the north coast of the Yukon. The Richardson Mountains trend north–south from east of the Barn Mountains south to the Peel River.

The mountains have remained largely unglaciated except for minor alpine glaciation in the British Mountains and the eastern flank of the Richardson Mountains (Fig. 165-2). The ecoregion is characterized by steep, V-shaped valleys in the higher ranges and gently sloping pediments where the valleys are broader.

The relief in the mountains ranges from 450 to 900 m. The highest elevations are associated with the western British Mountains and the southern Richardson Mountains where there are unnamed peaks over 1,600 m asl. In the northern Richardson and Barn mountains, the topography is more subdued.

The British, Barn and Richardson mountains are cut by large rivers flowing north to the Beaufort Sea. From the west, the most significant are the Malcolm, Firth, Babbage, Blow and Big Fish rivers. The southern slopes of the mountain ranges are drained by small tributaries to the Porcupine River. Most of the Richardson Mountains also drain to the Porcupine via the Bell and tributaries of the Eagle River. The south and east slopes of the Richardsons are part of the Peel watershed.

J. Meikle, Yukon Government

Figure 165-2. A view of the Richardson Mountains showing Laurentide glacial drift in valley bottoms and unglaciated upper slopes and ridgetops. Note the contrast between light coloured, lichen-dominated colluvial slopes and valley-bottom drift surfaces that are vegetated by darker coloured sedge tussock/moss communities.

BEDROCK GEOLOGY

This ecoregion contains well-exposed sedimentary rocks of Proterozoic to Cretaceous age and small Devonian granite intrusions, and spans three separate geological structures. The British and Barn mountains, an eastern continuation of the Alaskan Brooks Range, are part of the Arctic–Alaska Terrane, consisting of continental margin sediments (Wheeler and McFeely, 1991). The topographically subdued region east of the mountains is the Blow Trough, a mid-Cretaceous extension basin. The south-trending Richardson Mountains resulted from Paleozoic deep-water clastic sediments being uplifted by outward-verging thrust faults located at an interpreted westward-dipping crustal ramp (Lane, 1996) in latest Cretaceous or early Tertiary time.

Bedrock geology of the entire ecoregion is shown on regional maps by Norris (1981a,b,f,g) and described by various authors in his report (Norris [editor], 1997). Many regional aspects of the stratigraphy and structure have been studied in detail.

The British and Barn mountains comprise folded and faulted structural blocks, uplifted in early Tertiary time, separated by a structural depression along the Babbage River. The Romanzov Uplift, traversed by the Firth River, exposes a thick structural succession consisting of the following units: Proterozoic mixed carbonate and fine clastic rocks; latest Proterozoic to Cambrian sandstone — the Neruokpuk Formation, 600–1000 m thick; Cambrian and Ordovician volcanic and volcanic-clastic rocks with limestone and argillite — the Whale Mountain succession; and Ordovician to Devonian black argillite and siltstone — equivalent to Road River Formation. Most of the succession is directly correlated with the Proterozoic to mid-Paleozoic Selwyn Basin of the central Yukon (Lane and Cecile, 1989; Lane, 1991). Mount Sedgewick in the British Mountains is cored by a biotite quartz monzonite pluton (370 Ma; Mortensen and Bell, 1991). The Barn Range is a tectonic uplift of a structurally thickened succession of dark grey to black, red, and green shale, ridge-forming grey quartzite and siltstone, and light grey limestone (Cecile, 1988; Cecile and Lane, 1991) equivalent to the upper Hyland group and overlying Road River Formation. Two hornblende–biotite granites, Mount Fitton and Hoidahl Dome, have prominent orange-weathering pyrite haloes. The flanks of these two uplifts constitute the Endicott and Lisburne groups of Carboniferous age overlain by Kingak Formation from the Jurassic–Cretaceous. Blow River Trough contains 4 to 10 km of Albian flysch, in part the Rapid Creek Formation (Young, 1975).

The Richardson Mountains are divided by a structural and topographic depression at the head of the Vittrekwa River at the continental divide on the Dempster Highway with different structural styles to north and south. To the north, ridges formed by differential erosion of more resistant units are short and offset by faults. The White Mountains are an uplifted block of light-grey Paleozoic limestone, which produces extremely rugged topography, surrounded by dark brown clastic sediments of Ordovician to Devonian age. In contrast, the southern Richardson Mountains are a breached anticlinorium with sandstone and limestone of the Slats Creek and Illtyd formations, being Lower and Middle Cambrian respectively (Fritz, 1996) in the hinges, flanked by more resistant chert and limestone of the Road River Formation of Ordovician to Middle Devonian age. Throughout the Richardson Mountains are long, curved and near-vertical faults of the Richardson Fault Array. The southern Richardson Mountains remain seismically active (Forsyth *et al.*, 1996).

In general the oldest succession of mixed carbonate and clastic rocks underlies subdued topography and produces calcareous soil with common caliche surfaces (L. Lane, pers. comm., 1997). The blocky talus below thick limestone units, as well as from Precambrian sandstone units, provides denning sites for foxes, wolf and bear. Slopes underlain by the sandstone, as well as Cambro–Ordovician volcanic and volcaniclastic rocks are characteristically unstable and lightly vegetated with blocky talus cones. Cambro–Ordovician argillite and chert underlies subdued topography with fine, granular talus that is well vegetated and suitable habitat for burrowers. Steeply dipping chert layers locally produce jagged, razor-like ridge crests. The Carboniferous dark shale of the Kayak Formation and sandstone locally harbour evaporite minerals, used as salt licks by caribou, while the tilted limestone strata erode into rugged topography.

A variety of mineral types are known, although much of the northern part of the ecoregion was withdrawn from claim staking in 1978, limiting further investigations. The Blow River, Rapid Creek and Big Fish River area contain new phosphate minerals (Robinson *et al.*, 1992), including lazulite, the Yukon gemstone. This area also contains very large phosphatic iron manganese reserves. The Barn Mountains hold uranium in conglomerate of Carboniferous and Cretaceous Age as well as in skarns with molybdenum, tungsten and copper near the Fitton and Sedgewick granitic intrusions. Minor gold occurs at Mount Sedgewick and at Whale Mountain. The erosion of Devonian granite in nearby Alaska has produced the placer deposit in Sheep Creek, near the Firth River. A magnetite iron formation occurs locally in the Cambrian to Devonian units of the Romanzov Uplift near the Alaska–Yukon border (Lane *et al.*, 1995). Seams of anthracite are common in the Mississippian Kayak and Cretaceous Kamik formations throughout the ecoregion. The Richardson Mountains contain several galena and sphalerite occurrences, typically in breccia zones within the Illtyd (Pilon showing) and Road River (Vittrekwa showing) limestones. Magnetite, minor chalcopyrite and brannerite occur in a diatreme breccia within Proterozoic lime siltstone. Large gypsum lenses in the Richardson Fault Array straddle the Yukon–Northwest Territories border.

A spectacular exposure of Road River sedimentary rocks occurs at Canyon Creek, and quartzite of the Jurassic Bug Creek Group provides impressive cryoplanation terraces in the northern Richardson Mountains (Fig. 27 *in* Norris [editor], 1997).

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

This high relief, largely unglaciated terrain has been affected mostly by mass wasting and weathering. Rock outcrops are common, being mostly composed of friable sedimentary rocks such as sandstone, limestone and shale. At high elevations, tors, pinnacles and dyke-like ridges stand out at or near summits. The summits, as well as the uppermost slopes of mountains, are usually blanketed by unvegetated rock fragments either as felsenmeer or colluvium veneer, interspersed with frost-shattered crags.

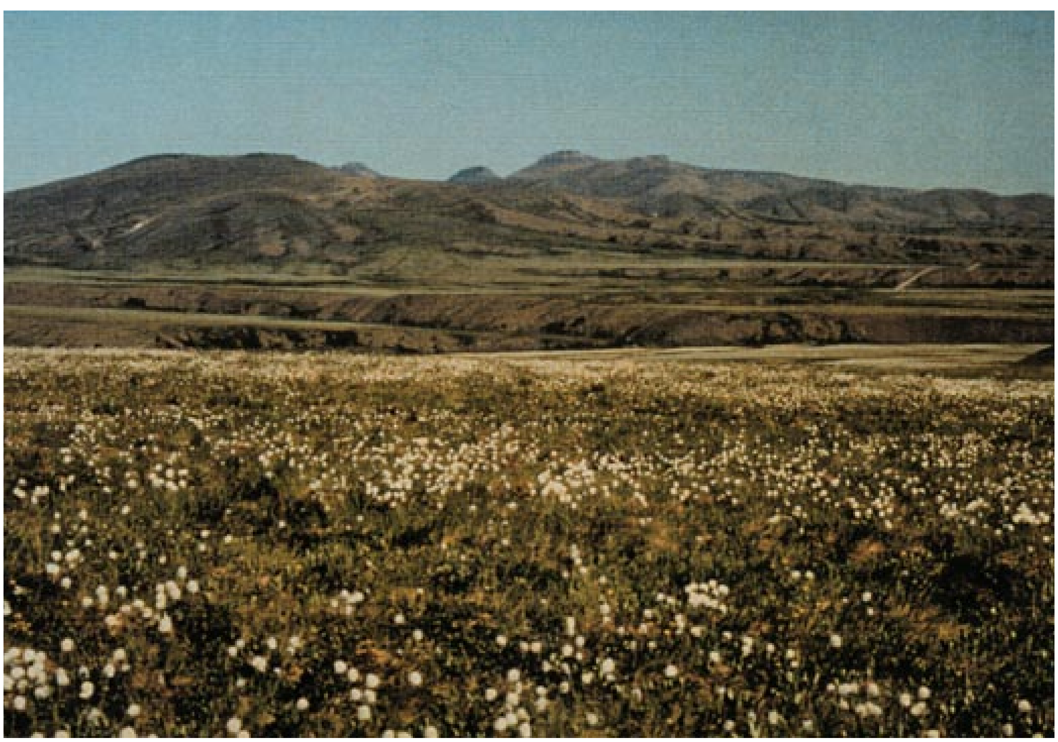
Middle and low elevations are covered by residual or weathered rock, or soliflucted and colluvial materials, which form fans or long, gentle pediment slopes. Pediments are extensively developed in this mountainous ecoregion, with three levels identified in the Richardson Mountains and at least six in the British Mountains (L. Lane, pers. comm., 1997) (Fig. 165-3). Stone circles and other patterned grounds are occasionally present.

Most small streams have coarse gravel beds. The streams are often entrenched in pediment surfaces. Upper slopes have developed intricate, feather-like drainage patterns. Thin loess deposits are common throughout the ecoregion.

Modern processes relate dominantly to colluvium deposits, including a variety of materials transported by solifluction and sheetwash (Fig. 165-4). Periglacial features include cryoplanation terraces found all along the northern Cordillera, with the highest concentration along the southern slopes of the British Mountains north of the Old Crow Basin (Lauriol and Godbout, 1988; Lauriol, 1990).

GLACIAL HISTORY

Localized alpine glaciers affected the highest mountains during Pleistocene glacial periods of undetermined ages. There are two restricted areas where local glaciers developed: at the headwater of Malcolm River in the British Mountains (Duk-Rodkin, in press) and east of Bell River in an unnamed peak in the Richardson Mountains (Duk-Rodkin and Hughes, 1992a). Cirque scars are found in both these areas, but no glacial deposits have been recognized in the valleys of the Richardson Mountains. Malcolm Valley has glacial features that could relate to three glacial periods, including the Late Wisconsinan. The identification of these three glacial periods is based on the degree of preservation of glacial features on these valleys.



A. Duk-Rodkin, Geological Survey of Canada

Figure 165-3. Pediment terraces on the eastern slope of the Richardson Mountains have been partly glaciated by the Laurentide ice sheet. The tundra vegetation in the foreground is dominated by cotton grass *(Eriophorum vaginatum)*.

Figure 165-4. The mottled texture of this slope results from solifluction, the sliding of the active layer over the underlying permafrost. The solifluction lobes, like rolls, are several metres across and up to 2 m high. They are composed of a mix of mineral soil, organic matter and rock fragments.

During its maximum extent, the Laurentide Ice Sheet extended up to 970 m asl in the southern Richardson Mountains, descending to 880 m asl in McDougall Pass. This Late Wisconsinan limit 30,000 years ago (Hughes *et al.*, 1981; Schweger and Matthews, 1991) is the only glacial limit represented in this ecoregion. Though the ice sheet crossed the continental divide in this ecoregion only at McDougall Pass, meltwater drained to the western side of the mountains at several sites, including the headwaters of the Road and Vittrekwa rivers. This resulted in several changes to pre-existing drainages, most importantly the westward diversion of the Porcupine River (Duk-Rodkin and Hughes, 1994) that caused the inundation of the Bell–Old Crow–Bluefish basins. The outlet of this proglacial lake cut a canyon to the west, establishing the Porcupine River as a tributary to the Yukon River. Today, the former thalweg of the paleo-Porcupine River in McDougall Pass is buried under 150 m of glacial drift. Terraces related to the preglacial drainage are found along both sides of the valley in McDougall Pass, some of which have been partially glaciated by the Laurentide Ice Sheet (Duk-Rodkin and Hughes, 1992a, 1994). The paleo-Porcupine River was one of the many drainage systems that were changed by the Laurentide Ice Sheet.

Pediment development has been ongoing since at least the late Miocene (McNeil *et al.*, 1993; Duk-Rodkin and Hughes, 1994). Lower pediment surfaces grade into alluvial fans towards the interior basins. Pediment surfaces commonly have a veneer of colluvium derived from local bedrock. Extensive pediment areas are found along the eastern and western slopes of Richardson Mountains (Duk-Rodkin and Hughes, 1992a,b). However, pediments along the eastern side of the mountains were covered by the Laurentide Ice Sheet (Fig. 165-3). On the deep glacial drift in McDougall Pass, the dominant surface units are morainal blankets, hummocky moraine and lacustrine deposits.

CLIMATE

Mountains in this ecoregion are oriented southeastward through the northern Yukon and then southward to the Peel River valley. Although not massive, with elevations from 500 to 1,600 m asl, these mountains are rugged and have significant climatic effects. The higher elevations have less extreme temperatures, but greater precipitation and wind velocity, than in surrounding terrain. Winds are stronger over higher elevations, but particularly significant is the funneling effect of the valleys. There are frequent occurrences of strong to gale-force winds that can develop through depressions when masses of cold Arctic air either spill into or out of the Yukon's interior during the winter. Due to the latitude, the sun remains above the horizon from early June to mid-July, and below the horizon from early December to early January.

Mean annual temperatures are near –7.5°C. Mean January temperatures are –20 to –25°C, but near –5°C temperatures are not uncommon. Equally frequent are temperatures near –40°C, particularly in the lower valley floors. Spring or summer conditions are generally delayed until early June. Mean temperatures are near 10°C in July, but again with variations from near freezing to 25°C.

Precipitation is relatively moderate ranging from 250 to 400 mm annually with the heaviest precipitation from June through August over the Richardson Mountains. Precipitation remains moderate through to December, primarily as snow from September onwards.

Winds are believed to be moderate, but during the winter can often be strong to gale force. The prime directions are west and east, but these can be strongly influenced by local topography. Active systems moving over the Beaufort Sea can result in strong outflows of cold Arctic air spilling through depressions such as the Blow and Babbage rivers. These winds can result in extensive snow redistribution.

Little long-term weather data are available from within the mountains but inferences can be made from such stations as Old Crow, Eagle Plains, Fort McPherson, Shingle Point and Komakuk Beach. Interesting data are becoming available from an automatic weather station at Rock Creek, near Wright Pass north of Eagle Plains. The wind data may be indicative of conditions in other passes.

HYDROLOGY

The northern watersheds of the ecoregion fall largely within the Arctic Hydrologic Region, while the southern Richardson Mountains watersheds extend down into the Northern Hydrologic Region. The area of waterbodies is relatively small; there are few large lakes within the ecoregion and wetland coverage is limited in this unglaciated landscape.

Because of the elongated nature of the ecoregion, hydrologic response is somewhat variable. The majority of the ecoregion is located north of 68°N and exhibits a relatively uniform response. The Richardson "panhandle," which extends to below 66°N, extends into a region of higher precipitation. There are two representative hydrometric stations within the Yukon portion of the ecoregion: Firth and Babbage rivers, though the Eagle River is on the periphery and is somewhat representative of the southern portion of the ecoregion. In addition, three hydrometric stations are adjacent to the ecoregion in Alaska: Kaparuk and Sagavanirktok rivers and the Sagavanirktok River tributary. Annual streamflow is generally characterized by a gradual increase in discharge in the spring, rising to a peak in May or June due to snowmelt inputs. Peak flows tend to be consistently earlier within the southern portion, and later with a more variable timing in the north. This ecoregion has among the highest peak flows and lowest winter low flows in the Yukon. Many of the first- and second-order headwater streams are steep and relatively short; therefore, streamflow response tends to be rapid and flashy. On these smaller streams, approximately 40% of the annual maximum flows are due to intense summer rainstorm events. Some small steep streams are susceptible to mud flows triggered by these summer rainstorms. Mean annual runoff is moderate ranging from 150 to 280 mm, with an ecosystem average of 208 mm. Mean seasonal and summer flows are likewise moderate with values of 15.8 X 10^{-3} and 11.4 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual flood is relatively high with a value of 128 X 10^{-3} $m^3/s/km^2$, while the mean maximum summer flow is more moderate with a value of 35 X 10^{-3} $m^3/s/km^2$. Minimum streamflow generally occurs during January or February in the southern portion of the ecoregion and earlier in the northern portion. The mean annual minimum flow ranges from zero in the northern portion to 0.04 X 10^{-3} $m^3/s/km^2$ in the southern portion. Mean summer minimum flow within the ecoregion is 1.9 X 10^{-3} $m^3/s/km^2$. Most streams experience zero winter flow.

PERMAFROST

Permafrost is continuous in the British–Richardson Mountains Ecoregion of the northern Yukon (Harris, 1986) (Fig. 21). Most of the ecoregion was not glaciated during the Quaternary period, so there are terrain features produced by over 2 million years of frost action. The ecoregion is accessible along the Dempster Highway, from which aprons of frost-shattered debris, extensive networks of patterned ground, and numerous solifluction lobes are visible on the mountainsides (Fig. 165-4). The land grading down from the Barn Mountains towards the Yukon Coastal Plain Ecoregion forms extensive pediments of gentle gradient (French and Harry, 1992). Similarly, high elevations within the Richardson Mountains have well-developed sequences of up to 15 cryoplanation terraces (Lauriol, 1990) — flat surfaces separated by short, steep rock walls, which have formed after long-term frost weathering of host material (Rampton, 1982).

The near-surface permafrost layers are often ice-rich, even in bedrock (EBA, 1985). Ice-rich ground has been detected at depths over 5 m by ground-probing radar along the Dempster Highway near the Yukon–Northwest Territories border (EBA, 1987a). Many features characteristic of continuous permafrost, such as ice wedges, may be found beneath the regolith, but soil movement down slope may mask their surface expression. Thaw slumps are occasionally seen in riverbanks where recent erosion has exposed ground ice.

Several of the rivers and creeks draining the ecoregion are fed by perennial springs, and extensive ice develops in the channel beds each winter. The largest aufeis, in the Firth River, is visible on satellite images taken well into summer (Lauriol *et al.*, 1991). This ice may be several metres thick and extend over 25 km^2.

There are no published determinations of permafrost thickness in this ecoregion, but data from neighbouring areas suggest depths of 200 to 300 m (Burgess *et al.*, 1982). The active layer is usually less than 0.5 m deep on pediments and lower slopes, but Rampton (1982) reports a thickness of 2.5 m at favourable well-drained upland sites.

SOILS

Soils in this ecoregion have formed under the influence of a subarctic climate, strong local relief and varied geologic parent materials. They are formed on mountainside colluvium slope deposits or on the large pediment surfaces of broad valleys. The near-surface permafrost is nearly continuous, except for localized occurrences of unfrozen ground along alluvial systems, glacio-fluvial terraces and some well-drained south-facing slope deposits. The soil–landscape relationships in this ecoregion have been described by Wiken *et al.* (1981) and more recently by Welch and Smith (1990) and are summarized in Figure 165-5. Well-developed periglacial landforms exist, including cryoplanation terraces and cryopediment slopes (French and Harry, 1992). Soils have formed in nonglacial parent materials except for those on the eastern flank of the Richardson Mountains, which were subjected to Laurentide glaciations during the Pleistocene.

All gently sloping surfaces tend to have soil development strongly influenced by cryoturbation. These Cryosols are often silty or clay-textured, saturated for most of the growing season, and classified as Gleysolic Turbic Cryosols. These soils tend to be acidic, particularly in association with shale bedrock; are high in organic matter and silt, and have active layers of less than 50 cm (see site 9, Tarnocai *et al.*, 1993). On pediment surfaces, these soils are associated with tussock tundra vegetation. Shallow soils over bedrock on upland surfaces above treeline exhibit a variety of patterned ground formations, mostly sorted and non-sorted nets and stripes, tend to be less saturated, and are classified as Orthic Turbic Cryosols. On mountain slopes below treeline where there is no near-surface permafrost, soils are most often classified as Eutric Brunisols, or occasionally as Melanic Brunisols if they have thick surface A horizons. Soils are classified as Orthic Turbic Cryosols wherever permafrost occurs on steep slopes (Fig. 165-6). Alluvial sands and gravels tend to lack strong cryoturbation features or a near-surface permafrost table, and are classified as Orthic or Humic Regosols. On older, more stable alluvial surfaces where permafrost is established, soils are typically classified as Regosolic Static Cryosols. On well-drained fluvial terraces, near-surface permafrost may be lacking and soils are classified as Orthic Eutric Brunisols.

One of the unique soil features of the ecoregion is the humus-rich, rendzina-like soil of the limestone areas of the British Mountains (Welch and Smith, 1990; Smith *et al.*, 1990,). Others are the cryoplanation terraces and summits of the Richardson Mountains with their associated patterned ground formations, unique soil fauna populations (Tynen *et al.*, 1991), and solifluction lobes (see site 7 in Tarnocai *et al.*, 1993).

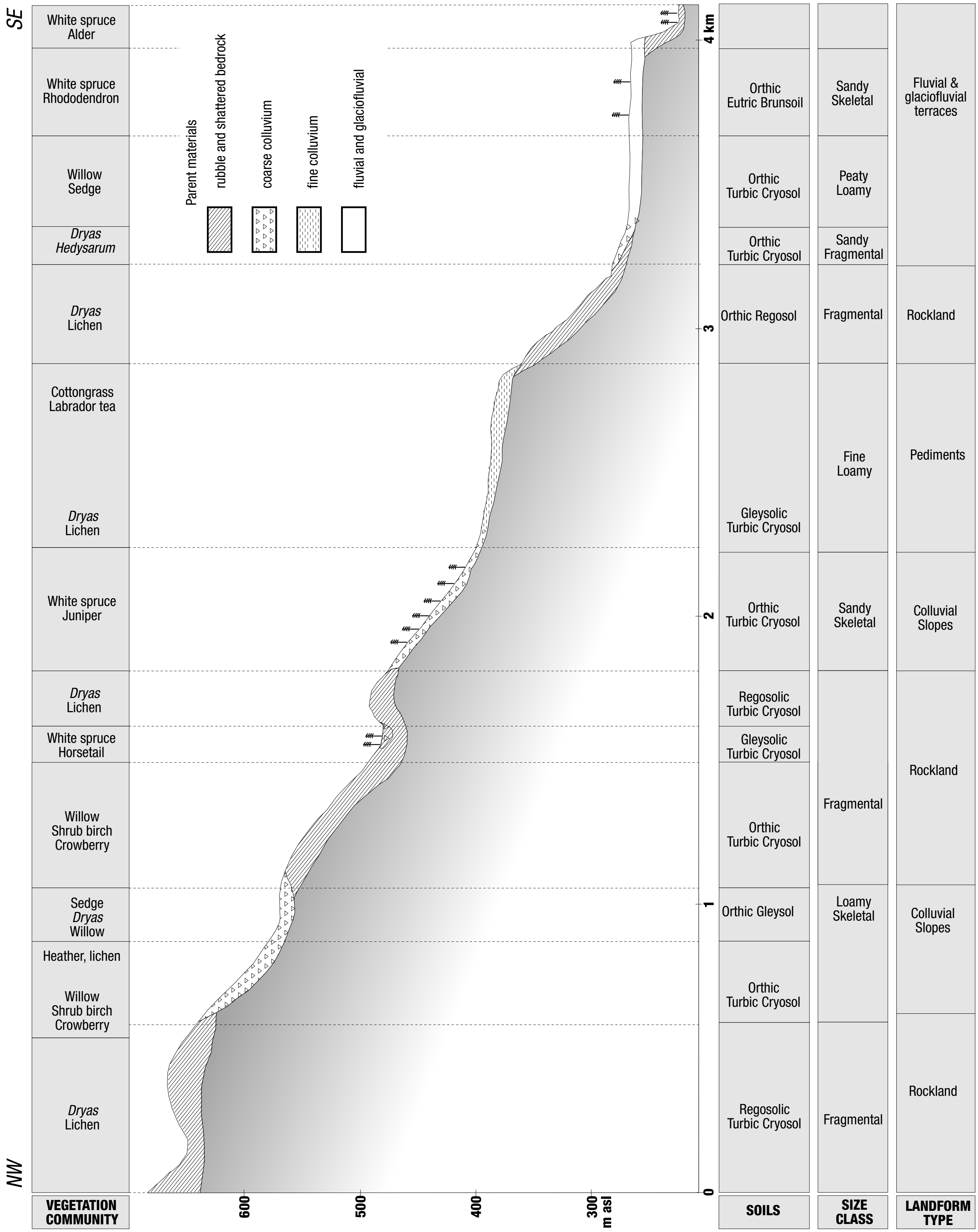


Figure 165-5. Cross-section of soil and vegetation relationships in the Firth River valley in the British Mountains portion of the ecoregion.

VEGETATION

The vegetation of the British–Richardson Mountains Ecoregion is dominated by shrub tundra. Treeline ranges from around 600 m asl in the south to 300 m asl in the north (Zoltai and Pettapiece, 1973; Ritchie, 1984; Loewen and Staniforth, 1997b). Ridge crests support dwarf willow or dryas–lichen tundra, often with sparse vegetation cover. Upper and middle slopes are covered by dry to moist, low shrub and heath tundra, while on lower slopes sedge tussock communities predominate. Shrub thickets are typical along creeks and drainage channels. Trees are limited to river valleys such as the Firth, Big Fish, Bell, and lower slopes with favourable aspects (Fig. 165-1).

On mountain and ridge crests, ranging from 330 to 1,600 m asl, the vegetation is dependent on the parent material. Because most of the area was not glaciated, the soil and vegetation communities reflect the underlying bedrock. Shrub willow (*Salix phlebophylla)* is the dominant cover on shale and sandstone. A sparse cover of *S. phlebophylla*, arctic bearberry, dryas, locoweed, and shrub birch often occurs on only 10 to 20% of the ground surface (Ritchie, 1984; Loewen and Staniforth, 1997b). On calcareous parent material (more extensive to the west in the British Mountains), a floristically rich, although very sparse, dryas–sedge alpine community with numerous forbs, including moss campion, northern sweet-vetch and anemone, and ground shrubs is more typical (Ritchie, 1984).

Slopes contain a mix of shrub and heath tundra. On moister snow accumulation sites and solifluction slopes, willow and ericaceous shrubs including mountain heather, blueberry, lingonberry, mosses and forbs are common. Slopes are often unstable in permafrost areas and many are characterized by scattered flows or slides. These create numerous microsites and intricate complexes of dry to moist vegetation communities. The scarps usually have dry, low shrubs, while the depressions below are wet, colonized first by moss, and then quite rapidly by shrubs. Earth hummocks also create diverse microsites. In the numerous drainages that transect the slopes, tall to medium willow grows with some shrub birch and alder, commonly with an understory of stepmoss, horsetail, forbs and grass (Kennedy, 1990).

On the gentle pediment surfaces of lower slopes, sedge tussock communities predominate. Cottongrass (*Eriophorum vaginatum)* is the major tussock-forming species associated with sedge (*Carex lugens)*, shrub birch, Labrador tea, blueberry, lingonberry and mosses dominated by *Aulacomnium*, *Tomenthypnum* and *Hylocomium*.

Major river valleys provide lower elevation sheltered environments and deeper active layers, which can support open stands of white spruce on inactive

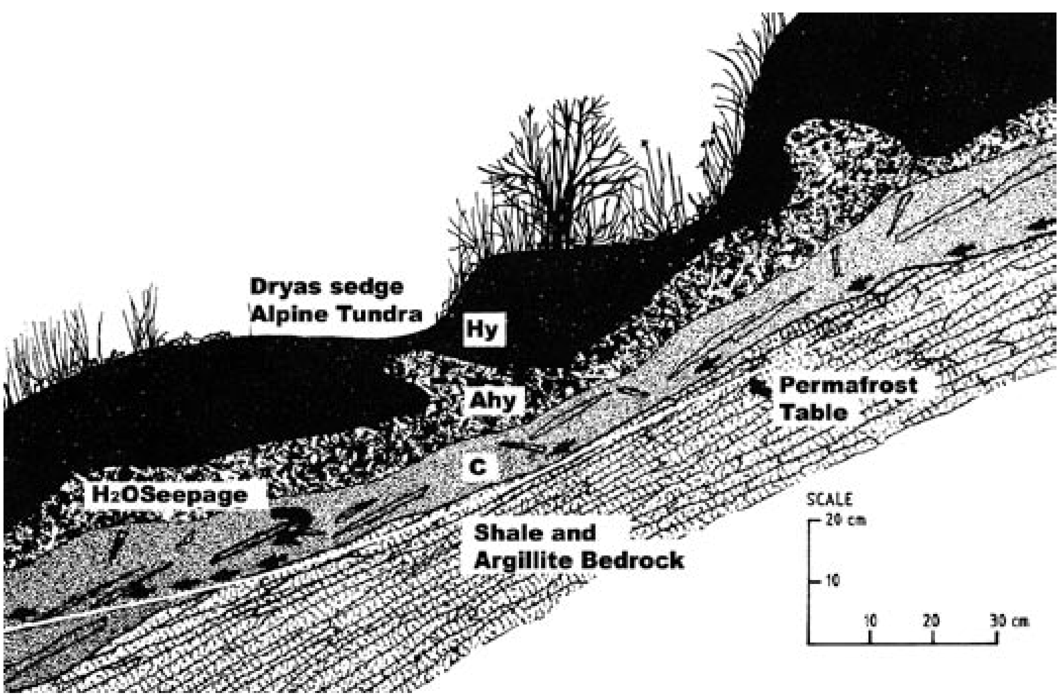


Figure 165-6. Cross-section of typical soil formation on steep slopes, Richardson Mountains. Soils typically have dark-coloured, humus-rich surface horizons (Hy and Ahy). These horizons are mixed with rock fragments as a result of solifluction and cryoturbation. These overlie a mineral horizon (C) of weathered bedrock (from Smith *et al.*, 1990).

river terraces and on well-drained slopes above the streams (Kennedy, 1990). Tamarack is found at treeline in the Richardson Mountains with white spruce on moist calcareous substrate. Balsam poplar is found along recent floodplains and is probably successional to white spruce if left undisturbed. Willow, and sometimes alder, thickets are associated with permafrost-free Regosolic soils on recent floodplains. Horsetails and annual herbs are found on the most frequently flooded sites beside the rivers (Welch and Smith 1990).

WILDLIFE

Mammals

This mountainous region is the primary Canadian calving area of the Porcupine barren-ground caribou herd (Fancy *et al.*, 1994). Caribou use the mountain ridges to maximize wind exposure and gain relief from biting insects in summer. The ecoregion is also used for spring and fall migrations and winter range by the herd. Dall sheep reach their northern limit of distribution in the British Mountains near the Alaska border and in the Richardson Mountains near the Northwest Territories border (Barichello *et al.*, 1989a). Most moose are seasonal residents of riparian habitats, migrating below treeline on the south slope of the mountains in winter (Smits, 1991).

Grizzly bears reach their highest density north of the Mackenzie Mountains here. Wolverines are abundant and heavily dependent on caribou, which they opportunistically cache for future use. River otters are present along fish-bearing streams. Singing Vole colonies and Varying Lemming are common. A list of mammal species known or expected to occur in this ecoregion is given in Table 4.

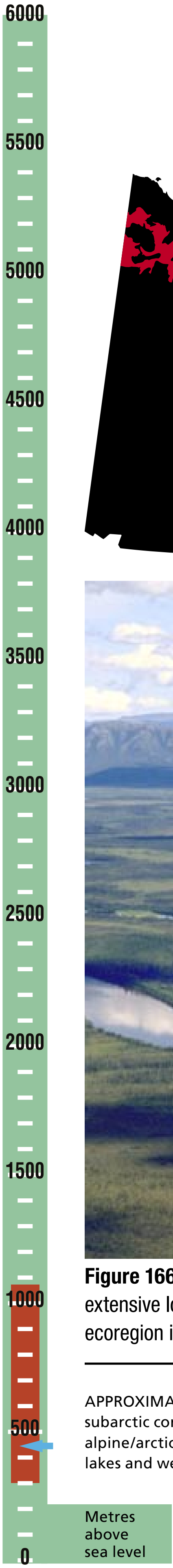
Birds

The Surfbird is a significant breeder in these rocky slopes and ridges, as its Canadian distribution is limited to these mountains and the Ogilvie Mountains (Frisch, 1987). The mostly barren uplands are utilized in summer by nesting Baird's Sandpipers, Hoary Redpolls, Horned Larks, Northern Wheatears and Gray-crowned Rosy Finch (Frisch, 1975, 1987; Godfrey, 1986).

Sedge tussock tundra provides habitat for many species such as Rock Ptarmigan, American Golden-Plover, Whimbrel, Long-tailed Jaeger and American Pipit (Frisch, 1975, 1987; Weerstra, 1997). Shrubby tundra at these and lower elevations is inhabited by Willow Ptarmigan, Northern Shrike, American Tree, Savannah and White-crowned Sparrows, Smith's Longspur and Common Redpoll (Godfrey, 1986; Frisch, 1987; Weerstra, 1997). Upland Sandpipers breed in sparsely treed, subalpine bogs (Frisch, 1987).

Scattered forests provide breeding habitat for Gray Jay, Townsend's Solitaire, Gray-cheeked Thrush, American Robin, Yellow-rumped Warbler and Fox Sparrow (Frisch, 1987; Weerstra, 1997). The rare Gray-headed Chickadee is occasionally found in this sparsely treed habitat, while the omnipresent Common Raven occurs throughout (Frisch, 1987; Sinclair *et al.* [editors], 2003).

Cliffs, banks, and canyon walls of the Firth River provide breeding sites for Rough-legged Hawk, Golden Eagle, Peregrine Falcon, Gyrfalcon and Say's Phoebe (Theberge *et al.* [editors], 1979; CWS, Birds of the Yukon Database). Harlequin Ducks occur in summer on swift flowing streams and smaller rivers (Frisch, 1987). Wandering Tattlers nest along gravel bars of mountain streams (Godfrey, 1986). Dense willow and alder along many of these watercourses provide habitat for breeding Yellow and Wilson's Warblers (Frisch, 1987). Tundra ponds provide breeding habitat for Red-throated Loon, Tundra Swan, Northern Pintail, Long-tailed Duck and Red-necked Phalarope (Frisch, 1987). Ferns and shallow water ponds provide breeding habitat for Northern Harrier, Least Sandpiper and Common Snipe (Frisch, 1987).



Old Crow Basin

Taiga Cordillera Ecozone

ECOREGION 166

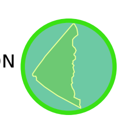
DISTINGUISHING CHARACTERISTICS: This ecoregion is a large physiographic basin with pediment and upland topography surrounding the Old Crow Flats Ecoregion. The ecoregion was left unglaciated during the Pleistocene, but much of the lower elevations were submerged under Glacial Lake Old Crow. The glacial lake formed when Laurentide ice blocked the former drainage outlet of the ecoregion, which was eastward to the Mackenzie Delta. This ultimately changed the direction of flow of the Porcupine River westward into Alaska and on to the Bering Sea via the Yukon River. The ecoregion contains spring and fall migration routes of the Porcupine caribou herd.

J. Meikle, Yukon Government

Figure 166-1. Confluence of the Bell and Eagle rivers. View eastward into the foothills of the Richardson Mountains, showing the extensive lowlands with thick accumulation of peat. Alluvial sites along the rivers are colonized by willow and white spruce. The ecoregion is underlain by continuous permafrost.

APPROXIMATE LAND COVER
subarctic coniferous forest, 60%
alpine/arctic tundra, 30%
lakes and wetlands, 10%

TOTAL AREA OF ECOREGION IN CANADA
14,590 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
14,590 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
3%

ELEVATIONAL RANGE
300–1,080 m asl
mean elevation 450 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Old Crow Basin** (excluding Old Crow Flats) and **Berry Creek Ecoregions** (Oswald and Senyk, 1977) • Equivalent to **Old Crow Basin Ecoregion** excluding Old Crow Flats (Wiken et al., 1981) • Portion of **Alaskan Boreal Interior Region** (CEC, 1997) • Portion of the **Interior Alaska/Yukon Lowland Ecoregion** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Old Crow Basin Ecoregion incorporates the Old Crow Pediplain, Old Crow Range and Bell River section of the Eagle Lowland physiographic units of Matthews (1986). The ecoregion is part of the Porcupine Plain and Plateau (Bostock, 1948). It includes the Old Crow Mountains, part of the Porcupine Plain, and the higher parts of the Old Crow, Bell and Bluefish basins (Hughes, 1987b).

The terrain is a uniform, gently sloped surface extending from the mountains down to the Old Crow Flats and the Porcupine River and its tributaries (Fig. 166-1). It is surrounded by the Keele Range and Dave Lord Range to the south, the Richardsons to the east and the British Mountains to the north.

Most of the ecoregion lies between 300 and 600 m asl. Only the Old Crow Range and a few other hills in the north rise higher. The highest point is in the Old Crow Range, just over 1,000 m asl.

BEDROCK GEOLOGY

Thick Tertiary and Quaternary lacustrine and fluvial sediments up to 1,200 m thick underlie all of the Old Crow Basin except a single exposure of Carboniferous shale near the mouth of Timber Creek (Morrell and Dietrich, 1993). The surrounding elevated areas are structural uplifts or resistant granite; some rivers have incised to bedrock. Large areas of outcrop are shown on regional geological maps by Norris (1981b,c,d) and the general distribution of rocks beneath the covering sediments by Wheeler and McFeely (1991).

Beneath the Old Crow Basin and the northern Old Crow Flats are a succession of transgressive passive margin deposits of the Endicott Group and stable shelf carbonate of the Lisburne Group (Norris [editors], 1997). Undated granite intrudes the Yukon–Alaska border northwest of the Old Crow Basin as Mount Ammerman. South of the Old Crow Basin and north of the Porcupine River are unnamed varicoloured clastic and carbonate rocks. These areas are cored by granitic intrusions of Middle Devonian age. The southeast lobe of the Old Crow Flats Ecoregion extends across the Aklavik Arch, where the rock succession contains unconformities between Carboniferous, Permian, Jurassic and Cretaceous rocks, indicating numerous periods of uplift. It includes part of the Bell Basin, beneath which is the structural intersection of northeast- and east-trending folds and thrusts with the north-trending Richardson Mountains (Lane, 1996). Here, river canyons expose dark clastic sedimentary rocks of the Permian Jungle Creek and Takhandit formations, the Jurassic-to-Cretaceous Parsons Group and the upper Cretaceous Eagle Plains Group.

Few mineral occurrences are known here. In the Old Crow Range, lead and zinc of Sunaghun showing (Yukon MINFILE, 2001) and tungsten of the Scheelite occurrence are found in the granitic rocks. Uranium, lead and zinc are found in the Dave Lord stock (Carswell occurrence). Copper and uranium in Carboniferous rocks were investigated near the Driftwood River. Hydrocarbon potential has been tested near Whitefish Lake in the Bell Basin (Lane, 1996) and shale-like lignite is exposed nine kilometres east of Old Crow village.

The caves on the Blue Fish River, which are of much archeological importance (Cinq-Mars, 1990), are part of a widespread paleokarst developed in the Devonian Ogilvie Formation.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

This ecoregion is formed mainly of gently sloping pediment surfaces that surround the Old Crow Flats. Colluvium covers approximately four-fifths of the ecoregion (Fig. 166-2). It derives from millions of years of weathering throughout the Late Tertiary and Quaternary in the surrounding mountains. Plateau and low relief uplands are characterized by broad valleys and at least two levels of pediments.

Surficial deposits are weathered rock or fine-textured colluvium up to a few metres thick on slopes (Hughes, 1969b). This colluvium tends to be silty and clayey on pediment surfaces. On steep slopes it is gravelly to blocky overlying carbonate bedrock, platy when overlying argillite, and blocky overlying limestone and quartzite. The pediment width ranges from 5 to 10 km along the northern side of the ecoregion, where they border calcareous rocks. Pediments are developed on shale, siltstone and sandstone in the east of the ecoregion, on granite in the west, and on carbonates in the north and southwest. The depressions and seepage lines are often covered by thicker organic material. Where there is no well-defined drainage channel, a feathered drainage pattern is enhanced

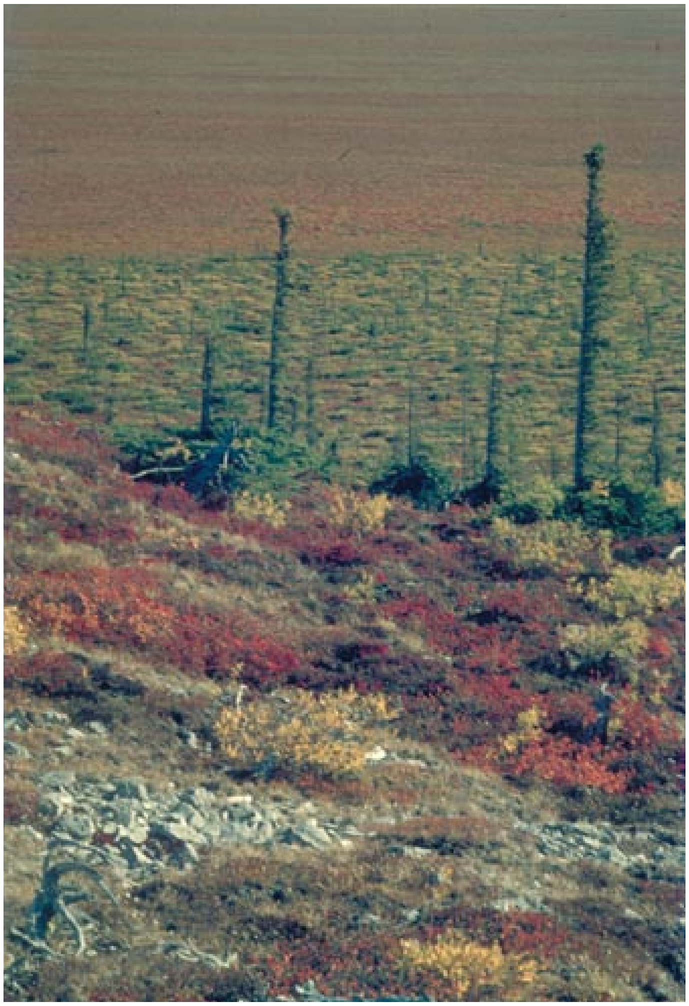

M. Hoefs

Figure 166-2. Between the Old Crow Flats and the British Mountains is the Old Crow Pediplain, which includes some of the limited outcropping in the ecoregion. This area is characterized by extensive gently sloping pediment surfaces, formed by millions of years of weathering.

by vegetation growth. Well-defined meandering channels are less common (Wiken *et al.*, 1981).

Glaciolacustrine deposits and alluvial deposits cover the remainder of the ecoregion (Hughes *et al.*, 1973).

GLACIAL HISTORY

This ecoregion is located within the unglaciated terrain of the northern Yukon. However, the eastern part of this ecoregion in the lower Bell River area contains glaciolacustrine sediments over 30 m thick. These sediments record the eastern part of Glacial Lake Old Crow, which formed when the Late Wisconsinan Laurentide Ice Sheet blocked drainage of the Porcupine and Rock rivers to the east and the Peel River to the south. This diverted the Mackenzie region drainage across the continental divide about 30,000 years ago (Lemmen *et al.*, 1994; Duk-Rodkin and Hughes, 1995; see Old Crow Flats Ecoregion). In the Bell Basin, faint shoreline traces indicate that the glacial lake was more extensive than the lacustrine sediment distribution in the basin.

These sediments reveal a complex history related to the drainage dynamics in the paleo-Porcupine River Valley, now occupied by the upper Bell River and its continuation on the eastern side of the Richardson Mountains as the Rat River (Duk-Rodkin and Hughes, 1994). The ice sheet blocked eastward drainage of the paleo-Porcupine River, forming temporary glacial lakes (Fig. 166-3). Catastrophic flooding is recorded in both Rock and Rat rivers (Catto, 1986; Schweger and Matthews, 1991). At McDougall Pass, the paleo-Porcupine River thalweg is buried under 150 m of Laurentide glacial drift. The sediments in Bell Basin record inundation of the basin by a glacial lake, deposition of several glaciolacustrine units, drainage of the lake, and subsequent development of terraces and modern floodplains that inset the glaciolacustrine sediments (Hughes *et al.*, 1973).

CLIMATE

Although the climates of the Old Crow Basin and Old Crow Flats ecoregions are very similar, some areas of higher elevation in the Old Crow Basin may have slightly higher precipitation, and temperatures may be slightly more moderate.

At this latitude north of the Arctic Circle, the sun is continuously above the horizon for approximately two weeks in the summer. During the winter, the area is dominated by an arctic high-pressure system. Infrequently, a strong low-pressure system moving over the Beaufort Sea can result in brief, windy, mild spells. During the short summer, the area is under a weak low-pressure system with relatively mild and moist air. Spring and summer are delayed by almost a month compared to the southern Yukon.

Mean annual temperatures are among the lowest in the Yukon, approximately –8 to –10°C with a strong seasonal variation. The average January temperature is –30 to –35°C; the average July temperature ranges from 12 to 15°C. Extreme winter minimums are –55 to –60°C, but above freezing temperatures have briefly occurred. Extreme

Figure 166-3. In response to being diverted by Laurentide Ice from its course through McDougall Pass and into the Mackenzie River, the Porcupine River flows westward into the Yukon River. It is pictured here at the Ramparts where downcutting continues.

summer maximums are 33 to 35°C, but frosts can occur at any time of the year. Winters are prolonged and generally extend from October to mid-May. The North Ogilvie Mountains to the south are enough of a barrier to retard southerly winds eroding the cold air from the lower elevations. The transition from winter to summer conditions is rapid. The prolonged low angle of the sun above the horizon during winter reduces the daily cycle of temperatures during this period.

Precipitation is relatively light, amounting only to 200 to 300 mm annually. The wettest period is June through August with monthly amounts of 30 to 45 mm. This summer precipitation falls as rain, primarily showers or thunderstorms. There have been some summer months with precipitation amounts of 100 to 150 mm. The driest period is January to April, averaging 10 to 15 mm of snow monthly.

Wind data are limited, although some data are available from the village of Old Crow. Winds are generally light at less than 15 km/hr, particularly during the winter months. Periods of moderate winds, 15 to 30 km/hr, occur less than a quarter of the time, coming primarily from the northeast and less frequently from the southwest. Winds greater than 40 km/hr are common.

Representative climate information is available from Old Crow.

HYDROLOGY

The Old Crow Basin Ecoregion is situated within the Northern Hydrologic Region. The ecoregion is narrow and irregular in shape, completely enveloping the Old Crow Flats Ecoregion. Flanked by the North Ogilvie Mountains to the south, the Richardson Mountains in the east, and the British Mountains in the north, the ecoregion drains the Old Crow Flats Ecoregion and surrounding slopes. The Porcupine River flows into Alaska where it is joined by the Coleen River, a major tributary. Flow within the ecoregion is divided by headwater tributary flows to the Old Crow River while lower reach tributaries flow directly into the Porcupine River (Fig. 166-3). The lower reaches of the north-flowing Eagle River and the southwest-flowing Bell River are the largest tributary streams of the Porcupine River. Intermediate streams include the Rock and Bluefish rivers and Lord Creek. South-flowing streams from the British–Richardson Mountains Ecoregion include the Driftwood River and Johnson, Timber and Thomas creeks. There are no lakes on the pediment surfaces surrounding the Old Crow Flats Ecoregion, however, numerous smaller, lowland and oxbow lakes are associated with the Porcupine, Bell and Eagle rivers, as well as some upland, headwater lakes. The largest waterbody is Whitefish Lake, in the southern portion of the ecoregion. The most significant wetland is the Whitefish complex, an area more similar to the Old Crow Flats than to the rest of the ecoregion.

There are no representative hydrometric stations records for the ecoregion; therefore, a regional analysis was carried out to estimate the characteristic streamflow characteristics. The ecoregion is sufficiently similar in physiography, vegetation, surficial geology and climate, to the adjacent Eagle Plains Ecoregion that streamflow characteristics may be transferred directly. The exception lies with winter low-flow characteristics, which are estimated to be approximately 50% of those in the Eagle Plains Ecoregion due to the increasing importance of permafrost with increasing latitude. Because of the very similar topography, it is estimated that annual and seasonal runoff characteristics and peak flows will be similar. As with the Eagle Plain Ecoregion, runoff is moderately low because of the relatively low relief. Within most ecosystem streams, annual streamflow is estimated to have an increase in discharge in April due to snowmelt, then rise to a peak in May. Summer rain events can produce secondary peaks, and sometimes the annual peak runoff. This is thought to be especially true of smaller streams, which more frequently experience peak rainfall events. Mean annual runoff is estimated to be moderately low with a value of 200 mm, while mean seasonal and summer flows are likewise estimated to be moderately low with values of 12 X 10^{-3} and 10 X 10^{-3} $m^3/s/km^2$ respectively. The mean annual flood and mean maximum summer flow are estimated to be moderately high and low with values of 93 X 10^{-3} and 31 X 10^{-3} $m^3/s/km^2$, respectively. The minimum annual and summer flows are estimated to be relatively low, with values of 0.34 X 10^{-3} and 2 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March or earlier with the relative magnitude among the lowest of all Yukon ecoregions, due to the increasing role of winter temperatures and permafrost on streamflow. Most small and intermediate streams frequently experiences zero winter stream flow.

PERMAFROST

The Old Crow Basin Ecoregion lies in the continuous permafrost zone. Lower elevations in the Old Crow Basin were covered by a glacial lake during the late Wisconsinan period. Permafrost was likely eradicated from beneath the lake at that time. The base of permafrost was encountered at 63 m depth in two holes drilled to provide a water supply for the community of Old Crow (EBA, 1982a); all holes drilled for construction in the community have encountered frozen ground within two metres of the surface. Annual mean near-surface ground temperatures are about –4°C (Stanley Associates, 1979). The active layer depth in the peatlands of the basin is usually greater than 40 cm and occasionally greater than 60 cm (Ovenden and Brassard, 1989).

Shallow lakes within the ecoregion are warm in summer and sufficiently deep to prevent freezing of lake-bottom sediments in winter. As a result, a talik persists beneath the lakes, many of which are sufficiently wide for the talik to penetrate though permafrost, theoretically. The lakes are oddly rectangular and oriented northeast–southwest or northwest–southeast. Their surface expression is likely unassociated with permafrost conditions, but may be a product of wind-generated currents (Mackay, 1956).

The low-lying terrain and pediment surfaces have a hummocky microtopography typical of moist taiga regions and near-surface permafrost is usually ice-rich. Ice-wedge polygons occur throughout the region, but they have not developed into the extensive networks characteristic of the Yukon Coastal Plain Ecoregion. There are well-developed, active ice wedges along the Porcupine River, growing syngenetically with floodplain deposits (Lauriol *et al.*, 1995).

Sedimentary sequences exposed in bluffs cut by the Porcupine River have been used to trace environmental conditions back to the late Tertiary (Pearce *et al.*, 1982). Ice-wedge casts in the sediments provide early evidence of permafrost in the Yukon (Burn, 1994).

SOILS

Soils in this ecoregion have formed under the influences of a strongly continental subarctic climate and unglaciated, broad, gently sloping basin topography. There have been few regional studies of the soils of the Old Crow Basin other than the ecological survey of Wiken *et al.* (1981) and a number of site-specific investigations associated with Quaternary research in the ecoregion (Morison and Smith, 1987).

Most of the landscape is composed of unglaciated pediment surfaces emanating from the surrounding ranges of the Richardson, Keele, Old Crow, Barn and British mountains. These colluvial surfaces are mantled with 1 to 2 m of fine-textured deposits supporting open black spruce forest or shrubby, tussock tundra vegetation. These soils are all characterized by shallow (<1 m) active layers and intensive frost churning and are classified as Gleysolic Turbic Cryosols, if they remain saturated through most of the growing season, or as Orthic Turbic Cryosol, if imperfectly drained. Upland areas support more forest growth and soils tend to be better drained. Paleosols composed of residual weathering products occur where older bedrock surfaces have escaped erosion (Tarnocai, 1987c). While most of the ecoregion is underlain by continuous permafrost, some permafrost-free soils, usually Eutric Brunisols, are found on well-drained, south-facing slopes in the uplands.

There are extensive wetlands near the Eagle and Bell river systems (Fig. 166-1). Here, peat accumulations may be over 2 m thick under fen and polygonal peat plateau vegetation. These wetland soils are classified as Fibric or Mesic Organic Cryosols (i.e. perennially frozen, semi-decomposed sedge and moss peat). Where the peat is less than 40 cm thick adjacent to the wetlands proper, the soils are classed as Gleysolic Turbic Cryosols.

VEGETATION

Open spruce–lichen–heath vegetation communities dominate the pediments of the Old Crow Basin. Pediment surfaces with slopes less than 5% are typically dominated by sedge and cottongrass tussocks. A sparse shrub layer of willow, shrub birch and ericaceous shrubs, and rarely black spruce, accompany the tussocks with sphagnum or other mosses between the tussocks. The stunted trees average about 4 m in height. Treeline is reached at 600 m asl (Zoltai and Pettapiece, 1973). Higher elevations of the Old Crow Range and other mountains rimming the ecoregion support scrub heath tundra (Hettinger *et al.*, 1973).

On imperfectly drained soils, open black and white spruce–lichen–heath communities are associated with earth hummocks and Orthic Turbic Cryosol soils. The understory vegetation is mainly shrub birch, ericaceous shrubs, mosses, and lichens dominated by *Cetraria*, *Cladina* and *Cladonia*. Paper birch and alder may be found on steep, east-facing slopes. Many seral stages are represented due to fire disturbance.

Lowland sites of the Bell and Whitefish basin areas are similar to those of the Old Crow Flats Ecoregion. Black spruce–lichen–heath communities dominate the frozen organic soils of the peat plateaus. Floating mats of sedges and mosses are also common. A succession of vegetation communities occurs on riparian sites (Fig. 166-4). Flood-tolerant species such as willow and alder colonize the floodplain, being taken over by white spruce and paper birch on more stable sites (Loewen and Staniforth, 1997a).

The scrub heath tundra, found on colluvial and residual slopes at higher elevations, consists of dwarf and low shrub birch and willows underlain by moss and lichen. On exposed ridges and slopes, the vegetation highlights non-sorted circles, nets and stripes. Where the underlying rocks are more resistant, rocks and boulders cover much of the surface.

C.D. Eckert, Yukon Government

Figure 166-4. Lowest elevations on this ecoregion are underlain by glaciolacustrine sediments from Glacial Lake Old Crow. The Whitefish wetland complex shown here is located in the eastern portion of the former glacial lake basin.

WILDLIFE

Mammals

The Old Crow Basin and Old Crow Flats possess the most abundant wildlife populations of the Taiga Cordillera, with many species reaching densities typical of the Boreal Cordillera of the southern Yukon. However, the diversity of rodents and ungulates is comparatively low. Grizzly bear, moose, wolverine, lynx, and marten are abundant. The Porcupine barren-ground caribou herd migrates through in spring and fall. Muskrat are abundant in the Whitefish Lake Wetlands at the confluence of the Eagle, Bell and Porcupine rivers. There is no information on populations of small rodents. A list of mammal species known or expected to occur in this ecoregion is given in Table 4.

Birds

The Porcupine and Old Crow drainages are significant nesting areas for Peregrine Falcon (Hayes and Mossop, 1978). Extensive fens and bogs associated with meandering rivers in the basin and tundra ponds on the plateaus are used by Northern Harrier, Least Sandpiper, Common Snipe, and Short-eared Owl in summer (CWS, Birds of the Yukon Database). Shrubby areas of willow, birch and alder along these watercourses provide nesting habitat for Yellow Warbler, Northern Waterthrush, and Wilson's Warbler (CWS, Birds of the Yukon Database). The Whitefish Lake complex at the confluence of the Bell, Eagle, and Porcupine rivers is an important wetland area for breeding and moulting geese and ducks (Dennington, 1985). While there is little documented information, it is known that this area supports breeding and moulting Greater White-fronted and Canada Geese, diving ducks, and possibly Tundra Swan (Dennington, 1985; Hawkings, 1994). Wetlands support waterbirds such as Red-throated and Pacific Loons, Horned and Red-necked Grebes, American Widgeon, Mallard, Northern Pintail, Green-winged Teal, scaup, goldeneye, Red-necked Phalarope, and Mew Gull (Dennington, 1985; CWS, Birds of the Yukon Database).

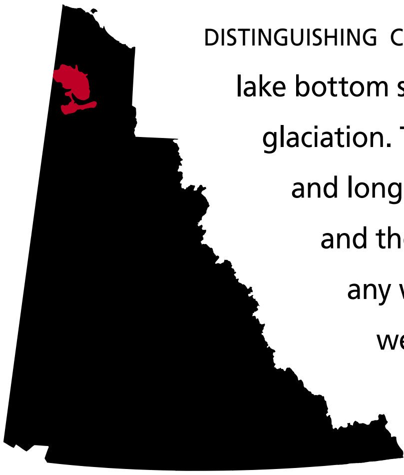
Spruce forests provide breeding habitat for Sharp-shinned Hawk, Red-tailed Hawk, Merlin, Northern Hawk Owl, Great Gray Owl, Gray-cheeked Thrush, and Yellow-rumped and Blackpoll Warblers (CWS, Birds of the Yukon Database). Year-round residents include Gray Jay, Common Raven, and Spruce Grouse at their northern limit (Rand, 1946; CWS, Birds of the Yukon Database).

Upland areas of tussock tundra support Arctic breeders such as Rough-legged Hawk and Long-tailed Jaeger. As well, American Kestrel, Rock Ptarmigan, American Golden-Plover, Whimbrel, Least Sandpiper, Savannah Sparrow, and Smith's Longspur may also breed in this habitat (CWS, Birds of the Yukon Database). Gyrfalcons breed on rocky ledges in these alpine areas and small numbers of Golden Eagle may also breed here (CWS, Birds of the Yukon Database). Birds such as Willow Ptarmigan, American Robin, American Tree Sparrow, White-crowned Sparrow, and Common Redpoll occur in shrubby tundra areas associated with subalpine forests (CWS, Birds of the Yukon Database). Scattered barren ridges and rocky slopes likely host small numbers of breeding Baird's Sandpiper, Horned Lark, and Gray-crowned Rosy Finch (Godfrey, 1986).

Old Crow Flats

Taiga Cordillera Ecozone

ECOREGION 167



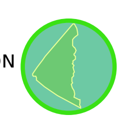
DISTINGUISHING CHARACTERISTICS: The extent of this eroregion is defined by the area of lake bottom sediments deposited by a glacial lake that formed at the end of the last glaciation. The climate of the ecoregion is strongly continental with warm summers and long, cold winters. The difference between the mean July temperature and the mean January temperature at Old Crow village is the greatest of any weather station in the Yukon. The ecoregion is composed of lakes and wetlands occupying a large topographic basin that forms an extremely important wildlife habitat. The ecoregion supports the most abundant waterfowl population within the Taiga Cordillera Ecozone in Canada.

J. Hawkings, Canadian Wildlife Service

Figure 167-1. The level landscape of the Old Crow Flats Ecoregion is covered by small lakes, wetlands and meandering streams. The outline of lakes changes over time through a cycle of erosion and permafrost decay, potential lake drainage, revegetation and re-establishment of permafrost.

APPROXIMATE LAND COVER
subarctic coniferous forest, 55%
lakes and wetlands, 35%
tussock tundra, 10%

TOTAL AREA OF ECOREGION IN CANADA
5,970 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
5,970 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
1%

ELEVATIONAL RANGE
325–610 m asl
mean elevation 327 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to Old Crow Flats portion of **Old Crow Basin Ecoregion** (Oswald and Senyk, 1977) • Equivalent to Old Crow Flats portion of **Old Crow Basin Ecoregion** (Wiken et al., 1981) • Portion of **Alaskan Boreal Interior Region** (CEC, 1997) • Portion of the **Interior Alaska/Yukon Lowland Ecoregion** (Ricketts et al., 1999) • Portion of **Yukon Old Crow Basin** (Nowacki *et al.*, 2001)

PHYSIOGRAPHY

The Old Crow Flats Ecoregion includes two parts joined along the Old Crow River: the Old Crow Flats or Basin, and the lowlands along the Porcupine River, from the mouth of the Driftwood River to the Bluefish River. This second part is a portion of the Old Crow Pediplain (Matthews, 1986), the Bluefish Basin (Hughes, 1987b), or the Porcupine Plain (Bostock, 1948).

This is a lowland area in which most of the elevation is less than 600 m asl. The basins, the result of downwarping or downfaulting, are sites of deposition. Local relief is about a few metres. Lakes are numerous, covering about 35% of the land surface. Many lakes are rectangular (Fig. 167-2) and oriented northwest–southeast, perpendicular to the prevailing wind.

The Old Crow River and its tributaries flow southward through the Old Crow Flats to the Porcupine River, which heads west into Alaska.

BEDROCK GEOLOGY

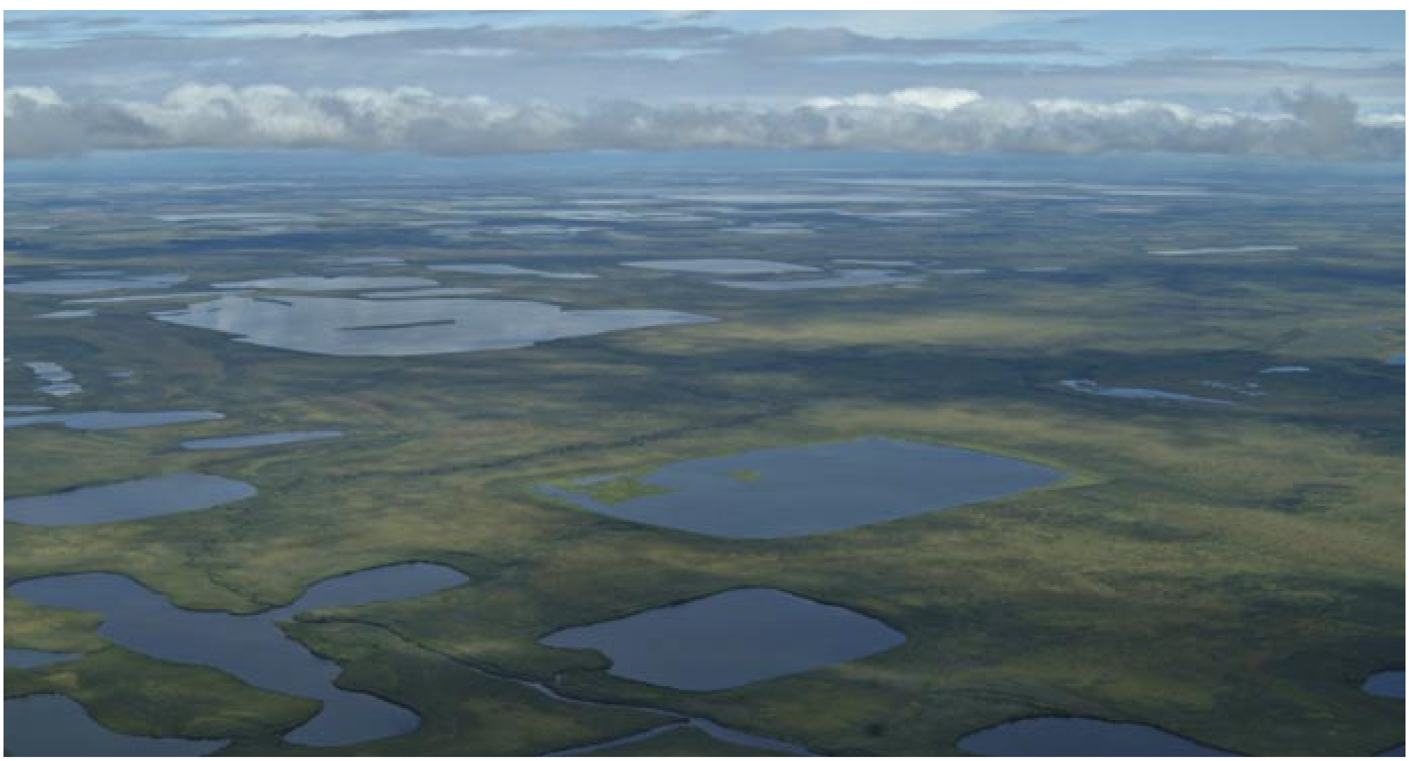
Thick Tertiary and Quaternary glaciolacustrine and fluvial sediments up to 1,200 m thick underlie all of the Old Crow Flats Ecoregion except a single exposure of Carboniferous shale near the mouth of Timber Creek (Morrell and Dietrich, 1993). The surrounding Flats contain several elevated areas that are structural uplifts or resistant granite; some rivers have incised to bedrock. Large areas of outcrops are shown on regional geological maps (Norris, 1981b,c).

Few mineral occurrences are present. The potential for oil and gas has been tested near Whitefish Lake in the Bell Basin (Lane, 1996) and shale-like lignite is exposed nine kilometres east of Old Crow Village.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

Most of the surface deposits in this ecoregion are composed of nearly flat, thick glaciolacustrine sediments overlain by frozen peats, often several metres thick. The entire area appears as a maze of small, shallow angular lakes, ponds and wetlands crossed by the Old Crow River and Johnson Creek with their broad meanders and oxbow lakes.

Ice-wedge polygons and oriented rectangular thermokarst lakes, as well as active layer detachment slides, retrogressive thaw flow slides, debris flows and rotational slumping, are all



J. Meikle, Yukon Government

Figure 167-2. Rectangular lake in the Old Crow Flats. Rectangular lakes are typically oriented with the prevailing wind. Vegetation debris blown across the surface tends to accumulate uniformly at the ends of long reaches.

indicative of ice-rich permafrost present in the fine-grained sediments.

The remainder of the area is covered by alluvium deposited by the Old Crow River or one of its tributaries. The alluvium tends to lack near-surface permafrost.

GLACIAL HISTORY

This ecoregion is located on flat terrain comprising the Old Crow and Bluefish Basin physiographic units. These basins were part of an extensive proglacial lake during the Late Wisconsinan; Glacial Lake Old Crow formed when the Laurentide Ice Sheet stood along the eastern slopes of the Richardson Mountains and Bonnet Plume Depression, blocking drainage of the Porcupine and Peel rivers. It thereby diverted all drainage from the Mackenzie Mountains region across the continental divide, causing inundation of the Bell–Bluefish–Old Crow Basins about 30 ka ago (Lemmen *et al.*, 1994; Duk-Rodkin and Hughes, 1995). This vast lake discharged westward through the present-day Ramparts of the Porcupine River. By the time McDougall Pass was free of ice, the outlet at The Ramparts had incised below the elevation of the pass, and the present westward drainage for the Porcupine River was established. Glacial Lake Old Crow shorelines are traceable discontinuously around the basins, reaching 366 m asl (Hughes *et al.*, 1973; Matthews *et al.*, 1987). Repeated catastrophic flooding related to fluctuations of the Laurentide Ice Sheet are recorded in the Porcupine River sediments west of The Ramparts into Alaska (Thorson, 1989), as well as in McDougall Pass (Catto, 1986) and Rock River (Schweger and Matthews, 1991). Over 70 m of unconsolidated sediments lie below the village of Old Crow, recording lacustrine, glaciolacustrine, delta, and fluvial sedimentation (Hughes, 1969b; Matthews *et al.*, 1987). The lacustrine sediments likely are related to tectonic activity on the Old Crow Basin and late Tertiary uplift of the Richardson Mountains which affected the Porcupine River in pre-glacial time (Duk-Rodkin and Hughes, 1994).

CLIMATE

The climate of the Old Crow Flats Ecoregion is very similar to that of the Old Crow Basin Ecoregion. However, some areas with higher elevation in the Old Crow Basin may have slightly higher precipitation, and temperatures may be slightly more moderate. When relatively calm and very cold air masses persist, the Old Crow Flats may experience colder temperatures than the surrounding upland areas.

During the winter, the area is dominated by an Arctic high-pressure system. Infrequently, a strong low-pressure system moving through the Beaufort Sea can result in short, windy, mild spells. During the short summer, the area is under a weak low-pressure system with relatively mild moist air. Spring and summer are delayed by almost a month compared with the southern Yukon.

Mean annual temperatures are among the lowest in the Yukon, approximately –8 to –10°C with a strong seasonal variation. Mean January temperatures are –30 to –35°C; the mean July temperature ranges from 12 to 15°C. Extreme winter minimums are –55 to –60°C, but above freezing temperatures have briefly occurred. Extreme summer maximums are 33 to 35°C, but frosts can occur at any time of the year. Winters are prolonged, and generally extend from October to mid-May. The North Ogilvie Mountains to the south are enough of a barrier to retard southerly winds eroding the cold air from the lower elevations. The transition from winter to summer conditions is rapid. The prolonged low angle of the sun above the horizon during winter also reduces the daily cycle of temperatures during those periods.

Precipitation is relatively light, amounting only to 200 to 300 mm annually. The wettest period is June through August, with monthly amounts of 30 to 45 mm. This summer precipitation is in the form of rain, primarily showers or thunderstorms. There have been some summer months with precipitation amounts of 100 to 150 mm. The driest period is January to April, averaging 10 to 15 mm of snow monthly.

Wind data are limited, although some data are available from the Old Crow village site. Winds are generally light at less than 15 km/hr, particularly during the winter. Periods of moderate winds of 15 to 30 km/hr occur less than one quarter of the time, primarily from the northeast, and less frequently from the southwest. Winds greater than 40 km/hr are common.

Representative climate information is available from Old Crow.

HYDROLOGY

The Old Crow Flats Ecoregion is level, encompassing the middle and lower reaches of the Old Crow River basin, an area known as the Old Crow Flats. The Old Crow River flows southward into the Porcupine River, of which a 120 km long, low-lying reach is included within the ecosystem. In addition to the Porcupine and Old Crow rivers, intermediate streams include the very lowest reaches of the Bluefish and Driftwood rivers, north- and south-flowing, respectively. Smaller streams include Johnson and Schaeffer creeks, and the lower reaches of Timber, Thomas, and Black Fox creeks. The coverage by waterbodies and wetlands is the highest of all Yukon ecoregions, estimated at about one third of the total area. The ecoregion contains hundreds of interconnected lakes, including many that are large and unnamed.

There is only one representative historical hydrometric station record for the ecoregion: Old Crow River. Though it is a relatively large watershed, the nature and consistency of the ecoregion's topography allows for the transfer of its hydrologic characteristics throughout the ecosystem. The hydrologic characteristics are completely dominated by the waterbody and wetland storage features of the ecosystem, such that these characteristics can be scaled down to smaller basins with little loss in accuracy. Because of the extremely low relief, runoff and peak flow events are likewise low. Annual streamflow is estimated to have an increase in discharge in April due to snowmelt, rising to a peak in May or June. Because of the significant storage throughout the ecosystem, summer rain events do not produce significant secondary peaks as in most other ecoregions.

Mean annual runoff, the lowest of all ecoregions, is 98 mm, while mean seasonal and summer flows are likewise relatively low with values of 7.1 X 10^{-3} and 3.5 X 10^{-3} $m^3/s/km^2$ respectively. The mean annual flood and mean maximum summer flow are moderate to low with values of 56 X 10^{-3} and 12 X 10^{-3} $m^3/s/km^2$, respectively. The minimum annual and summer flows are both near the lowest of all ecoregions with values of 0.03 X 10^{-3} and 0.3 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March or earlier with the relative magnitude among the lowest of all Yukon ecoregions, due to the increasing role of winter temperatures and permafrost on streamflow. Unlike other ecoregions at this high latitude, winter flows are higher due to storage contributions. All streams, other than the Porcupine River, occasionally experience zero winter flows.

PERMAFROST

The Old Crow Flats Ecoregion lies in the continuous permafrost zone. Old Crow Flats were covered by Glacial Lake Old Crow during the Late Wisconsinan. Permafrost was likely eradicated from beneath the lake at that time. The base of permafrost was encountered at 63 m depth in two holes drilled to provide a water supply for the community of Old Crow (EBA, 1982a). All holes drilled for construction in the community have encountered frozen ground within 2 m of the surface. Annual mean near-surface ground temperatures are about −4°C (Stanley Associates, 1979), and the active layer depth in the peatlands of the basin is usually more than 40 cm and occasionally greater than 60 cm (Ovenden and Brassard, 1989).

Shallow lakes within the ecoregion are warm in summer, and sufficiently deep to prevent freezing of lake-bottom sediments in winter. As a result, a talik persists beneath the lakes, many of which are sufficiently wide for the talik to penetrate through permafrost, theoretically. The lakes are oddly rectangular and oriented northeast–southwest or northwest–southeast (Fig. 167-2). Their surface expression is likely unassociated with permafrost conditions, but may be a product of wind-generated currents (Mackay, 1956).

The low-lying terrain and pediment surfaces have a hummocky microtopography typical of moist taiga regions and near-surface permafrost is usually ice-rich. Ice-wedge polygons occur throughout the region, but they have not developed into the extensive networks characteristic of the Yukon Coastal Plain Ecoregion. There are well-developed, active ice wedges along the Porcupine River, growing syngenetically with floodplain deposits (Lauriol *et al.*, 1995).

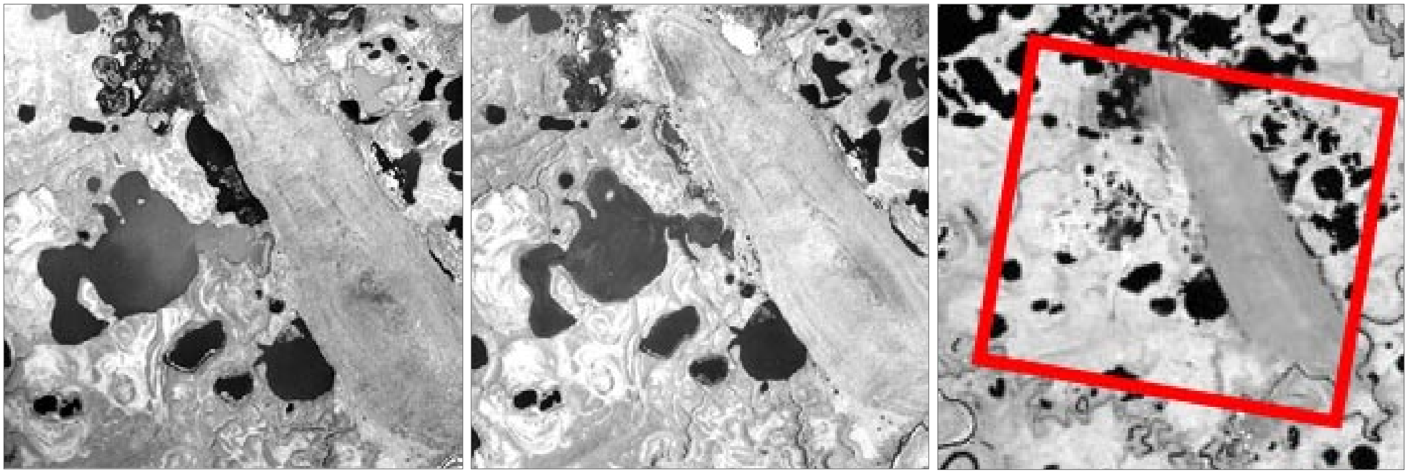
Sedimentary sequences exposed in bluffs cut by the Porcupine River have been used to trace environmental conditions back to the late Tertiary (Pearce *et al.*, 1982). Ice-wedge casts in the sediments provide early evidence of permafrost in the Yukon (Burn, 1994).

SOILS

The soils in this ecoregion have formed within the extensive wetlands of the Old Crow Flats. Soil parent materials found throughout the ecoregion include lacustrine silts and clays, alluvial deposits, accumulated peat and thermokarst sediments, and slumps. The fine-textured soil parent materials of the Old Crow Flats are usually ice-rich and have experienced cryoturbation during their formation. As all of the ecoregion existed as a lake basin during the Late Pleistocene, the soil parent materials are younger here than in the surrounding pediments and mountain ranges. Soils are often high in incorporated organic matter resulting from the formation and cycling of organic debris in earth hummocks that underlie the open, black spruce forest. Wetlands have considerable peat accumulations in some locations. Wetland forms include peat plateau bogs and ribbed fens (Fig. 167-3). These soils are mostly classified as Mesic Organic Cryosols. The only portions of the landscape without near-surface permafrost are the active alluvial landforms associated with the major rivers of the ecoregion, the Old Crow and Porcupine, and recently drained lake basins. These soils are classified as Regosols, or as Regosolic Static Cryosols if permafrost has re-established in these materials.

As with other lowland regions of the Low Arctic and Subarctic, there exists a cycle of lake formation through thermokarst, lake drainage by stream capture, and wetland establishment with peat accumulation leading ultimately to a subsequent round of thermokarst and lake formation (Fig. 167-4). There are distinctive soil and vegetation features associated with each stage within the "thaw-lake" cycle (MacKay, 1997; Eisner and Peterson, 1998). As ground ice is exposed through erosion, tremendous melting occurs, often with considerable disruption to the surrounding landscape. This process of thermokarst can generate fresh surfaces on which soil development begins. Recently disrupted materials will not have evidence of active cryoturbation for some years. These soils

Figure 167-3. The Old Crow Flats Ecoregion is characterized by extensive sedge fens surrounding irregular lakes with emergent vegetation, including horsetail, bur-reed, yellow pond lily and buckbean. Slightly higher elevation peat plateaus support open stands of stunted black spruce in the distance.



1951 1972 1999

Figure 167-4. The highly dynamic nature of shallow thaw lakes adjacent to Timber Hill in the Old Crow Flats Ecoregion is illustrated in this series of aerial photographs (1951, 1972) and a satellite image (1999 Landsat 7 ETM, band 4). Drainage of the lakes is related to change in the drainage pattern controlled by local degradation and aggradation of near-surface permafrost (adapted from Labreque *et al.*, 2001). The red box on the right-hand photo corresponds to the area of the 1951 and 1972 photos.

may be classified as Static Cryosols if permafrost has re-established.

VEGETATION

The vegetation of the Old Crow Flats Ecoregion reflects the distribution pattern of cyclical formation and draining of lakes and wetlands, and intervening sparsely treed uplands. The vegetation ranges from shallow-water emergent wetland types to graminoid meadows, sphagnum blankets, shrub thickets, and sparsely treed heath and tussock tundra. The Porcupine and Old Crow rivers and their tributaries have cut deep channels dissecting the wetland surface.

There is a complex "thaw-lake" cycle of thermokarst lakes forming and growing larger by thermokarst erosion of the banks, and then draining as outlets are eroded. Because of this ongoing cycle, there is a complex pattern of vegetation found at all stages of the process (National Wetlands Working Group, 1988). Much of the Flats are underlain by thick peat. Shallow-water wetlands supports dense communities of bur-reed and yellow pond lily (Fig. 167-3). Shore marshes and fens on the lake margins consist of *Carex aquatilis*, *Arctophila fulva*, horsetail, and buckbean. Moist parts of drained lakebeds support sedges, grasses and water-tolerant forbs (Fig. 167-5), succeeded by tall willows. Gradually, as the permafrost table re-establishes within the rooting zone, the willows die from lack of moisture. *Arctophila fulva*, or *Calamagrostis* grasslands with scattered willow and alder, dominate other drained lakebeds. Low-centre polygons, an early stage of lowland polygon development (National Wetland Working Group, 1988), are also found in old drained basins. The vegetation of the low-centre polygons consists of sphagnum mats with sedges and some dwarf shrubs (Ovenden and Brassard, 1989; J. Hawkings unpubl. data)

Much of the "upland" area is also wetland. Polygonal peat plateau bogs are dominated by lichen heath (Ovenden and Brassard, 1989; Eamer *et al.*, 1996). Sparse, scraggly black spruce, and low shrubs are underlain by sphagnum moss in moister parts, and by reindeer lichen on drier parts of peat plateaus (Murray, 1997).

On the drier mineral "upland" soils between the lakes, cottongrass tussock and open spruce/shrub/lichen communities are typical. On the best-drained sites, sparse black and white spruce, shrub birch, Labrador tea, blueberry and other ericaceous shrubs and lichen predominate. On imperfectly drained soils, extensive areas of sedge tussocks with sparse white and black spruce and Labrador tea are found (Zoltai and Pettapiece, 1973; Eamer *et al.*, 1996; J. Hawkings, unpubl. data).

Where rivers have cut up to 20 m below the surface of the flats, white spruce with some black spruce, paper birch and aspen occupy favourable warm

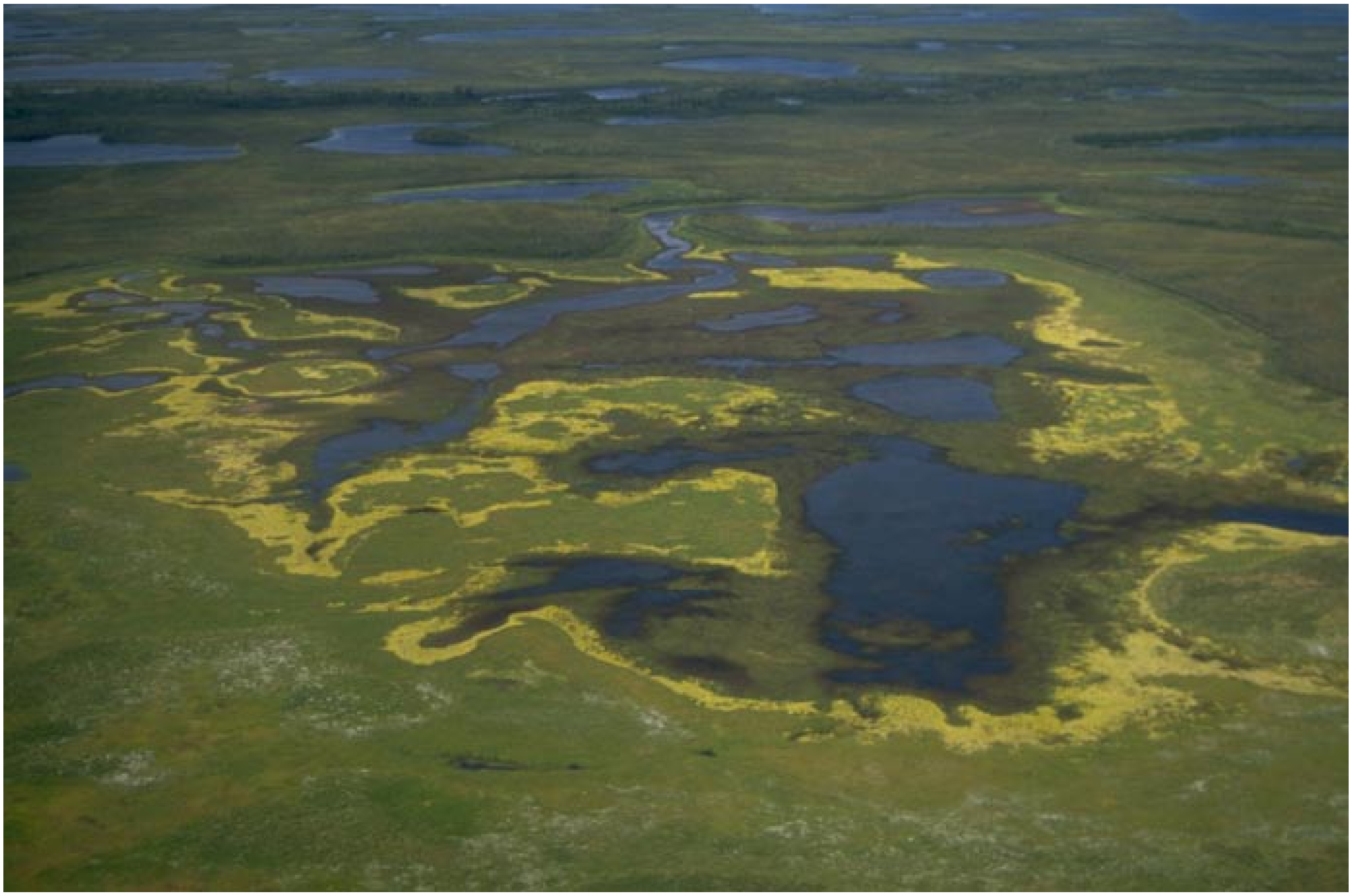


Figure 167-5. A recently drained lake in Old Crow Flats Ecoregion supports lush growth of colonizing sedges, grasses and yellow Mastadon flower *(Senecio congestus)*.

slopes with deeper active layers. The deciduous trees usually follow some disturbance, such as fire. Alder, shrub birch and soapberry, with ground shrubs and herbs, dominate the understory. Balsam poplar is found on the active floodplains.

WILDLIFE

Mammals

The Old Crow Flats possess some of the most abundant wildlife populations of the Taiga Cordillera, with many species reaching densities typical of the Boreal Cordillera of the southern Yukon. However, the diversity of rodents and ungulates is low by comparison.

This is both a unique and highly productive ecoregion of the Yukon. The vast wetlands are home to moose, grizzly bear, muskrat and mink. Moose are present only during summer, migrating to the head of drainages in the British Mountains in the fall. The most abundant muskrat populations in the Yukon, numbering in the hundreds of thousands, are near the northern edge of their range and experience slow growth and low productivity (Simpson *et al.*, 1989). The Flats are on the annual spring and fall migration routes of the Porcupine Caribou, which numbers about 150,000 individuals. The mammals of this ecoregion have received little attention other than opportunistic observation during caribou and waterfowl studies. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Birds

The interconnected lakes and marshes dominating this landscape are the single most important waterfowl area in the Yukon, providing over 500,000 waterbirds with breeding, moulting, and staging habitat (Yukon Waterfowl Technical Committee, 1995). More than 100 bird species have been recorded on the Flats, including at least 21 species of waterfowl (Hawkings, 1996).

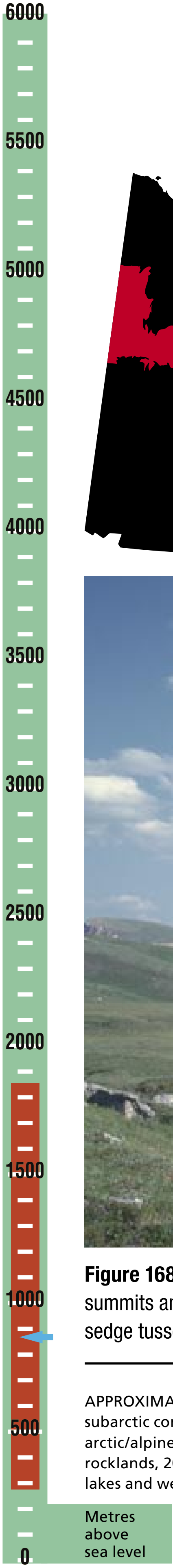
According to aerial surveys conducted each June by the U.S. Fish and Wildlife Service, breeding populations over the past 30 years have included 20,000-100,000 American Widgeon, 10,000 to 100,000 Northern Pintail, 5,000 to 40,000 Canvasback, 50,000 to 100,000 scaup, 20,000 to 80,000 White to winged and Surf Scoters, and 10,000 to 30,000 Long-tailed Duck (Hawkings, 1996). The Old Crow Flats also support three species of loons, Tundra Swan, White-fronted Goose, and a variety of other waterbirds. Banding studies have shown these birds to be associated with all four North American flyways. Waterfowl are more concentrated here than at other locations in the north. For example, densities of ducks on the Flats are usually about 80 ducks/km^2, two to three times higher than in any of the 11 primary waterfowl breeding grounds surveyed annually in Alaska by the U.S. Fish and Wildlife Service. Some of these birds breed and moult on the Flats, while others, such as Barrow's Goldeneye, do not breed there, but come in midsummer from further south to undergo their annual moult (Hawkings, 1996).

Other waterbirds occurring in these wetlands include Lesser Yellowlegs, Solitary, Spotted, and Least Sandpipers, Common Snipe, Red-necked Phalarope, and Herring, Mew, and Bonaparte's Gulls (CWS, Birds of the Yukon Database). Common songbirds associated with wetlands include Yellow Warbler, Northern Waterthrush, and Rusty Blackbird (Canadian Wildlife Service, unpubl.).

Peregrine Falcon are known to nest along cliffs and cutbanks of the Porcupine and Old Crow drainage (Hayes and Mossop, 1978) and Golden Eagle and Gyrfalcon nest on cliffs and rock ledges in tundra areas. Other raptors include Osprey, Bald Eagle, and Northern Harrier (Sinclair *et al.* [editors], 2003).

Species common in shrub tundra include Willow Ptarmigan, American Robin, American Tree, Savannah, Fox, and White-crowned Sparrows, and Common Redpoll (CWS, Birds of the Yukon Database). Gray-headed Chickadee, a rare resident of these subarctic forests, has been observed on a few occasions and likely breeds in shrubby riparian habitats (Murie, 1928; Eckert, 1994; Sinclair *et al.* [editors], 2003).

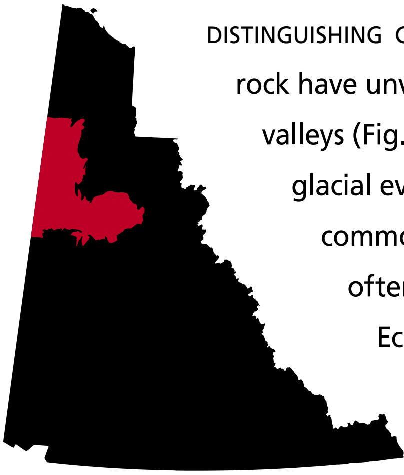
Subarctic forests provide breeding habitat for Merlin, Three-toed Woodpecker, Gray-cheeked and Varied Thrushes, Blackpoll Warbler, and Dark-eyed Junco (Sinclair *et al.* [editors] 2003). Year-round residents of these subarctic forests probably include Gray Jay and Common Raven (Godfrey, 1986).



North Ogilvie Mountains

Taiga Cordillera Ecozone

ECOREGION 168



DISTINGUISHING CHARACTERISTICS: Mountains of modest relief formed of sedimentary rock have unvegetated summits and rubble covered slopes, separated by broad valleys (Fig. 168-1). This ecoregion was largely ice-free during the most recent glacial event, but has evidence of older glaciations. Periglacial landforms are common. The coldest daily minimum winter temperatures in the Yukon are often recorded in valleys of this ecoregion. The North Ogilvie Mountains Ecoregion provides wintering grounds for the Porcupine caribou herd and is home to perhaps the only mammal species restricted to the Yukon — the Ogilvie Mountain lemming.

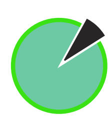
M. Hoefs

Figure 168-1. The Northern Ogilvie Ranges are characterized by strata of light grey limestone and dolostone with unvegetated summits and cliff bands. Chemical weathering produces humus-rich calcareous soils. Alpine tundra is composed of heath and sedge tussock cummunities as seen in the foreground.

APPROXIMATE LAND COVER
subarctic coniferous forest, 50%
arctic/alpine tundra, 25%
rocklands, 20%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
39,260 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
39,260 km^2



ECOREGION AREA AS A PROPORTION OF THE YUKON
8%

ELEVATIONAL RANGE
280–1,860 m asl
mean elevation 870 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **North Ogilvie Mountains Ecoregion** (Oswald and Senyk, 1977) • Portion of **Taiga Cordillera Region** (CEC, 1997) • Portion of the **Ogilvie/ Mackenzie Alpine Tundra Ecoregion** (Ricketts et al., 1999) • Contiguous with the **North Ogilvies Ecoregion of Alaska** (Nowacki *et al.*, 2001)

PHYSIOGRAPHY

The North Ogilvie Mountains Ecoregion includes the North Ogilvie physiographic region, the Keele Range, part of the Dave Lord Range and the Central Ogilvies. Matthews (1986) lumped the Central Ogilvies with the South Ogilvies. Bostock (1948) and Hughes (1987b) divided the Ogilvie Mountains into the higher South Ogilvies and the remainder, the North and Central Ogilvies and the Taiga Valley, which conforms more closely to the ecoregion boundary. Hughes (1987b) and Bostock (1948) have mapped the Keele Range and the Dave Lord Range, sometimes included in the Keele Range, as part of the Porcupine Plateau. The Taiga Ranges form the eastern part of the North Ogilvie Mountains; they are separated from the South Ogilvies and Wernecke by the Taiga Valley. The Nahoni Range is also part of the North Ogilvies.

Ranges in the Northern Ogilvie Mountains are less rugged and lower in elevation than the South Ogilvies. With a few exceptions the terrain consists of flat-topped hills and eroded remnants of a former plain (Oswald and Senyk, 1977). Castellations, like battlements along ridge tops, surrounded by long scree slopes are characteristic of the long period of erosion in unglaciated areas. The mountains in the south are higher and the valleys are cut deeper, giving relief greater than 1,200 m. There are two summits over 1,850 m asl in the southern Taiga Ranges. In the north the mountains range from 1,000 to 1,400 m asl and the valleys are less deeply entrenched, resulting in less than 800 m of local relief.

The North Ogilvie Mountains Ecoregion is the source of numerous rivers but large lakes are few. Only along the Blackstone River and around the junction of Rae Creek and the West Hart with the Hart River, are lakes common (Hughes, 1969). The Bluefish and Useful lakes are in the Keele Range.

BEDROCK GEOLOGY

This ecoregion encompasses the Keele Range and the Taiga–Nahoni Fold Belt, which extends through the Nahoni Range and the North Ogilvie Mountains. The ecoregion is almost entirely underlain by sedimentary formations; no granitic rocks are known. Regional geology is depicted on bedrock maps by Norris (1981c,e; 1982a,b,c) and Thompson (1995). Lower Paleozoic stratigraphic units are described by Morrow (1999). Less complete descriptions of the Proterozoic inliers are found in Green (1972) and Norris (editor, 1997), while a detailed description of the Upper Paleozoic and Mesozoic formations in the adjacent area is given by Dixon (1992). A classic description along the Yukon–Alaska border is in Cairnes (1914).

The Taiga–Nahoni Fold Belt (Norris [editor], 1997) is underlain by a thick succession of craton-derived sediment and carbonate shelf deposits of Proterozoic through Middle Devonian age, referred to as the Yukon Stable Block. The oldest units exposed in the cores of anticlines are metasandstone, siltstone and argillite, probably the Quartet Group of the Wernecke Supergroup and overlying Windermere equivalent rocks.

The Lower Paleozoic succession is about 2,500 m thick. At the base are two Cambrian units: white limestone of the Illtyd and orange-weathering sandstone of the Slats Creek Formation. Unconformably overlying these are two distinctively different units representing sediments of the Mackenzie Platform and the Richardson Trough. The former underlies ridges and cliffs. It is the Bouvette Formation (Morrow, 1999; formerly referred to as the Cdb unit) and up to 900 m thick. It consists of a lower section of yellowish-grey finely layered dolostone with pockets of mud-chip breccia and siltstone, a middle unit of light-grey, vuggy, crystalline dolostone and an upper part with very thick beds of light-grey dolostone (Fig. 168-2). The latter is the Road River Formation of black shale, chert and siltstone. It typically underlies valleys and smooth shaley slopes.

The Devonian Ogilvie Formation of dark-grey limestone and Imperial and Canol formations of black, sulphide-rich shale are overlain by Carboniferous shale and limestone of the Ford Lake Formation, brown Carboniferous dolostone of the Hart River Formation, Permian Takhandit Formation limestone, and the Triassic Shublik Formation. These units are exposed in synclines of north-trending folds that change to broad, east-trending warps southeast of the Ogilvie River. The Shublik Formation consists of black limestone, mudstone, siltstone and sandstone, with notable shell and conglomerate beds (p. 253-265 *in* Norris [editor], 1997). The Jurassic Kingak siltstone with softer shale and harder sandstone intervals, overlain by Early Cretaceous Kamik sandstone and quartzite, is preserved in the northwestern Ogilvie Mountains and Keele Range.

Figure 168-2. Tor formed in light-grey dolostone bedrock in the North Ogilvie Mountains Ecoregion. Note the unvegetated colluvial slope immediately below the tor and the black spruce-dominated taiga forest in the valley bottom. Raptors including Golden Eagle, Peregrine Falcon, and Gyrfalcon nest in these rocky outcrops.

The oldest exposed rock is calcareous shale, quartzite, red and green siltstone, and thin-bedded dolostone of the Tindir Group, which resembles other successions of the Late Proterozoic-to-Cambrian Windermere Supergroup. The overlying Bouvette Formation dolostone and Carboniferous Ettrain limestone and Permian Jungle Creek Formation are exposed in the north on flanks of the Dave Lord Uplift. Porcupine Terrane was thrust eastward in middle Tertiary time and the boundary is the Yukon Fault (Fig. 3.17 *in* Norris [editor], 1997).

The ecoregion contains at least six classes of mineral deposits. Barite veins and lenses occur in Lower Paleozoic dolostone. Galena and sphalerite in quartz breccia and veins are locally present in the Jones Ridge, Ogilvie and Takhandit formations as well as in the Endicott Group of Porcupine Terrane. Oolitic magnetite and banded iron formation are found in the Permian Jungle Creek Formation. Copper, with cobalt and arsenide mineralization is common where mafic dykes intrude Proterozoic dolostone. The Rusty Springs prospect consists of silver, copper and zinc mineralization in limonitic chert. Coal seams are present in the Cretaceous Kamik Formation in the Kandik Basin.

Naturally acidic streams drain iron-sulphide-bearing siliceous shale units such as the Canol Formation. A tributary of Engineer Creek, at km 180 on the Dempster Highway, and nearby Red Creek, have iron-hydroxide bottoms and low pH in which aqueous zinc is particularly high. Downstream, the ferric hydroxides precipitate along the creek; chemical reactions, including neutralization, serve to capture zinc, cadmium, lead and copper so that the aqueous concentration of most metals is nearly normal in Engineer Creek (Kwong and Whitley, 1992).

Dall sheep use the exposed saline beds of the Ogilvie Formation near Sapper Hill as salt licks. Exposures of the black Canol Formation and Ford Lake shale are locally and seasonally coated with an evaporite crust containing calcium and iron sulphide, though mostly gypsum, and are commonly used as mineral licks by wildlife.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

Bedrock surfaces occupy at least 20% of this ecoregion. Many summits have tors, characteristic of unglaciated areas (Fig. 168-2). These structures are angular, frost-shattered rock outcrops. Tors develop in easily shattered rocks like shales, sandstones and dolomite. Here they are found both at the peaks and on the side of middle-to-high elevation unglaciated slopes.

Surface deposits include colluvium, which covers approximately one-third of the land surface of the ecoregion. Pediment slopes formed by erosion characterize the intermontane basin that are common within the ecoregion. The slopes extend from broad valleys over considerable distance to the foothills of subdued mountains.

The southern and western portions of the ecoregion have extensive deposits of colluvial and scree materials on slopes and castellations on the crests of the more rugged, mountainous ridges. Rock fragments of many scree and colluvial slopes are uniform in size from toe to crest. The depth of the material is variable but generally shallow. Gentler slopes are frequently overlain with loess and/or silty colluvium and capped with organic material. Erosion scarps in sedimentary rock form striking features at many locations.

Glacial deposits cover approximately 35% of the ecoregion and include till and glaciofluvial outwash.

Earth hummocks and tussock fields often cover valley bottoms. Beaded streams, large peat plateaus, and palsas are also common. Aufeis is a common feature throughout. Slopes are frequently striated with parallel downslope drainage patterns or runnels (Oswald and Senyk, 1977).

Modern processes are largely associated with landslide activities, rock slides and debris flows. Periglacial processes include soil creep, solifluction, and active layer detachment slides. Cryoplanation terraces are common in the Keele Range (Lauriol and Godbout, 1988).

GLACIAL HISTORY

This ecoregion includes both glaciated and unglaciated terrain. During pre-Reid glaciations, a discontinuous ice-free corridor existed between extensive alpine glaciers that formed in the mountain ranges of this ecoregion. Well-developed pediment landforms now characterize these unglaciated areas. Extensive pediments characterize these unglaciated areas.

Pre-Reid features include very subdued and highly colluvial moraine, drainage diversions, and outwash plains or terraces. Glaciers were more extensive on the east flanks of the North Ogilvie Mountains than to the west. Piedmont glaciers occupied Ogilvie Valley east and south of Mount Klotz and coalesced with piedmont glaciers from the northern slopes of South Ogilvie Mountains. The meltwater drainage from these piedmont glaciers is traceable around and across Mount Skookum Jim. Glaciers also extended to Miner River from the Mount Bragg area. Outwash plains and terraces extend along Ogilvie River and its southern tributaries.

As in other parts of the northern Cordillera, features associated to the last two glaciations are much better defined. During the Reid glaciation, glaciers formed on the piedmont slopes along the eastern North Ogilvie Mountains and valley glaciers along the western side. During this glaciation, part of the northwest headwaters of the Ogilvie River was diverted northward into Miner River. McConnell Glaciation was restricted to individual valley glaciers in the Mount Klotz and Mount Bragg area.

CLIMATE

Weather systems from the Gulf of Alaska drop most of their moisture before they reach the slopes of this ecoregion, but some moisture reaches this area in systems moving eastward through Alaska. The result is moderate precipitation, coming predominantly as rain in the summer. Because of its northern latitude, temperatures are fairly low, but are not as extreme as in the lowlands of the Old Crow Basin and Flats to the north.

Mean annual temperatures are from –7 to –10°C, but there is considerable variation due to season and elevation. Winters are prolonged, lasting generally from October to May. Mean January temperatures in the lower valleys are near –30°C, with extremes to –50 to –60°C. Infrequently, mild spells associated with strong southerly winds can result in above freezing temperatures. At higher elevations, January means are some 10 degrees higher at near –20°C, with milder, windy weather more common. Summers are brief with mean July temperatures ranging from 12°C in the valley floors to 6°C over the higher terrain. Extremes can reach 30°C but periods of cool weather with frost can occur anytime.

Precipitation is moderate, ranging from 300 to 450 mm, with the heaviest precipitation over the higher terrain of the southern portion of this region. The period from February through May is dry with average monthly precipitation amounts of only 10 to 20 mm. June through August is the wettest period with monthly rain amounts of 40 to 60 mm, mostly in the form of showers or thunderstorms. Monthly rainfall values of over 100 mm have occurred. Snow is the main form of precipitation from September to May, with the heaviest amounts in the fall.

No wind data are available in this region. Depending on orientation, winds are expected to be moderate to light in most of the valleys of the ecoregion.

The only climate station in this ecoregion is Ogilvie River. Reference data from Eagle Plains and Klondike can be used to indicate conditions at intermediate elevations.

HYDROLOGY

The ecoregion drains the Ogilvie Mountains flowing westward into the Yukon and Porcupine rivers within Alaska, northeastward into the Peel River basin, and northward into the Porcupine River basin. There are no large rivers within the ecoregion, though there are numerous, major intermediate streams including the Ogilvie, Blackstone, Hart, Whitestone, Miner, Fishing Branch, and Bluefish rivers. Smaller streams draining into Alaska include the Tatonduk, Nation, Kandik, and Black rivers, and Orange Creek. Though the ecoregion has considerable relief, there are no glaciers within its boundaries. There are few major lakes or wetland areas within the ecoregion. Wetland coverage is limited largely to locations in the upper reaches of the Ogilvie and Blackstone River valleys, the site of a terminal moraine of the Reid glaciation (Hughes, 1968). These are examples of karst-related flow in some systems such as the Fishing Branch River.

There are only two representative hydrometric stations within the ecoregion: Ogilvie and Blackstone rivers, though with some adjustment, stations within the Mackenzie Mountains Ecoregion can be used to represent hydrologic response. Annual streamflow is generally characterized by a gradual increase in discharge in the spring, rising to a peak in May or June due to snowmelt inputs. This ecoregion has among the highest peak flows and lowest winter low flows in the Yukon. Many of the first- and second-order headwater streams are steep and relatively short; therefore, streamflow response tends to be rapid and flashy. On these smaller streams, approximately 40% of the annual maximum flows are due to intense summer rainstorm events. Some small, steep streams are susceptible to mud flows triggered by these summer rainstorms.

Along the Dempster Highway, the headwaters of Engineer Creek are prone to flash floods following summer thunderstorms because the unvegetated dolostone talus on surrounding mountainsides has little capacity to hold moisture.

Mean annual runoff is moderately high with little variation, ranging from 178 to 445 mm, with an ecoregion average of 324 mm. Mean seasonal and summer flows are both moderately high with values of 22 X 10^{-3} and 17 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual and mean summer floods are both moderate with values of 92 X 10^{-3} and 46 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March or April in the southern portion of the ecoregion, and earlier in the northern portion. The mean annual and summer minimum flows are moderate and high, with values of 0.90 X 10^{-3} and 7.5 X 10^{-3} $m^3/s/km^2$, respectively. Because of the increasing permafrost coverage associated with the increasing latitude, most smaller streams experience zero winter flows relatively frequently.

PERMAFROST

The North Ogilvie Mountains Ecoregion has continuous permafrost. The ecoregion was largely unglaciated, so much of the terrain has been exposed to at least 2 million years of periglacial conditions. The mountains exhibit the landform patterns of a frost-weathered landscape with talus accumulations at the base of most slopes. The upper surfaces of many mountains are barren and frost-shattered. Permafrost thickness have not been measured directly in the ecoregion, but depths of 300 to 700 m have been inferred from geophysical records, with the deepest permafrost inferred south of Eagle Plains Ecoregion. In the carbonate rocks of northern karst landscapes, cold air drainage in caves and other solution cavities likely increases the depth of permafrost (Lauriol and Clarke, 1993).

Paleomagnetic evidence from stalagmites in caves south of Old Crow indicates that permafrost formed in the early Quaternary and has been present ever since (Lauriol *et al.*, 1997). These features stopped growing once groundwater circulation ceased following permafrost aggradation. Cryoplanation terraces are well developed on Tsiittoh Choh Mountain in the Keele Range, where their development is assisted by the solubility of the host limestone (Lauriol, 1990).

The Dempster Highway traverses southern portions of the ecoregion, where permafrost is sometimes absent close to watercourses. Where gravel is perennially frozen, the active layer may be up to 1 m thick. The ground is usually icy beneath peat or other organic accumulations (Klohn Leonoff, 1986). Michel (1983) describes massive ice up to 18 m deep at one site near the highway, as well as ice over 20 cm thick at the surface of permafrost. Occasional pingo development has been observed in the Blackstone River valley (Fig. 168-3).

There is considerable mineralized groundwater flow in the southern portions of the ecoregion, with persistent development of icings (aufeis) in river channels each winter (Harris *et al.*, 1983b).

SOILS

Soils have formed in this ecoregion under the influence of moderate relief topography, a strong continental climate, and continuous permafrost.

Limestone dominates the numerous, small, rounded, mountain ranges including the Nahoni, Keele and Hart ranges. The upper slopes of the ranges tend to be covered by coarse angular rubble with little vegetation cover or soil formation. Well-drained middle slopes tend to have unique rendzina-like soils on which mixed open forests of aspen and white spruce grow (Fig. 168-4). These soils are characterized by thick accumulations of humus-rich surface horizons produced as a result of the weathering of carbon from limestone, a long unglaciated history of soil development, and cold temperatures that inhibit decomposing microbial activity (Schreier and Lavkulich, 1985).

Lower slopes are characterized by abundant soil moisture and extensive permafrost. The predominant soil formations are Orthic and Gleysolic Turbic Cryosols. Pediments cover most valley bottoms other than some glaciofluvial and alluvial landforms associated with major streams and rivers. Along the Ogilvie and Blackstone rivers, gravelly soils may be without near-surface permafrost and are classified as Eutric Brunisols. Some valleys in the upper Blackstone and headwaters of Engineer Creek contain mid-Pleistocene moraine deposits. Soils tend to be well developed with deep sola and evidence of Luvisol formation, presumably from times of temperate paleoclimate (site 17 *in* Tarnocai *et al.*, 1993).

There are a few small basin formations between the main ranges in the ecoregion, such as the upper Ogilvie and Hart rivers, in which wetlands can

J. Meikle, Yukon Government

Figure 168-3. An open system pingo exposed and eroded by the Blackstone River reveals ice-rich, deformed alluvial sediments. The dark void at the base of the sediment layer resulted from river erosion of pingo ice. The exposed face of the pingo collapsed three weeks after the photo was taken (June 1999).

Figure 168-4. This limestone ridge near the confluence of the Wind and Peel rivers illustrates the influence of aspect on vegetation and soil development. The south-facing slope (left of the ridge) supports an open forest of White Spruce *(Picea glauca)* growing on Brunisolic soils with an active layer greater than one metre thick. The north-facing slope supports tundra vegetation atop Cryosolic soil and near-surface permafrost.

be found. These contain many small thermokarst lakes and ponds. These wetlands are composed of sedge and sphagnum peat. For the most part, these wetland soils are underlain by permafrost and thus classified as Organic Cryosols.

VEGETATION

The vegetation of the North Ogilvie Mountains is distinguished by the high incidence of calcareous sedimentary bedrock, which is host to numerous calcium-loving plants. Many of these are considered rare glacial relicts (Kennedy and Smith, 1999).

Alpine tundra vegetation dominates the subdued mountain topography of the North Ogilvies. Sedge tussock communities mantle the unglaciated pediments, while most valleys contain open spruce taiga communities. Treeline is reached around 900 m asl (Oswald and Senyk, 1977).

Many ridge crests and scree slopes are sparsely vegetated. On ridges and slopes with calcareous substrates at higher elevations, *Dryas* communities are common. These are diverse communities with numerous sedges and forbs, typically including *Dryas integrifolia*, *Saxifraga tricuspidata*, and *Parrya nudicaulis*. Many species are endemic to calcareous soils in unglaciated parts of North America. Rare species include *Eritrichium aretioides* (Stanek *et al.*, 1981; Brooke and Kojima, 1985). Where the bedrock is more acid, willow–ground shrub–lichen communities predominate, associated with patterned ground (Stanek, 1980).

Low shrub tundra is common on low elevation ridges and mid-slopes. Shrub birch, low willows, blueberry and lichens dominate this community. On gentler pediment slopes with near-surface permafrost, shrub–tussock tundra is most common.

Below treeline, sparse spruce–shrub tundra communities mantle the slopes. Well-developed shrub layers include willow, shrub birch, and Labrador tea. Better-drained southerly aspects support white spruce–shrub–forb types that include rhododendron, shrubby cinquefoil, and rose. On more gentle slopes, black spruce–shrub–sedge tussock communities are more common.

White spruce–feathermoss forests occupy some alluvial terraces as well as some protected, well-drained, permafrost-free sites. These fluvial sites are the most productive in the ecoregion, with trees reaching 30 m. Sparse shrubs, including willow, alder, rose, and Labrador tea, shade feathermosses, ground shrubs, diverse forbs and horsetail of the understory. Younger fluvial deposits often support dense stands of balsam poplar, and, in areas of frequent flooding, dense willow thickets (Stanek *et al.*, 1981; MacHutcheon, 1997; Kennedy and Smith, 1999).

WILDLIFE

Mammals

Grizzly bear, wolverine, Dall sheep, the Ogilvie Mountains lemming, and collared pika epitomize this mountain wilderness. The Ogilvie Mountains lemming may be the only mammal species restricted to the Yukon; it is found in only one other ecoregion, the adjacent Mackenzie Mountains Ecoregion.

A small population of stone sheep is found in the western Ogilvie Mountains (Barichello *et al.*, 1989a). Ranges of the Hart River woodland caribou and Porcupine herds overlap in the Peel River watershed. The population of the Hart River herd was estimated to be 1,200 in 1978, and the Porcupine herd numbered about 123,000 (in 2000). The Fishing Branch River is a chum salmon spawning ground, which attracts grizzly bear, mink, river otter and wolverine.

Most mammal species have received little attention and ranges can only be estimated. Species known or expected to occur in this ecoregion are listed in Table 4.

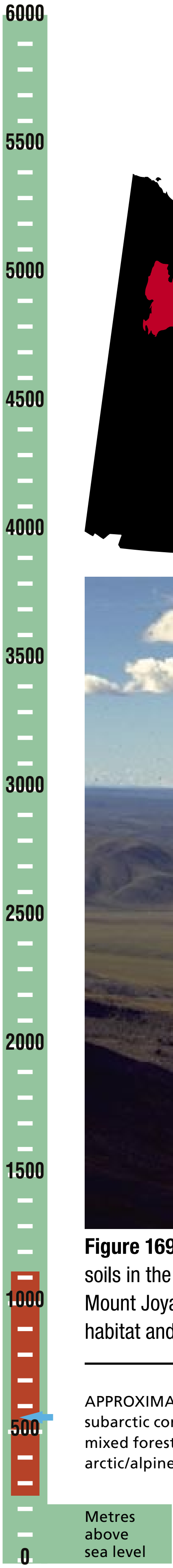
Birds

Large rivers offer breeding habitat for Canada Goose, Red-breasted and Common Mergansers, and Mew Gull. Harlequin Ducks breed on smaller, swift flowing mountain streams (Frisch, 1987). Red-throated Loon and Long-tailed Duck breed on tundra ponds and lakes (Williams, 1925; Frisch, 1987). Wetland breeders include Horned Grebe, American Widgeon, Mallard, Northern Shoveler, Northern Pintail, Green-winged Teal, Greater and Lesser Scaup, Bufflehead, Barrow's Goldeneye, Bald Eagle, Northern Harrier, Lesser Yellowlegs, Least Sandpiper, and Common Snipe (McKelvey, 1977; Frisch, 1987). Common songbirds inhabiting marshy areas include Yellow Warbler, Savannah Sparrow, and Rusty Blackbird (Frisch, 1987).

Breeding bird species that occur in white spruce forests include Northern Flicker, Say's Phoebe, Ruby-crowned Kinglet, American Robin, Yellow-rumped Warbler, Fox Sparrow, and Dark-eyed Junco (Williams, 1925; Frisch, 1987). Year-round residents include Gray Jay, Common Raven, and Boreal Chickadee (Williams, 1925; Frisch, 1987). Bogs and willow thickets along streams at treeline are productive habitats for Upland Sandpiper and Orange-crowned and Wilson's Warblers, while Northern Shrike and Townsend's Solitaire reside in the adjacent subalpine forests (Frisch, 1975, 1987).

Broad expanses of willow, alder, and low shrub birch in upland areas provide breeding habitat for Willow Ptarmigan, American Tree Sparrow, White-crowned Sparrow, and Common Redpoll (Brown, 1979; Frisch, 1987).

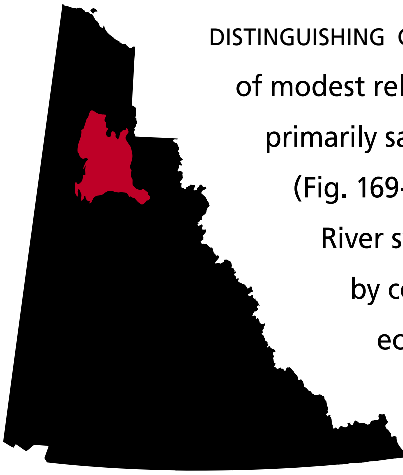
Raptors that nest on cliffs and rocky outcrops include Golden Eagle, Peregrine Falcon, and Gyrfalcon (Frisch, 1987; CWS, Birds of the Yukon Database). Nesting gyrfalcons hunt along rocky slopes and dry ridges for prey species such as Rock Ptarmigan (Frisch, 1987; Sinclair *et al.* [editors], 2003). Horned Lark and Northern Wheatear reside in upland barren areas along with small colonies of Surfbirds, whose Canadian breeding distribution is centred in these mountains (Frisch, 1987). Alpine meadows are inhabited in summer by American Golden-Plover, Baird's Sandpiper, Long-tailed Jaeger, Short-eared Owl, American Pipit, and Smith's Longspur (Frisch, 1987).



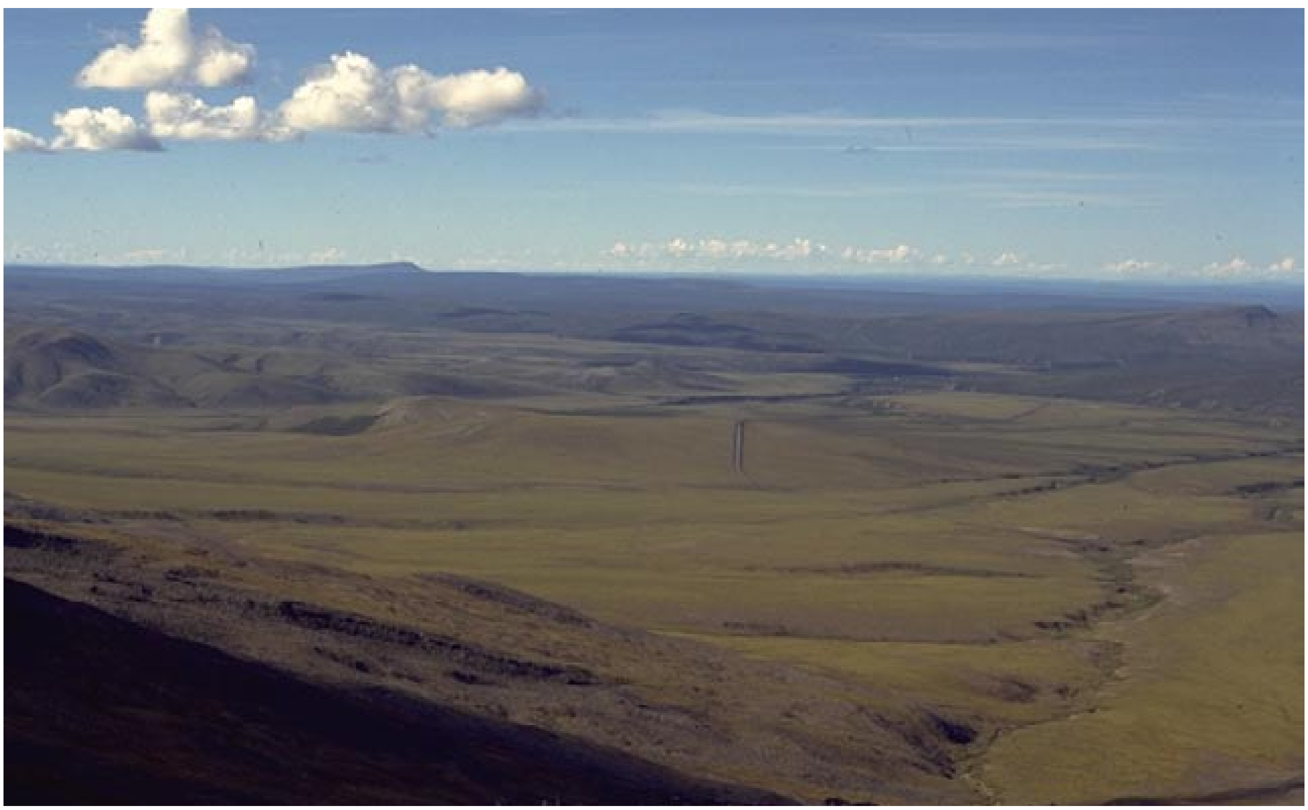
Eagle Plains

Taiga Cordillera Ecozone

ECOREGION 169



DISTINGUISHING CHARACTERISTICS: Eagle Plains Ecoregion is an intermontane basin of modest relief underlain by Devonian through Cretaceous sedimentary rocks, primarily sandstone and shale. Extensive pediments shape lower slopes (Fig. 169-1). The ecoregion drains into both the Yukon and Mackenzie River systems. Much of the area escaped glaciation, but is now underlain by continuous permafrost and periglacial features are common. This ecoregion has one of the lowest levels of mammalian diversity in the Taiga Cordillera Ecozone because habitat diversity for many species is limited.

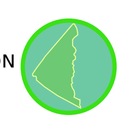


J. Meikle, Yukon Government

Figure 169-1. The Eagle Plains landscape. The Eagle River valley was created from the outflow of Glacial Lake Hughes. Alluvial soils in the Eagle River valley support small stands of balsam poplar *(Populus balsamifera)* and white spruce *(Picea glauca)* forests. Mount Joyal, seen as the small peak in the horizon, is one of the higher points (925 m asl) within the ecoregion and supports alpine habitat and well-developed cryoplanation terraces.

APPROXIMATE LAND COVER
subarctic coniferous forest, 90%
mixed forest, 5%
arctic/alpine undra, 5%

TOTAL AREA OF ECOREGION IN CANADA
20,400 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
20,400 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
4%

ELEVATIONAL RANGE
250–1,110 m asl
mean elevation 560 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent **Eagle Plain Ecoregion** (Oswald and Senyk, 1977) • Portion of **Taiga Cordillera Region** (CEC, 1997) • Portion of **Interior Alaska/Yukon Lowland Taiga Ecoregion** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Eagle Plains Ecoregion occupies the Eagle Lowland of Matthews (1986), or part of the Porcupine Plateau and Porcupine Plain as defined by Bostock (1948) and Hughes (1987).

The Eagle Plains lie between the Richardson Mountains to the east and the North Ogilvies to the west. Most of the rolling low-relief terrain lies between 300 and 600 m asl (Oswald and Senyk, 1977), although a few high points are over 1000 m asl. Both the Porcupine and Peel rivers have cut down to less than 300 m asl.

Most of the ecoregion drains north via the Whitestone, Porcupine and Eagle rivers and their tributaries to the Yukon River watershed. The southeast corner drains east via the Ogilvie, Peel and Wind rivers to the Mackenzie; however, this is probably fairly recent. The Hart, Blackstone, and Ogilvie rivers drained north to the Porcupine, but have recently been captured by the Peel River by rapid downcutting (Bostock, 1948). The walls of Aberdeen Canyon on the Peel River are about 50 m high (Fig. 169-2).

Very few lakes are found in the ecoregion except on the floodplains of the Whitestone, Porcupine and Eagle rivers. Most of these are either oxbow lakes in old meander channels or thermokarst lakes. Moose, Davis and Palmer lakes, and a few others between the Peel and Wind rivers in the glaciated part of the ecoregion, are the exception.

BEDROCK GEOLOGY

This ecoregion encompasses Devonian through Cretaceous sedimentary rocks representing an intermontane basin sandwiched between the uplifted Richardson, North Ogilvie and Dave Lord Mountain ranges. The rare outcrops are confined to downcutting streams draining into the Eagle and Rock rivers and excavations along the Dempster Highway. Over the rest of the subdued topography of the ecoregion, unvegetated areas consist of loose chips of the underlying shale and sandstone units.

The distribution of rock units at the surface is shown by Norris (1981c,e,f; 1982a,b) and the units are chronologically described by Norris (editors, 1997) and Dixon (1992). Lower- to middle

J. Meikle, Yukon Government

Figure 169-2. The Aberdeen Canyon on the Peel River is cut into thickly bedded limestone overlying calcareous shale of the Hart River Formation (Carboniferous age). The gentle scarp visible in the middle distance (arrow) is the eroded face of silty deposits of Glacial Lake Hughes.

Cretaceous Eagle Plains Group, consisting of light-coloured sandstone and siltstone separated by darker shale intervals, underlies two-thirds of the ecoregion. In the central and western parts of the ecoregion, the zebra-striped patterns of these light- and dark-coloured strata outline the gently folded nature of the terrain. Beneath this unit is an erosional unconformity that systematically truncates older rock units. The gentle, southern, regional dip of the older units results in a distribution of broad bands across the southeastern and eastern third of the ecoregion. In northeast succession from the vicinity of Eagle Plains Lodge, these include the Beiderman Argillite (Lower Cretaceous), the Jungle Creek Formation (Permian), the Ettrain Formation (Upper Carboniferous), the Hart River Formation and Ford Lake Shale (Lower Carboniferous), and the Imperial Formation (Upper Devonian). Prominently exposed along the Dempster Highway are beige limestone of Hart River Formation at about km 340, conglomerate and conglomerate-rich sandstone with black shale and coal horizons of the Upper Devonian to Lower Carboniferous Tuttle Formation at km 359. Exposures of brown siltstone, sandstone and shale with nodules of the Imperial Formation exist between the Arctic Circle and the Rock River. An undivided and unnamed Paleozoic carbonate (CDb unit, now Bouvette Formation) is exposed in several thrust-cored anticlines near the Peel River.

Gentle, moderately plunging folds have north-trending axes in the western part of the ecoregion, and bend to easterly trends in the southern area. These folds and minor contraction faults developed during the Late Cretaceous Laramide Orogeny. A second, more intense regional deformation in Early Tertiary time resulted in block faulting, such as Deception Fault near the eastern edge of the ecoregion, along the geological boundary of the Richardson anticlinorium. The entire block upon which the Eagle Plains lie was displaced eastward during Early Tertiary time (Lane, 1996).

The Eagle Plains have proven hydrocarbon reserves, but no known coal or metallic mineral deposits. Three of the 11 wells drilled before an exploration moratorium in 1968 intersected porous Carboniferous and Permian sandstone in the Chance and Dagleish anticlines in the southern and southeastern part of the ecoregion. Approximate reserves in this area are $2.8 \times 10^9\ m^3$ of gas and $3.1 \times 10^6\ m^3$ of oil (T. Bird, *in* Hamblin, 1990).

SURFICIAL GEOLOGY

Colluvial deposits cover most of the ecoregion; the remaining areas are covered by mostly alluvial sediments along river systems with a few glaciofluvial and glaciolacustrine deposits associated with meltwater generated by glacial activity outside the ecoregion. The tectonic origin of this region has resulted in thick accumulations of colluvial deposits on ridge crests and slopes (Thomas and Rampton, 1982c). Pediment surfaces commonly have a veneer of fine colluvium generated from local upslope bedrock.

The ecoregion lies within the zone of discontinuous permafrost where permafrost is up to 200 m thick, with taliks present in major rivers (Thomas and Rampton, 1982c). Ice-wedge polygons occur in poorly drained, fine-grained soils. Modern processes include thermokarst subsidence and soil creep, cryoturbation, solifluction, and active layer detachment slides on shale.

GLACIAL HISTORY

This ecoregion is comprised dominantly of unglaciated terrain, with the exception of parts of the Nahoni Range where there is scattered evidence of a past local glaciation of undetermined age. However, glaciers outside this ecoregion have influenced the major rivers, with up to three levels of glacially controlled terraces present (Thomas and Rampton, 1982c).

Major meltwater outlets exited the eastern slopes of the North Ogilvie Mountains, near Mount Klotz and Mount Bragg, and the northern slopes of the South Ogilvie Mountains, via Ogilvie, Miner, Whitestone, Blackstone and Hart rivers, during all glacial periods known in the area. At the Late Wisconsinan maximum (ca. 30 ka; Hughes *et al.*, 1981; Schweger and Matthews, 1991), the Laurentide Ice Sheet blocked drainage of the Peel River and its southern tributaries forming Glacial Lake Hughes, and diverting the drainage northward through the Eagle River discharge channel (Duk-Rodkin and Hughes, 1995). Glacial Lake Hughes received all the water exiting the Mackenzie and Wernecke mountains and the Ogilvie, Blackstone and Hart river basins. The Eagle and Porcupine rivers were the two major contributors to the inundation of the Old Crow, Bluefish and Bell basins.

Pediment surfaces are widespread along major rivers and streams, such as the Whitestone and Ogilvie rivers and the western slopes of Richardson Mountains (Fig. 169-3). Three levels of pediments are identified in the Richardson Mountains, with ongoing development since at least the late Miocene (McNeil *et al.*, 1993; Duk-Rodkin and Hughes, 1994).

CLIMATE

Winter conditions are prolonged, usually extending from October to early May. This is due in part to the northerly latitude and the warmer south winds that infrequently erode cold air from the valleys north of the Ogilvie Mountains. This ecoregion lies near the Arctic Circle, therefore the periods of continuous sun above or below the horizon are relatively brief.

Mean annual temperatures are near –7.5°C, but there is strong seasonal variation; during the winter, there is an elevation variation though local relief is not great. Average January temperatures range from –31°C on the lower valley floors to near –25°C over the higher terrain. This is believed to be the result of relatively light winds during the winter and the settling of the coldest air in the valley bottoms. Mean July temperatures are not as dependent on elevation and are near 13°C. Extreme temperatures range from –60 to 30°C; again the extreme minimums are more common in the valley floors. Frost can occur at any time of the year.

Precipitation is moderate with annual amounts near 400 mm. Most precipitation falls as rain during the summer months, primarily in showers and thunderstorms. Mean June through August amounts are 50 to 80 mm per month. The lightest precipitation is from September through April as snow. Little to no wind data are available in this ecoregion. It is believed that winds are generally light from November to March although prolonged periods of moderate easterly winds can occur, due to predominant cells of high pressure over the northern Yukon. Frequently, strong southwesterly winds can occur as the high-pressure cells move over the central Yukon. During the summer, winds will be moderate to light and most frequently from the west or east.

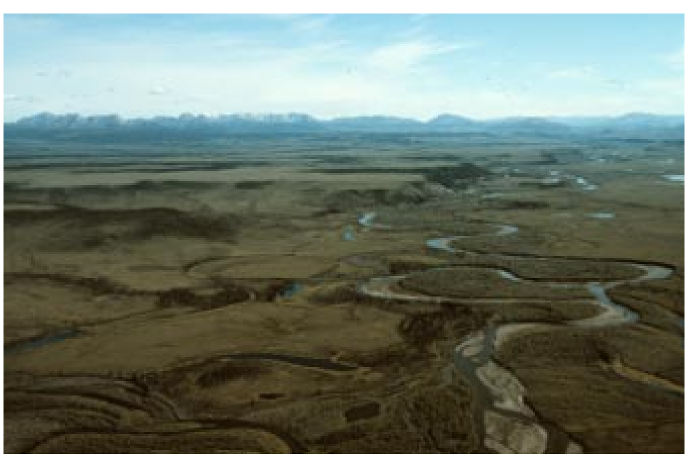

A. Duk-Rodkin, Geological Survey of Canada

Figure 169-3. Pediment surfaces extend from the Richardson Mountains to the Eagle River valley, as shown above. The pediments began forming during the Late Miocene, about 5 million years ago.

Representative stations for climatic data are Eagle Plains, Parkin (closed) and, to a lesser degree, Old Crow.

HYDROLOGY

The majority of the flow out from the Eagle Plains Ecoregion is to the Porcupine River, which flows northward through the northern portion. The north-flowing Eagle River, a tributary of the Porcupine, is another large stream within the ecoregion. Intermediate Porcupine River tributary streams include the north-flowing Whitestone River and the south-flowing Johnson Creek. The ecoregion also contains the lower portion of the Rock River, which flows into the Bell River, a tributary of the Porcupine. Coverage by waterbodies is less than 1% of the ecoregion. There are no large- or intermediate-sized lakes. While there are a few upland lakes in the headwater regions of the ecoregion, the majority of waterbodies consist of lowland, oxbow lakes associated with the Porcupine and Eagle rivers. There are a few large wetlands within the Porcupine and Eagle River lowlands.

There are three historical representative hydrometric stations: Whitestone, Eagle and Porcupine rivers. Annual streamflow is characterized by an increase in discharge in April due to snowmelt leading to a peak flow in May within most ecosystem streams. Summer rain events will produce secondary peaks, and sometimes the annual peak, throughout the summer. This is especially true of smaller streams, which more frequently experience peak rainfall events. Mean annual runoff is moderately low, ranging from 173 to 233 mm with an ecosystem average of 201 mm, while mean seasonal and summer flows are likewise moderately low with values of 12×10^{-3} and 10×10^{-3} $m^3/s/km^2$, respectively (Table 2). The mean annual flood and mean maximum summer flow are moderately high and low with values of 93 X 10^{-3} and 31 X 10^{-3} $m^3/s/km^2$, respectively. The minimum annual and summer flows are relatively low with values of 3 X 10^{-3} and 20 $m^3/s/km^2$ respectively. Minimum streamflow generally occurs during March or earlier with the relative magnitude lower than most other ecoregions due to the increasing role of winter temperatures and permafrost on streamflow. Many small streams experience zero winter flows relatively frequently.

PERMAFROST

Eagle Plains Ecoregion is underlain by continuous permafrost. Ground temperature measurements at the North Cath drill site, near the border with the North Ogilvie Mountains Ecoregion, indicate permafrost thickness of 89 m (Fig. 22), but various geophysical records suggest the base of ice-bearing permafrost may be considerably deeper. Mean near-surface ground temperatures at the Eagle River bridge are –3°C (Johnston, 1980; –2.8°C in 1991–1992, Tarnocai *et al.*, 1993). Rapid permafrost aggradation has been recorded in freshly exposed sediments of Eagle River (Crampton, 1979). The active layer thickness is generally less than 1 m (Tarnocai *et al.*, 1993).

Ground ice was encountered at all sites in the ecoregion examined for granular material in association with Dempster Highway maintenance and construction (EBA, 1990a). Extensive ground-ice accumulations were delineated in near-surface horizons during drilling for the potential Dempster Highway pipeline (Michel, 1983). Examination of the isotopic characteristics of near-surface icy sediments recovered from near Eagle River indicates that the ice formed during the Wisconsinan period, when Eagle River was part of the drainage route for

S. Smith, Agriculture and Agri-Food Canada

Figure 169-4. Cross-section of a well-developed earth hummock under black spruce forest near Eagle Plains Lodge. The permafrost table undulates in a mirror image beneath the surface of the hummocks. The active layer is up to 90 cm thick under the hummock and only 30 cm thick in the mossy inter-hummock depressions (tape measure on the left). This is a good example of an Orthic Eutric Turbic Cryosol with highly cryoturbated soil horizons, typical of the soils of subarctic Canada.

Figure 169-5. Extensive black spruce–paper birch woodlands exist on well-drained uplands throughout the ecoregion.

meltwater from the Laurentide Ice Sheet to the Old Crow Basin (Michel, 1983). Ice wedges and near-surface segregated ice are the prevalent forms of ground ice.

SOILS

Soils form under a cold continental climate on the broad, gently sloping, unglaciated surfaces that characterize this ecoregion. General soil and landscape relations have been described for the ecoregion by Tarnocai *et al.* (1993).

Near-surface permafrost is extensive, and absent only from active alluvial locations and some south-facing upper slopes. On these well-drained landscape positions under open black and white spruce stands, soils are classified as Dystric Brunisols (site 3 *in* Smith *et al.*, 1990). When associated with sandstone bedrock of the Eagle Plains Group, these soils may have pH as low as 4.0 and contain large amounts of iron oxides, a reflection of long periods of weathering. In other upland sites, often at elevations just above treeline, Turbic Cryosols produce patterned ground formations including well-developed sorted and non sorted nets and stripes (site 11 *in* Tarnocai *et al.*, 1993). Turbic Cryosols associated with earth hummocks are most commonly found under open stands of black spruce, birch and larch. Active layers vary from 20 cm in the inter-hummock area to over 90 cm immediately below the hummock forms. A cross-section of a typical earth hummock near Eagle Plains Lodge is shown in Figure 169-4. Annual mean soil temperature at 50 cm depth within the earth hummocks is about –3°C (Smith *et al.*, 1998). Forest fires disrupt the thermal regime of most middle and upper slope positions, causing a lowering of the permafrost table and releasing stored frozen water. In some cases, thaw slumps are triggered, as can be seen around km 300 on the Dempster Highway.

VEGETATION

Much of the Eagle Plains Ecoregion is characterized by black spruce woodlands associated with earth hummocks. Black spruce–tussock tundra dominates the lower slopes (Zoltai and Pettapiece, 1973). At the highest elevations, over about 800 m, shrub tundra with non-sorted nets and circles occurs on plateau summits. Tussock tundra lies on level and gently sloping surfaces (Fig. 169-5).

The black and white spruce woodlands common on uplands of the Eagle Plains are typically rich in shrubs, such as Labrador tea, shrub birch, willows, alder, blueberry, rose, lowbush cranberry and spirea, over a moss and lichen groundcover. White spruce with a lichen understory is more common on better-drained sites (Russell *et al.*, 1992; Murray, 1997).

On fine-textured soils of gentle gradients and lower slopes, the black spruce–shrub tundra contains Labrador tea, shrub birch, crowberry, lingonberry and spirea (Fig. 169-6). Cottongrass tussocks dominate the groundcover, though bog cranberry, cloudberry, lichen and moss are significant. Tamarack is often a component of the canopy.

Forest fires are a significant component of the landscape ecology. Paper birch typically is the first tree species to colonize burns, although on warm, well-drained sites aspen and balsam poplar may be found (Zoltai and Pettapiece, 1973). Extensive black spruce–paper birch woodlands (Fig. 169-5) indicate the extent of old burns (Terrain Resources Ltd. 1996). Fires increase the depth of the active layer and may trigger numerous slope failures.

Willow, alder and balsam poplar colonize active alluvial deposits along the major rivers.

The shrub tundra found above 800 m is often associated with patterned ground, such as raised-centre mudboils. Shrub birch, willow and prostrate shrubs dominate the vegetation. Cottongrass tussocks are also found at higher elevations in areas of impeded drainage in the Embankment Hills.

WILDLIFE

Mammals

This ecoregion has one of the lowest levels of mammalian diversity in the Taiga Cordillera, because it does not provide suitable habitats for many of the rodent and ungulate species found elsewhere. However, many species of voles find suitable habitat here and predators such as marten, ermine and red fox are common. Barren-ground caribou of the Porcupine herd use this area primarily in the fall and winter. The herd numbered about 123,000 in 2001. Large predators such as wolf, wolverine and grizzly and black bear (Fig. 169-6) are found in low densities. Information on mammal species other than caribou is poor. Species known or expected to occur in this ecoregion are listed in Table 4.

Birds

There is key nesting habitat for Peregrine Falcon along the Porcupine and Eagle rivers (Hayes and Mossop, 1978; Peepre and Associates, 1993). Wetlands are inhabited by small numbers of Pacific and Red-throated Loons, Tundra Swan, Greater White-fronted Goose, Canada Goose, American Widgeon, Green-winged Teal, Bufflehead, Lesser Yellowlegs, Solitary Sandpiper, and Common Snipe (McKelvey, 1977; Frisch, 1987).

Common Merganser, Spotted Sandpiper, Herring and Mew Gulls, a few Bald Eagle, Belted Kingfisher, and a few Bank and Cliff Swallow colonies exist along rivers (Frisch, 1987). Swift mountain

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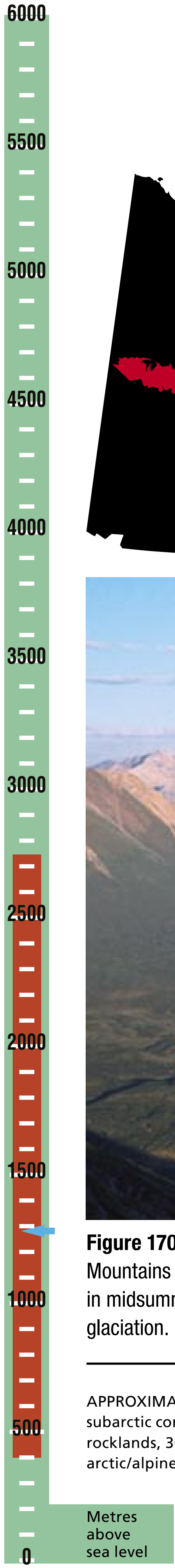
Figure 169-6. Black bear (brown phase) with cub grazing in shrub tundra vegetation.

streams support breeding Harlequin Duck and American Dipper (Frisch, 1987). Riparian thickets provide breeding habitat for Willow Ptarmigan, Alder Flycatcher, Yellow Warbler, Wilson's Warbler, American Tree Sparrow, and Lincoln's Sparrow (Frisch, 1987).

Upland forests provide breeding habitat for resident Northern Goshawk, Spruce Grouse, Northern Hawk Owl, Three-toed Woodpecker, Gray Jay, Common Raven, Boreal Chickadee, Pine Grosbeak, White-winged Crossbill, and Common Redpoll (Frisch, 1987). In winter, birds from higher altitudes or latitudes, including Gyrfalcon and Willow Ptarmigan, join these year-round residents (Frisch, 1987). Swainson's, Gray-cheeked, and Varied Thrushes, Bohemian Waxwing, Yellow-rumped and Blackpoll Warblers, and Dark-eyed Junco migrate north each spring to breed in these forests (Frisch, 1987). American Kestrel, Say's Phoebe, American Robin, Orange-crowned Warbler, and Chipping, Fox, and White-crowned Sparrows breed in the many forest openings and shrub habitats (Frisch, 1987). Swainson's Hawk, which is extremely rare elsewhere in the Yukon, regularly occurs in summer and is usually seen soaring over stunted spruce forest, leading to speculation that they may nest in the area.

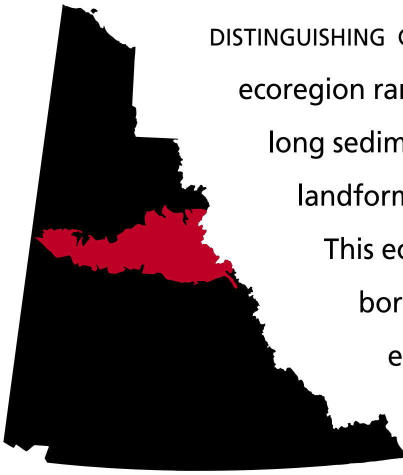
Alpine tundra supports low numbers of Golden Eagle and Rock Ptarmigan and is probably used in summer by small numbers of Horned Lark, American Pipit, and Gray-crowned Rosy Finch (Frisch, 1987). Upland Sandpiper and Townsend's Solitaire breed in the subalpine zone (Frisch, 1987).



Mackenzie Mountains

Taiga Cordillera Ecozone

ECOREGION 170



DISTINGUISHING CHARACTERISTICS: The sedimentary rocks that underlie much of the ecoregion range in age from Early Proterozoic to Middle Jurassic, a 1.6 billion year long sedimentary record exposed in few other places in Canada. Spectacular landforms are associated with multiple glaciations and periglacial weathering. This ecoregion encompasses a significant ecological transition from the boreal in the south to the taiga in the north. The Yukon portion of the ecoregion is home to some of the largest woodland caribou herds in the territory.

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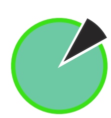
Figure 170-1. Broad U-shaped valleys and bare mountain ridges characterize the Wernecke Mountains in the Mackenzie Mountains Ecoregion. This southward view in the upper Snake River drainage shows braided streams with small aufeis remaining in midsummer (right side of photo) and small lakes contained within a glaciofluvial complex from the most recent McConnell glaciation. Half of the area of this ecoregion lies above treeline, which at this latitude is about 1200 m asl.

APPROXIMATE LAND COVER
subarctic coniferous forest, 50%
rocklands, 30%
arctic/alpine tundra, 20%

TOTAL AREA OF ECOREGION IN CANADA
86,460 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
42,900 km^2



ECOREGION AREA AS A PROPORTION OF THE YUKON
9%

ELEVATIONAL RANGE
400–2,750 m asl
mean elevation 1,290 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent **Eagle Plain Ecoregion** (Oswald and Senyk, 1977) • Portion of **Taiga Cordillera Region** (CEC, 1997) • Portion of **Ogilvie/Mackenzie Alpine Tundra Ecoregion** (Ricketts et al., 1999)

PHYSIOGRAPHY

This ecoregion includes the South Ogilvie and Wernecke (Fig. 170-1) mountains, a broad band of mountains conventionally thought of as separating northern Yukon from central Yukon. It also encompasses much of the Mackenzie Mountains proper; the Bonnet Plume Range and the Knorr Range in northeastern Yukon, and the northern portions of the Backbone and Canyon ranges (Matthews, 1986) of the Northwest Territories. Within the South Ogilvie Mountains of the Yukon, the Tombstone and Cloudy ranges are spectacular ranges in the westernmost portion of this ecoregion.

The relief is generally between 750 and 1,500 m. Only a few peaks exceed 2,100 m elevation, although the highest, Mount McDonald in the Bonnet Plume Range, is more than 2,740 m asl. The floodplain of the Bonnet Plume River as it exits the ecoregion is the lowest elevation in the ecoregion at less than 600 m asl.

These mountains form part of the Mackenzie–Yukon hydrologic divide. They drain southward into the Yukon River and the Bering Sea, and north to the Mackenzie and Beaufort Sea. To the south are the headwaters of the Stewart, Nadaleen, McQuesten and Klondike rivers; to the north, they begin the Ogilvie, Blackstone, Hart, Wind, Bonnet Plume and Snake rivers. Lakes are few and small in the ecoregion.

BEDROCK GEOLOGY

The entire ecoregion lies within the Cordilleran Foreland Fold and Thrust Belt (Gabrielse and Yorath [editors], 1991). The rock units and structures largely define the landscape. Resistant carbonate protrudes as steep and rugged ridges, clearly revealing mountain-scale folds, while recessive siltstone, shale and major faults underlie intervening valleys. This is particularly evident in the southern Ogilvie and Wernecke mountains where older rocks are exposed in an erosional window. Second, distinctive peaks in the Tombstone and Antimony ranges are cored by syenite to quartz diorite intrusions. The intrusive rocks are frost-fractured along vertical joints, resulting in sheer cirque walls and blocky talus (Fig. 170-2). Bedrock of the ecoregion has been mapped (Green, 1972; Blusson, 1974; Norris, 1982c,d; Thompson, 1995) and is described in Gabrielse and Yorath (editors, 1991; chapters 5–9), which includes coloured illustrations (Plates 3–10, 13–15 and 29 *in* Gabrielse and Yorath [editors], 1991) of the spectacular geology exposed in the ecoregion.

The sedimentary rocks range from Early Proterozoic to Middle Jurassic, a 1.6 billion year sedimentary record exposed in only a few other places in Canada. Sandstone, siltstone, and a prominently weathered orange-brown, thinly bedded dolomite, older than 1,750 Ma, constitute the Wernecke Supergroup (Delaney, 1981). Succeeding units, including dark-coloured shale, thick- and thin-bedded dolomite and sandstone comprise the overlying Fifteenmile (Thompson, 1995) and Pinguicula (Thorkelson and Wallace, 1995) groups in the western half of the ecoregion, and Mackenzie Mountain Supergroup east of the Snake River. From 750 to about 600 Ma, maroon shale, sandstone and conglomerate reflect widespread rifting (Mustard and Roots, 1997) and glaciation (Eisbacher, 1981).

All these older rocks are unconformably overlain in the northern part of the ecoregion by thick-bedded, grey and white Paleozoic carbonate in the west and sandstone in the east. This renewed continental shelf setting is called the Mackenzie Platform. The southern third of the ecoregion is part of the Selwyn Basin. Between them is the Dawson Fault, a reactivated boundary. Selwyn Basin is defined by a deep-water succession of grit and shale (the Hyland Group, part of Windermere Supergroup) overlain by black shale and chert, the Road River Group, with mafic volcanic lenses, minor limestone and siltstone units of Cambrian and Ordovician age. North of Dawson and around the Tombstone Mountains is a thrust panel of quartzite, black argillite and limestone of Upper Paleozoic through Jurassic age. Sub-circular 90 and 94 Ma granitic stocks intruded both folded sedimentary rocks and thrust faults.

The distribution of metallic minerals varies greatly within this broad ecoregion. Entire ranges of sedimentary strata are almost devoid of mineralization, but some structures and rock units have many known occurrences and, therefore, high potential for ore deposits. The Bonnet Plume Range contains uraniferous mineral brannerite; abundant iron as hematite; and traces of copper, barium, cobalt and gold in irregularly shaped breccia bodies (Archer and Schmidt, 1978). A very large hematite iron deposit lies in the headwaters of the Snake River. Significant lead- and zinc-rich veins occur in the south end of the Bonnet Plume Range, as well as in the southern Wernecke and Ogilvie

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Figure 170-2. Steep walls result from exfoliation of syenite in the Tombstone Range. Vertical joints in the rock allow water to penetrate and freeze, incrementally levering out large slabs from the bedrock core. Talus blocks are then reduced in size by physical and chemical weathering, and with time become vegetated by moss and lichen.

mountains. Numerous copper–zinc–lead showings are known in the western Wernecke Mountains near the Hart River volcanogenic massive sulphide deposit. A similar deposit, in Upper Paleozoic quartzite, indicates a prospective horizon for more of these deposits along the southern edge of the ecoregion (Turner and Abbott, 1990). The Tombstone and adjacent stocks contain large, low-grade concentrations of uranium (Bremner, 1994) and adjacent skarn hosts copper–gold (Marn 116B#056) as well as possible porphyry-style gold, copper or molybdenum occurrences. Areas underlain by Devonian to Carboniferous black shale of Imperial Formation or Earn Group have high background barium, zinc, lead and arsenic concentrations, and host local barite and nickel–platinum stratiform deposits. Coal seams are abundant in the Bonnet Plume drainage and near the Monster River, at the northeastern and northwestern edges of the ecoregion.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

Colluvial deposits cover approximately 70% of the area, while glacial deposits, primarily within glaciated valleys, cover about 25%. The remaining 5% includes organic, alluvial and lacustrine deposits.

Modern processes include landslides, rotational slumps, rock fall, and debris flows. Landslides have occurred around Tombstone Mountain and the headwaters of the Wind and Bonnet Plume rivers. Retrogressive thaw–flow slides are developed mainly in lacustrine deposits within discontinuous permafrost. Periglacial features such as pingos, cryoplanation terraces, solifluction lobes, stone polygons, and rock glaciers are present.

The very long exposure of surfaces to weathering, frost shattering and soil creep has resulted in well-developed colluvial blankets on most surfaces at middle to high elevation and thick alluvial fans and aprons in valley bottoms. These deposits can also be subjected to slope- and permafrost-related processes and disturbed surfaces are usually susceptible to retrogressive thaw slides, or detachment slides common on soliflucted surfaces. Several large rockslides in the 30 to 50 X 10 m^3 class are indicative of possible rapid and severe mass movements, sometimes affecting the drainage of rivers, as was the case in the past with the Bonnet Plume River. A few slides were mapped (Thomas and Rampton, 1982a) in the Ogilvie Mountains between 64°15'N and 64°25'N. Another large slide was mapped on the west side of Lake Creek (Vernon and Hughes, 1966). The sedimentary rocks in the area are prone to such catastrophic slumps when the bedding plane is subparallel and steeper than the slope surface (Ricker, 1974).

Solifluction and soil creep are present on many of the hillside and valley walls and are often an indication of permafrost presence. Colluvial fans and talus cones are considered to be unstable and, in many cases, ice-rich. Valley bottoms are occupied by fluvial and morainal sediments and are often overlain by peat deposits of variable thickness, with evidence of patterned ground or cryoturbation. Palsa bogs have been mapped throughout the ecoregion and ice wedges are common in fine-grained sediments. Following disturbance, some of the melting ice wedges can leave depressions up to 3 m wide and 2 m deep.

Rock glaciers and debris-covered glaciers, as well as ice-cored or ice-rich talus cones, are abundant in the Yukon portions of the ecoregion. Active rock glaciers show unvegetated steep fronts (Fig. 170–3) and are usually located at elevations above 1,820 m. Inactive rock glaciers are mostly vegetated, have a rounder front profile, and usually begin at elevations as low as 1,000 m asl. Rock glaciers occupy northeast- to northwest-facing cirques, and occasionally more southerly aspects, particularly in the Wernecke Mountains. Debris-covered glaciers can be as thick as 60 m and head in cirques with steep, north-facing headwalls.

Braided rivers have unstable channels and are subject to seasonal flooding after ice thaw and rain storms. Expansive river icing (aufeis) takes place on most streams. In addition, alluvial and colluvial fans are usually susceptible to erosion and channel migrations.

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Figure 170–3. A rock glacier in the Bonnet Plume Range, cored by ice at its snout and fed by repeated rockfall at its head.

GLACIAL HISTORY

A record of several pre-Reid glaciations starting in the late Pliocene is preserved in the South Ogilvie Mountains portion of the ecoregion. These glaciations are recorded in the Tintina Trench and along the northern slopes of the South Ogilvie Mountains (Duk-Rodkin, 1996). Evidence of the youngest two glaciations, the Reid (ca. 200 ka) and the McConnell (ca. 23 ka), is found in most mountain valleys (Duk-Rodkin, 1996; Kennedy and Smith, 1999). The extent of glaciers during older glaciations was greater than during subsequent ones, a pattern observed throughout the northern Cordillera. Morphologic evidence of glaciation is widespread and is mainly related to the last two glacial periods (Vernon and Hughes, 1966; Duk-Rodkin, 1996).

The Wernecke Mountains portion of the ecoregion was largely covered by the Cordilleran Ice Sheet. The western margin of this ice sheet formed valley glaciers that merged with local glaciers from the South Ogilvie Mountains. Cordilleran valley glaciers also extended westward to the Hart River area and towards the Tintina Trench during pre-Reid glaciations. During the Reid Glaciation, main and local valley glaciers coalesced in the central part of this ecoregion. Local ice caps may also have been present. During the McConnell Glaciation, glaciers occupied only about 50% of cirques thought to have been active during the Reid Glaciation (Vernon and Hughes, 1966). Cordilleran glaciers during the McConnell Glaciation did not reach the central part of this ecoregion. Pre-Reid moraines are absent or subdued and highly colluviated. Reid-age features are also subdued compared to the well-preserved features of the McConnell Glaciation.

In the northern part of the region, the Snake and Bonnet Plume river valleys were affected by the Late Wisconsinan Laurentide Ice Sheet (ca. 30 ka; Hughes *et al.*, 1981; Schweger and Matthews, 1991). At its maximum extent, the ice sheet blocked the drainage of all streams in the Mackenzie and Wernecke mountains, creating a meltwater channel system that crossed divide areas of the Canyon Ranges, exited through a meltwater channel connecting the Arctic Red, Snake, and Bonnet Plume rivers and the Bonnet Plume Depression, and drained into Glacial Lake Hughes (Duk-Rodkin and Hughes, 1995).

CLIMATE

The mountains of the ecoregion act as a second major barrier to air masses moving off the Gulf of Alaska inland. The barrier generates a wet belt, particularly along the southern slopes. These mountains are also formidable enough to stop shallow layers of cold arctic air from reaching the central and southern Yukon.

Mean annual temperatures are near –6°C. There is a seasonal variability, but locally it is not as marked as in many other Yukon ecoregions due to the consistently high elevations here. Mean January temperatures are near –25°C and in July near 8°C. Extreme temperatures from near –50 to 30°C have occurred in the valley floors but probably only range from –35 to 15°C over the highest terrain. In part due to the higher elevations, thawing temperatures can occur in all the winter months and frosts at anytime during the summer.

Precipitation is relatively heavy, particularly over the eastern portions of this ecoregion. Typical annual amounts range from 450 to 600 mm, higher in some years. The heaviest precipitation occurs in July and August with monthly amounts of 50 to 70 mm. Even during the summer, this precipitation can occasionally be in the form of snow, particularly over the higher terrain. The least amount of precipitation is from December to May with monthly amounts of 20 to 30 mm.

Little wind data are available in this ecoregion. The prime storm tracks trend well south or north of this area, so prolonged periods of light winds are expected. However, periods of strong winds may occur due to the higher elevations and funneling effects within the extensive mountain peaks and ranges.

The only climate station that exists in this ecoregion is Klondike. Some inferences could be made using historical data from Ogilvie, Elsa and Tungsten.

HYDROLOGY

The Mackenzie Mountains Ecoregion straddles the divide between the Yukon and Peel river drainage basins. The ecoregion drains the Ogilvie and Wernecke mountains in the central Yukon, as well as the Backbone Ranges of the western Northwest Territories. Major streams include the Hart, Wind, Bonnet Plume, Snake and upper Stewart rivers in the Yukon, as well as the Arctic Red, Mountain and Twitya rivers in the Northwest Territories. Smaller streams include the Beaver, McQuesten, North Klondike, Chandindu and Fifteenmile rivers. The ecoregion is very rugged with considerable relief, and as such, the streamflow characteristics typify that of a high-energy mountain system. A few of the higher mountain peaks contain cirque glaciers. There are no major lakes, though there are numerous intermediate and small upland lakes including Bonnet Plume, Ortell, Fairchild, Pinguicula and Kathleen lakes. Wetland coverage is primarily limited to the upper reaches of the major river valleys (Fig. 170-4).

There are four representative hydrometric stations within the ecoregion: Bonnet Plume and North Klondike within the Yukon portion of the ecoregion, and the Twitya and Mountain rivers within the

Northwest Territories portion of the ecoregion. Annual streamflow is generally characterized by a gradual increase in discharge in the spring, rising to a peak in June or July due to snowmelt inputs. The exception lies within small headwater basins immediately downstream of the glaciated area. In these basins, peak flows occur in July or August due to high elevation snowfield and glacier melt. Many of the headwater streams are steep and relatively short; therefore, streamflow response tends to be rapid and flashy. On these smaller streams, approximately 40% of the annual maximum flows are due to intense summer rainstorm events. Some small steep streams are susceptible to mud flows triggered by these summer rainstorms. Mean annual runoff is moderately high with values ranging from 350 to 445 mm, with an ecosystem average of 377 mm. Mean seasonal and summer flows are likewise moderately high with values of 25 X 10^{-3} and 20 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are moderate with values of 92 X 10^{-3} and 52 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March or April in the southern portion of the ecoregion, and earlier in the northern portion. The mean annual minimum and mean summer minimum flows are moderately high and high with values of 1.3 X 10^{-3} and 8.3 X 10^{-3} $m^3/s/km^2$, respectively.

PERMAFROST

The Mackenzie Mountains Ecoregion straddles the southern boundary of the continuous permafrost zone. Permafrost is found throughout the ecoregion because of its elevation, with near-surface ground temperatures usually above –4°C (Harris *et al.*, 1983b). At Keno Hill, just south of the ecoregion, Wernecke (1932) reported 135 m of permafrost. Placer miners working in the upper reaches of creeks in the Mayo District, also near the southern border of the ecoregion, regularly encounter frozen ground and ground ice in surficial deposits. Similar conditions could be expected within this ecoregion.

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Figure 170-4. A valley-bottom, headwater fen wetland in the upper Bonnet Plume River in the Wernecke Mountains portion of the ecoregion. These headwater fens are the most common form of wetland in the ecoregion.

The Dempster Highway crosses the western portion of the ecoregion. Inspection of geotechnical records from drilling associated with highway maintenance and construction indicates an increase in permafrost occurrence with distance north of Tintina Trench. During a detailed investigation at km 60 to 78, permafrost was encountered in 56% of 165 holes (Department of Highways and Public Works Canada, 1974). Brown (1967) reported permafrost continuous above alpine treeline along the road, with ice wedge networks developed in plateau areas. Ice-rich ground is mainly encountered in moraine and colluvial deposits on hillsides, but when these overlie gravel, the coarse material may be cemented by a matrix of ice (EBA, 1990b). Moist valley-bottom sediments contain ground ice (EBA, 1990b) and thermokarst lakes. There are relatively few pingos in the ecoregion, because surficial materials are predominantly fine-grained. There are a few palsas in some of the valleys.

Occasionally, high, north-facing cirques host debris-covered glaciers, presumably relict from Neoglacial periods (Vernon and Hughes, 1966; Hughes, 1983a). Rock glaciers are also found in the northern portion of the ecoregion, but these occur over a wider range of elevations (Vernon and Hughes, 1966). Above treeline, the ground exhibits features common to periglacial terrain: solifluction lobes on slopes, and a range of patterned ground features at flatter sites. Cryoplanation terraces are evident above glacial limits (e.g. Hughes, 1983b). Extensive bedrock outcrops are frost-weathered throughout the ecoregion, with talus accumulations at their bases.

There is considerable seasonal groundwater flow through the active layer in this terrain, with regular growth of frost blisters in valley floors (Pollard and French, 1984), and persistent development of ice in river channels each winter (Harris *et al.*, 1983b).

SOILS

Strong relief and a continental climate characterize this mountainous ecoregion. Valley bottoms experience very cold winter temperatures and permafrost-affected soils are predominant in the ecoregion. There has been little detailed soils work done in the Yukon portion of the ecoregion except for the area around the Tombstone Range in the South Ogilvie Mountains (sites 17–23 *in* Tarnocai *et al.*, 1993; Kennedy and Smith, 1999).

Soils have formed primarily from colluvial parent materials derived from a variety of lithologies of sedimentary and metamorphic origin. Bedrock outcrops and felsenmeer are common along ridges and summits. Alpine tundra environments exhibit patterned ground formations associated with Turbic Cryosols; in the more level topography of mountain passes, ice-wedge formations underlie most of the soil surface. Upper slope colluvium is coarse and often without near-surface permafrost. Eutric and Dystric Brunisols form depending on the reaction of the parent geologic materials; where materials are more unstable, Regosols are most common. Lower- and mid-slope positions vary in texture and in temperature regime. Warmer aspects often support Brunisols and associated spruce forest. Cooler aspects and moister sites tend to have Cryosol development under open stands of black spruce.

Most of the ecoregion has been subject to localized valley glaciation so that moraine and glaciofluvial materials are found on most valley bottoms. Eutric Brunisols are formed on gravelly glaciofluvial deposits; however, most finer-textured materials have Turbic Cryosol formation. This is particularly true in the higher elevations and mountain passes (Kennedy and Smith, 1999). There are no extensive wetlands in this ecoregion, although localized depressions on valley floors contain ribbed fens and occasional peat plateau bogs. All are underlain, at least in part, by permafrost, and the soils are both Gleysolic Turbic Cryosols and Organic Cryosols.

VEGETATION

The vegetation of the Mackenzie Mountains Ecoregion is primarily alpine tundra interfingered with valleys of taiga forest. The steep mountains separated by narrow valleys have lichen-ground shrub alpine tundra on summits and slopes, sparsely vegetated scree slopes, and shrub-dominated subalpine valleys or treed valleys at lower elevations (Fig. 170-5). Treeline is around 1,200 m asl, though slightly lower in the South Ogilvie Mountains in the west of the ecoregion (Oswald and Senyk, 1977). Lodgepole pine and subalpine fir are largely absent from the ecoregion. No systematic regional vegetation surveys exist for this ecoregion except in the proposed Tombstone Park area in the western corner (Kennedy and Smith, 1999).

Shrub- and herb-rich white spruce communities are found on low-elevation alluvial sites and similar, though often less diverse, communities are found along the sides of valleys. Shrubs include Labrador tea, willow, rose, soapberry and alpine blueberry; horsetail, lupine, and bear root characterize the herb layer. Typically, white spruce may be found on the sides of the valleys while shrub birch communities dominate coarser valley deposits. Stands of black and white spruce or mixed stands of spruce, aspen, paper birch and balsam poplar are found at low elevations (LGL, 1981; Stanek *et al.*, 1981; Kennedy, 1992; MacHutcheon, 1997).

Balsam poplar, willow and alder colonize recent floodplain deposits that are permafrost free. These communities typically have an understory of diverse forbs. Tall willow–sedge swamps establish along creek drainages and lake margins with a groundcover dominated by sedges and moss, with other graminoids and sparse but diverse forbs (Kennedy and Smith, 1999). Seepage sites on mountain slopes host a diverse forb community (Fig. 170-6). Poorly drained, gently sloping lower slopes, with near surface permafrost and Gleysolic Turbic Cryosol soil formation, are dominated by low shrub tussock tundra. Sedge tussocks with Labrador tea, shrub birch and other ground shrubs constitute this community. Tall willow swamps indicate drainages with deeper active layers.

Shrub birch–willow communities dominate middle elevations. These communities are found both on mountain slopes and on river terraces in subalpine valleys (Russell et al., 1992; MacHutcheon, 1997; Kennedy and Smith, 1999). On drier sites with Brunisolic soils, Dryas and ground shrubs such as net-veined willow, lowbush cranberry, Labrador tea and lichen underlie the shrub birch. Juniper and kinnikinnick grow on the driest sites. Scattered white spruce may be present at lower elevations. On moister sites, willow predominates with Dryas, moss, lichen, and commonly bearberry, lowbush cranberry, alpine blueberry, cloudberry, and sometimes horsetail.

At the highest elevations (>1,500 m), exposed sites and steep, unstable slopes may be bare rock or rock and rubble. Rock lichens such as *Umbilicaria* spp. colonize the rubble talus while very sparse forbs,

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Figure 170-5. Scattered stands of boreal forest are present in valley bottoms along the southern fringes of the ecoregion. South-facing slopes support closed forest (white spruce where well drained, black spruce elsewhere). Stand structure and age are controlled by fire history. View northward toward the Nadaleen Range, from the lower Nadaleen River valley.

Figure 170-6. Above treeline (1,200 m elevation) in the upper Stewart River valley, are verdant slopes of monkshood *(Aconitum delphinifolium,* blue), goldenrod *(Solidago multiradiata)*, wild sweet pea *(Hedysarum boreale,* pink) and other wildflowers. These well-drained slopes are free of near-surface permafrost and receive long summer sun. An important factor is abundant seepage from melting snow at higher elevations. Runoff from the dolomite, argillite and siltstone ranges tends to be alkaline and enhances the diversity of plant communities.

graminoids and bryophytes establish in sheltered pockets (Kennedy and Smith, 1999). Lichen, *Dryas* spp., dwarf willow and ericaceous shrubs dominate more gentle slopes usually associated with patterned ground and Turbic Cryosol soils (Jingfors and McKenna, 1991). White mountain heather communities are common on mesic to moist sites with northerly aspects and where snow persists late in the season. Periglacial features such as solifluction lobes and patterned ground are outlined by vegetation patterns. Steep slopes are often very sparsely vegetated.

WILDLIFE

Mammals

Grizzly bear and wolverine, indicators of ecosystem health, are abundant here, though wolves are not. Woodland caribou of the Bonnet Plume and Hart River herds range in the north and the Redstone herd ranges in the southeastern part of the ecoregion. The Bonnet Plume herd, numbering about 5,000, and the Redstone herd, numbering 5,000 to 10,000, are among the largest woodland caribou herds in the Yukon. Dall sheep are found in the northern and eastern sections of the ecoregion and Stone sheep are more common to the south and west (Barichello *et al.*, 1989a).

Collared pika, singing vole, and Ogilvie Mountains lemming are characteristic small mammals. The Ogilvie Mountains lemming may be the only mammal species restricted to the Yukon, and occurs in only one other ecoregion (North Ogilvie Mountains Ecoregion). The deer mouse, least chipmunk, and hoary marmot reach their northern range limits here. Most mammal species have received little attention and ranges can only be estimated. Species known or expected to occur in this ecoregion are listed in Table 4.

Birds

Few documented bird records exist for this remote ecoregion. Overall, waterbird populations are low; there are few wetlands. Swift-flowing mountain streams are inhabited in summer by Harlequin Duck and Wandering Tattler, and possibly year-round by American Dipper (Osgood, 1909; Frisch, 1987). Small numbers of Trumpeter Swans breed in the upper reaches of the Stewart River (McKelvey and Hawkings, 1990). Mew Gull and Belted Kingfisher breed on some lower elevation lakes and rivers while Solitary and Spotted Sandpipers occur along the shores and marshes of these scattered wetlands. Riparian thickets of willow, alder, and birch support breeding songbirds such as Alder Flycatcher, Orange-crowned Warbler, Yellow Warbler, Northern Waterthrush, Savannah Sparrow, and Lincoln's Sparrow (Frisch, 1987).

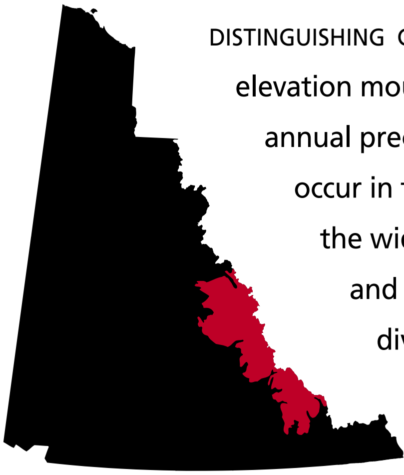
Spruce forests provide breeding habitat for Merlin, Northern Flicker, Swainson's Thrush, Yellow-rumped Warbler, Blackpoll Warbler, and Dark-eyed Junco (Osgood, 1909; Frisch, 1975). Peregrine Falcon nests on bluffs overlooking the forested valleys (Osgood, 1909; Canadian Wildlife Service, unpubl.). Year-round residents include Northern Goshawk, Northern Hawk Owl, Three-toed Woodpecker, Gray Jay, Common Raven, and Boreal Chickadee (Frisch, 1987).

At higher elevations, Townsend's Solitaire nest in open subalpine forests, while Upland Sandpipers favour tundra just above treeline (Frisch, 1987). Near treeline, shrub birch and willow provide breeding habitat for Willow Ptarmigan; Northern Shrike; Wilson's Warbler; and American Tree, White-crowned, and Golden-crowned Sparrows (Frisch, 1987; Sinclair, 1996). Exposed, rocky slopes support small numbers of White-tailed Ptarmigan, Northern Wheatear, Gray-crowned Rosy Finch (Sinclair, 1995), and possibly Horned Lark (Osgood, 1909; Frisch, 1975; Sinclair, 1996). Golden Eagle and Gyrfalcon nest on cliffs and ledges, while Snow Bunting is known to breed on north-facing cirques with areas of permanent snow (Osgood, 1909; Frisch, 1975). Surfbird, a species whose Canadian breeding range is restricted to the mountains of the northern Yukon, inhabits heath-covered slopes (Frisch, 1987). Alpine tundra provides breeding habitat for Rock Ptarmigan, Short-eared Owl, and American Pipit (Frisch, 1975; Canadian Wildlife Service, unpubl.).

Selwyn Mountains

Taiga Cordillera Ecozone

ECOREGION 171



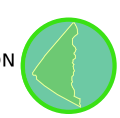
DISTINGUISHING CHARACTERISTICS: This ecoregion is characterized by rugged, high-elevation mountain ranges, many supporting alpine glaciers. Some of the highest annual precipitation values in the Yukon, outside of the Pacific Maritime Ecozone, occur in this ecoregion. The heavy snow blanket insulates many valleys from the widespread establishment of permafrost. Subalpine shrub–birch–willow and alpine vegetation predominate. These areas support the highest diversity of mammals in the Taiga Cordilleran Ecozone, including the northern limit of the range for flying squirrel, little brown bat, jumping mouse, wood rat, mule deer and mountain goat.

J. Meikle, Yukon Government

Figure 171-1. The Selwyn Mountains Ecoregion forms the last major cordilleran barrier to eastward-moving weather systems and produces a "wet belt" in eastern Yukon. The ice sheets on Keele Peak are the most extensive outside of Kluane National Park.

APPROXIMATE LAND COVER
boreal/subalpine coniferous forest, 65%
rocklands, 15%
alpine tundra, 20%

TOTAL AREA OF ECOREGION IN CANADA
71,890 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
35,578 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
7%

Metres above sea level

ELEVATIONAL RANGE
745–2,970 m asl
mean elevation 1,380 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Itsi Range and Logan Mountains Ecoregions** (Oswald and Senyk, 1977) • Portion of **Taiga Cordillera Region** (CEC, 1997) • Portion **Ogilvie/Mackenzie Alpine Tundra Ecoregion** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Selwyn Mountains Ecoregion incorporates the Hess and Logan mountains, which form the Yukon–Northwest Territories border between 61°N and 64°N. About half of the ecoregion extends into the Northwest Territories.

The Hess and Logan mountains are the rugged, high-elevation physiographic units (Matthews, 1986) in this ecoregion. They consist of mountains and ridges separated by broad valleys. Between the Hess and Logan mountains is a less rugged area with broader valleys, the headwaters of the Pelly River. The Tasin, Rogue and Itsi ranges make up the Hess Mountains. Most of the massifs are cored by more resistant intrusive rocks. Keele Peak (Fig. 171-1), the Itsi Range and peaks in the Logan and Rogue ranges support alpine glaciers.

Keele Peak is 2,970 m asl and the highest point in the ecoregion. Numerous other mountains are over 2,200 m asl and much of the area lies above 1,500 m asl. Local relief ranges from 900 to 1,500 m.

The Hess Mountains drain mainly west to the Stewart and Macmillan rivers and southwest via the Ross River. The Logan Mountains drain west via the Pelly River and south through tributaries of the Frances, Hyland and Coal rivers to the Liard River. Lakes are found occasionally throughout the ecoregion but are more common in the broader valleys between the Hess and Logan mountains. Pelly Lakes are the largest waterbodies in the ecoregion.

BEDROCK GEOLOGY

The geology of the Yukon part of this ecoregion differs markedly from that portion in the adjacent Northwest Territories. It is characterized by dark-weathering Paleozoic clastic sedimentary rocks of the Selwyn Basin tectonic assemblage, rather than the colourful Proterozoic and Paleozoic carbonate strata of the Mackenzie Platform in the Northwest Territories. Regional geological maps exist for most of the Yukon portion of the ecoregion (Gabrielse *et al.*, 1973; Gordey and Irwin, 1987; Gordey and Anderson, 1993; Cecile, 2000), although some are in preliminary form (Blusson, 1966; Roots *et al.*, 1995).

The Selwyn Basin was a deep-water depositional environment with periodic clastic influx and reducing conditions. The oldest rocks are a thick, widely exposed sequence of coarse sandstone, conglomerate and maroon shale of the Hyland Group (this and all subsequently mentioned units are described in Gordey and Anderson, 1993). These Late Proterozoic to Cambrian sediments are overlain in adjacent areas by the dull grey-brown shale Gull Lake Formation, and by thin-bedded limestone of the Rabbitkettle Formation, both of Cambrian age. The Road River Group is the most widespread unit, commonly underlying subdued topography. It includes black and silvery weathering shale and grey chert, which northward is increasingly green or blue.

In Late Devonian time, the Selwyn Basin was inundated by chert–quartz sandstone and chert pebble conglomerate of the Earn Group, eroded from the units further west (Abbott *et al.*, 1986). Atop these dark-coloured rocks, thin remnants of turbidic sandstone and shale of the Tsichu, Mount Christie and Jones Lake formations are locally preserved. Numerous sub-circular plutons of hornblende and biotite granite of the Selwyn Plutonic Suite (92–106 Ma) form extremely rugged massifs, such as Horn Peak, Keele Peak, Itsi Range and Mount Billings. The plutons are encircled by a 0.5 to 2 km wide zone of contact metamorphosed, high-standing and commonly rusty-weathering sedimentary rocks, though surrounding areas have typically low relief.

In Late Jurassic and Early Cretaceous time, the sedimentary strata were intensely deformed into tight folds, separated by thrust faults. Seemingly enormous thicknesses of similar strata are really thin beds imbricated by layer-parallel thrust faults. Furthermore, horizontal thrust faults, rarely apparent without regional structural analysis (e.g. Gordey, 1981), underlie most of the ecoregion. Two regional-scale, dextral faults, the Hess and Macmillan (Abbott and Turner, 1990), extend northwest from the headwaters of their namesake rivers. Large unexplained earthquakes occasionally shake the region (Wetmiller *et al.*, 1989) and may trigger the rockslides in jointed, well-bedded, carbonate rocks perched above the glacially deepened valleys (Eisbacher, 1977, 1978).

Most known mineralization consists of shale-hosted zinc, lead and tungsten in altered carbonate rock near granite plutons; thus, certain sedimentary horizons and plutons have potential for ore deposits. Near Macmillan Pass, zinc, lead and barite deposits are spatially related to syndepositional faults (Abbott and Turner, 1990) in the Earn Group, which also contains barite deposits and geochemical anomalies. Road River shales contain large stratiform zinc–lead deposits at Howards Pass, 40 km southeast of Macmillan Pass. Mactung, 5 km northeast of Macmillan Pass, and Cantung, 105 km north of Watson Lake, are significant scheelite deposits in the ecoregion. Sub-economic zinc–lead–silver (copper–tungsten) skarn showings are abundant around the granite north of Mount Billings, east of Tillei Lake. Other deposit types include the Plata–Inca argentiferous galena in quartz veins cutting black shale about 15 km northeast of the mouth of Rogue River, and gold, bismuthenite and gem-quality sphalerite collected from sheeted quartz veins within the Emerald Lake pluton.

SURFICIAL GEOLOGY AND GLACIAL HISTORY

The Selwyn Mountains Ecoregion was a centre of ice accumulation and intense glacial erosion during the McConnell glaciation of the Yukon (Bostock, 1966). Alpine landforms such as horns and arêtes are common in this area. Significant accumulations of glacial sediments are present only in the bottoms of major valleys where moraine and glaciofluvial deposits can be found. Upper slopes and side valleys are blanketed with Holocene colluvium deposits of various thickness and particle size.

Ice crossed the continental divide from west of the Nahanni Valley to feed the Selwyn Lobe of the Cordilleran Ice Sheet (Jackson, 1987). The Selwyn Mountains also shed ice south into the Liard Basin (Dyke, 1990a) and fed eastward flowing glaciers which merged with the Laurentide Ice Sheet in the Mackenzie Valley (Jackson and Mackay, 1991; Jackson *et al.*, 1991; Jackson, 1994). The major expansion of glaciers in this region occurred less than 26,000 years ago (Jackson and Harington, 1991; Jackson *et al.*, 1991). Deglaciation occurred from the top down, with upland areas being the first to emerge while valleys remained under stagnant valley glaciers (Jackson, 1987, 1994). During the postglacial period, streams incised into the glaciated terrain left flights of stream terraces and built alluvial fans. Intense mechanical weathering and mass wasting created mantles of colluvium on mountain slopes. Cirque glaciers and rock glaciers advanced during the Little Ice Age of the past few centuries; rock glaciers remain active in many areas (Jackson and MacDonald, 1980; Jackson, 1987; Dyke, 1990b). Alpine glaciers of significant size remain today on Keele Peak, Horn Peak, the Itsi Range and numerous peaks east of Tillei Lake in the Logan Mountains.

CLIMATE

This ecoregion is located on the western slopes of the continental divide between the Yukon and Northwest Territories. Elevations rise from near 1,000 m asl along this ecoregion's eastern boundary to an average of 1,700 m asl along the divide. Seasonal variations and the effect of elevation result in a complex climate. Useful but limited climatic data are available from Sheldon Lake (Twin Creeks), Yukon and Tsichu River and Tungsten, Northwest Territories.

Mean annual temperatures are believed to range from –5 to –8°C. Mean temperatures are expected to be near –20°C in January, and 5 to 10°C in July. Summer temperatures are lower in summer at the higher elevations. Temperature extremes in January in the valley floors can range from –55 to 3°C, but over the higher terrain temperatures would probably range from –30 to –5°C. In July, extremes would range from –5 to 30°C in the valley floor and from –5 to 15°C over higher terrain. Frost can be expected at any time of the year.

Precipitation is moderate and locally heavy with annual amounts of 600 to 700 mm. These are the highest values for precipitation in the Yukon outside of the coastal ranges (Fig. 171-1). The winter months have mean amounts of 30 to 50 mm with the least amounts from February to April. The wettest months are July and August with rainfall amounts of 60 to 90 mm. Even during the warmer months the precipitation may fall as wet snow or snow pellets.

There is little wind data, but winds are believed to be light to moderate. Due to funnelling effects in the mountain ranges, it is expected that periods of strong winds should be expected at any time of year.

HYDROLOGY

The ecoregion straddles the Northwest Territories border from the Hyland River in the south to the Lansing River in the north. It drains the Selwyn Mountains to the west and south through the upper Hyland (Fig. 171-2) into the Liard River basin; the Pelly, Ross, Macmillan, Hess, Rogue and Lansing rivers into the Yukon River basin within the Yukon, and the South Nahanni, Keele and Mountain rivers to the south and east within the Northwest Territories. Streamflow characteristics typify that of a high-energy mountain system. Several of the highest mountain peaks contain alpine glaciers. There are no major lakes, though there are numerous medium-sized and small lakes including Pelly, Fortin, Itsi, Fuller, Keele and Arrow lakes. Wetland coverage is limited but distributed throughout the major river valleys.

There are 12 representative hydrometric stations for the ecoregion: Hyland, South Macmillan, Hess and Pelly rivers, and King and Boulder creeks within the Yukon portion of the ecoregion. Other representative stations within the Northwest Territories portion of the ecoregion include Flat, Tsichu, and Silverberry rivers and Mac and Lened creeks. Though several glaciers are present, their respective areas are relatively small; therefore, hydrologic response within the ecoregion does not generally exhibit characteristics typical of a glaciated system. The exception lies within first- and second-order basins immediately downstream of the glaciated area. Annual streamflow within these exceptional areas is characterized by a gradual increase in discharge in the spring, rising to a peak in July or August due to high elevation snowfield and glacier melt. In non-glaciated systems, peak flows occur in June as a result of snowmelt inputs.

This ecoregion has among the highest peak flows in the Yukon. Many of the first- and second-order headwater streams are steep and relatively short; therefore, streamflow response tends to be rapid and flashy. On these smaller streams, approximately 40% of the annual maximum flows are due to intense summer rainstorm events. Some small, steep streams are susceptible to mud flows triggered by these summer rainstorms. Mean annual runoff is generally high, though variable, ranging from 290 mm in lower elevation basins to 705 mm in higher elevation basins with an ecosystem average of 536 mm. Mean seasonal and summer

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Figure 171-2. Mixed stands of white spruce, subalpine fir and black spruce occur along the upper Hyland River in the southeastern portion of the ecoregion. The alpine vegetation, as seen here in the Billings Range (background), is a much more common vegetation condition over most of the ecoregion.

flows are likewise high, with values of 37 X 10^{-3} and 30 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flows are moderately high with values of 127 X 10^{-3} and 76 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March or April in the southern portion of the ecoregion, and earlier in the northern portion. The mean annual minimum and mean summer minimum flows are likewise high, with values of 1.3 X 10^{-3} and 8.8 X 10^{-3} $m^3/s/km^2$, respectively.

PERMAFROST

The Selwyn Mountains Ecoregion is in the widespread discontinuous permafrost zone. Harris (1986) suggested that permafrost is continuous above 1,300 m asl in the north of the ecoregion, and above 1,450 m asl in the south. In valleys, permafrost is often absent or discontinuous due to snow accumulation in winter. In Macmillan Pass, at 1,106 m asl, permafrost occurs in the valley bottom as isolated palsas (Kershaw and Gill, 1979; Harris and Nyrose, 1992) and is not extensive. The active layer in these peat mounds is less than 60 cm thick and overlies up to 5 m of permafrost (Kershaw and Gill, 1979). Mean near-surface ground temperatures in the valley at Macmillan and Howards passes are above 0°C (Burgess *et al.*, 1982).

At higher elevations, there are plenty of features that indicate the presence of permafrost. Hundreds of rock glaciers were noted by Dyke (1990a) in the southern portion of the ecoregion (Fig. 171-3), as well as debris-covered glaciers and small cirque glaciers. The terrain was glaciated; a veneer of drift that has developed solifluction lobes covers most mountainsides. The active layer in this drift is often over 1 m deep, due to its coarse nature (Dyke, 1990a). Ground ice is prevalent in glaciolacustrine sediments and ubiquitous in organic soils, which form blanket bogs in some valleys (Jackson, 1987).

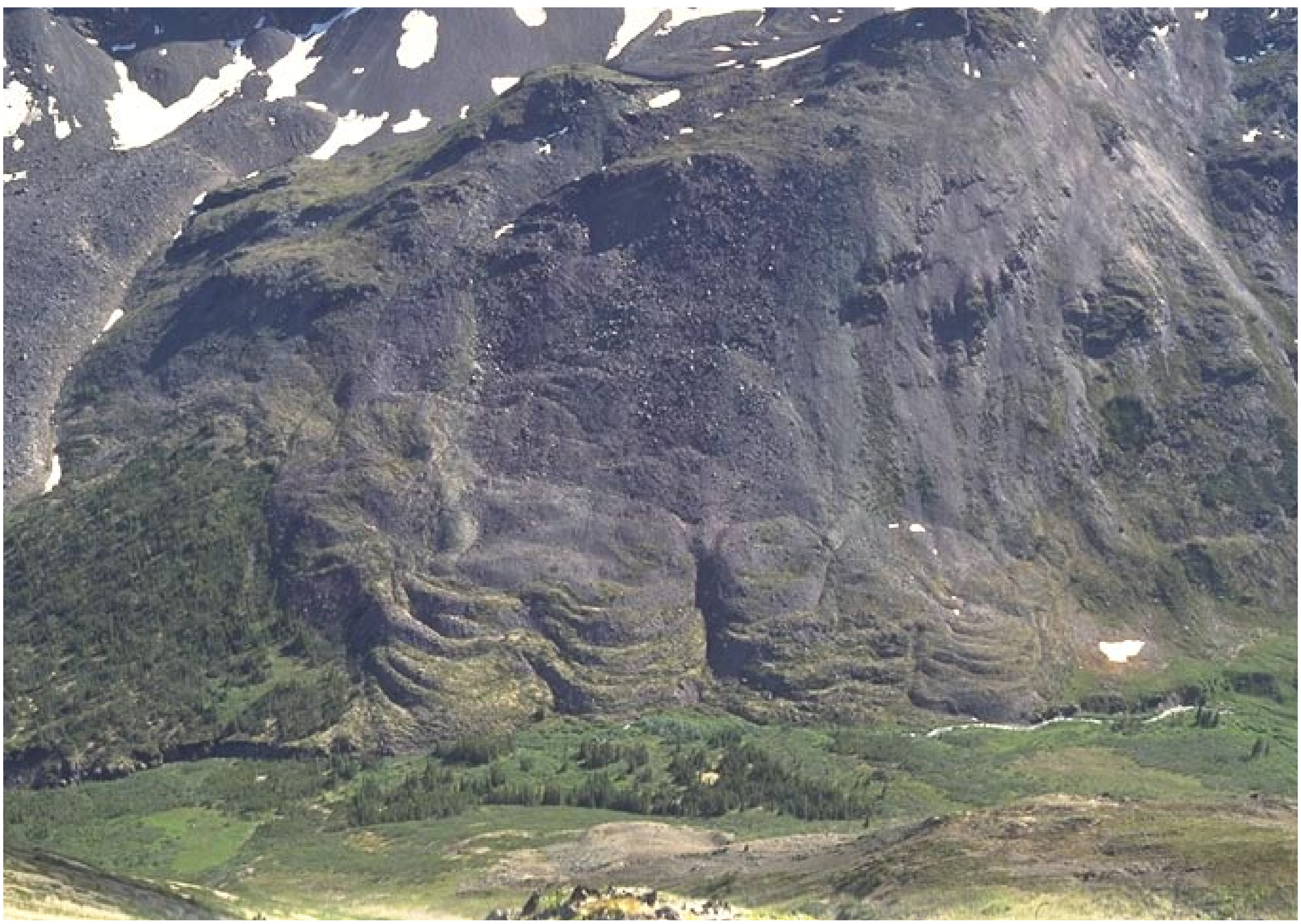

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Figure 171-3. Series of rock glaciers formed in coarse talus in the Lansing Range. The rock glaciers are visible as lobes of rock debris along the lower slope that "flow" as a result of an ice core.

SOILS

Soils in this rugged, high-elevation ecoregion have formed under the influence of a relatively moist, continental climate on a variety of geologic parent materials. Detailed soil studies have been conducted in the northern part of the ecoregion in the Macmillan Pass area (Department of Renewable Resources, 1981) and in the southern portions of the ecoregion in the upper Hyland River watershed (Zoladeski and Cowell, 1996).

Mountain summits and ridges are characterized by bedrock outcrops and shallow soil over bedrock. Coarse colluvium associated with felsenmeer or active alpine glaciers supports Regosol formation. Alpine environments present a mosaic of soils, such that a complex of Turbic Cryosols and Eutric Brunisols co-exist depending on moisture regime and the extent and location of permafrost. North-facing slopes and seepage areas tend to be underlain by permafrost, particularly in the northern portion of the ecoregion where Regosolic Turbic Cryosols and Orthic Turbic Cryosols are found on slopes under open-canopy black spruce forests. Warmer slopes tend to be without permafrost and support Eutric and Dystric Brunisols, depending on the mineralogy of parent materials. Occasional Orthic Humo–Ferric Podzols occur on well-drained parent materials at subalpine elevations (Department of Renewable Resources, 1981).

A variety of glacial materials are found on lower slopes and valley bottoms. Moraine most often supports Eutric Brunisol formation. Strong leaching in gravelly glaciofluvial materials leads to the development of Dystric Brunisols and, in some localities, Orthic Humo–Ferric Podzols. This is the only ecoregion in the Yukon where podzolic soils are significant.

There are some extensive wetlands in major valley systems. Sedge-dominated wetlands, or fens, are often without permafrost; their associated soils are Typic Mesosols. Where sphagnum peat accumulates, peat plateau bogs underlain by near-surface permafrost support Organic Cryosol formation.

VEGETATION

The vegetation of the Selwyn Mountains is mainly alpine and subalpine. Valleys and middle to lower slopes are forested (Fig. 171-2).

Alpine ridges and peaks are sparsely vegetated. The vegetation composition of alpine areas varies greatly within short distances due to microtopography, microclimate and changes in bedrock lithology. The more nutrient-rich limestones and carbonate-rich shales host different plant assemblages, including more forbs (dryas, anemone and gentian) than the more acidic bedrock types.

Lichen–grass communities with lots of exposed soil and rock dominate the most extreme sites at high elevations. Dwarf shrub communities are common on slopes and ridges between 1,200 and 1,800 m asl, occupying slightly moister sites than the lichen-dominated communities. White mountain heather, crowberry and alpine blueberry, grass, sagewort, gentian, feathermoss, *Cetraria* and reindeer lichens are the typical plants found in these areas. Rock lichen colonizes scree slopes.

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Figure 171-4. Near treeline, the vegetation consists of open stands of subalpine fir trees intermingled with krummholz surrounded by heath–forb meadows. This ecoregion contains many mineralized showings in the exposed rock of alpine areas.

Shrub birch–willow communities dominate much of the subalpine including many colluvial slopes, coarser deposits of subalpine valleys, and gentle moraine slopes in the northern part of the ecoregion along the Northwest Territories border (Department of Renewable Resources, 1981). Shrub birch has an understory of alpine blueberry, crowberry, feathermoss and lichens, with willow on moister sites.

Subalpine fir is also common in the subalpine found between about 1,200 and 1,600 m asl. Sparse trees and krummholz growth forms predominate with increasing elevation. On dry southerly exposures, sparse patches of fir krummholz form the treeline (Fig. 171-4). Denser stands of fir and fir krummholz are found on north-facing slopes.

Black spruce predominates at lower elevations through much of the ecoregion. In the valleys, patches of white and black spruce, subalpine fir, and mixed stands are interspersed with shrubland and wetlands. White spruce–feathermoss stands are restricted to river floodplains associated with Regosolic and Gleysolic soils (Zoladeski and Cowell, 1996).

Black spruce is found on lower slopes or level areas with near-surface permafrost and Cryosols in organic and moraine parent materials. On these poorly drained sites, black spruce is associated with shrub birch, willow, Labrador tea, sphagnum, feathermosses and lichen. On slightly better drained mounds and moraine slopes, lichen and shrub birch dominate the understory.

Lodgepole pine is restricted to old burns in the lower part of the Hyland River Valley and possibly other lowland areas on the margins of the ecoregion.

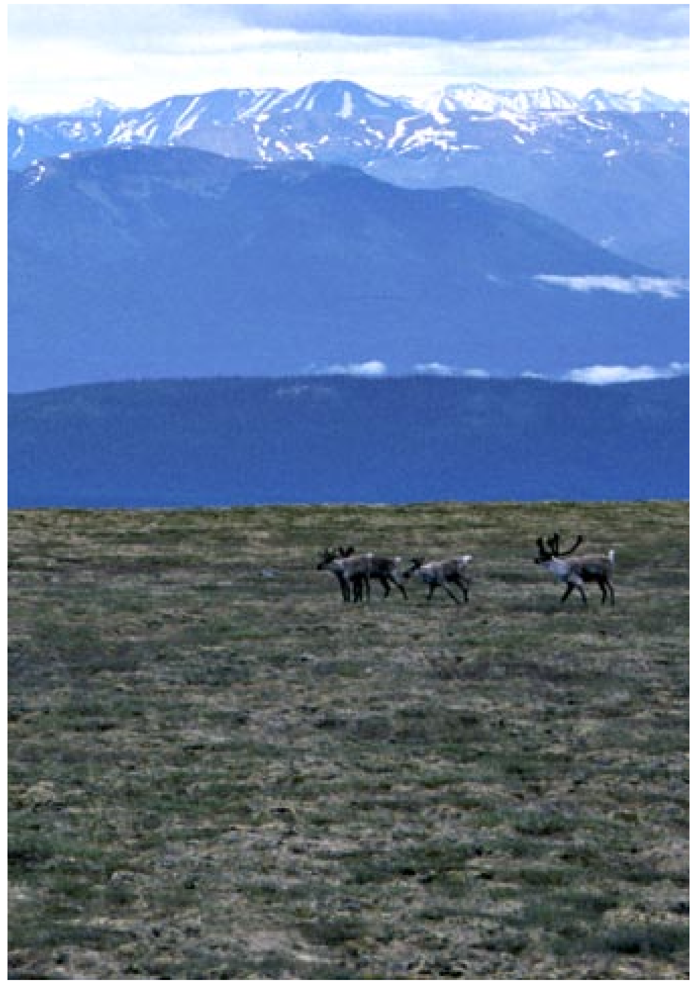

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Figure 171-5. The Selwyn Mountains Ecoregion is used by large woodland caribou herds for calving and summer habitat. The Yukon portion of this ecoregion receives heavy snowloads, forcing the Finlayson and Tay (above) caribou to migrate to winter range in the Yukon Plateau North Ecoregion.

WILDLIFE

Mammals

The Selwyn Mountains possess the highest diversity of mammals in the Taiga Cordillera of the Yukon. Woodland caribou are present as two herds largely confined to the Yukon; the Tay River herd was estimated at 3,800 in 1996 and the Finlayson herd was estimated at 4,100 in 1999 (Fig. 171-5). Also, a number of woodland herds range across the Yukon–Northwest Territories border. Of these, the best studied is the Nahanni herd estimated at about 900 in 2001. Other caribou are known to live in the alpine blocks of the upper Hyland and Coal watersheds in the Yukon. These caribou and the Nahanni herd all appear to use a large wintering area within Nahanni National Park and south of the park. Their range use is known only from movements of a few satellite radio-collared caribou.

The highest densities of mountain goats in the Yukon, outside of Kluane National Park, occur in the Logan Mountains, within this ecoregion. They reach their northern limit of distribution in Yukon's Itsi Range (Barichello and Carey, 1988). Dall sheep are found in the eastern sections and Stone sheep in the western sections of the ecoregion.

Other species at their northern limit here include the Northern Flying Squirrel, Meadow Jumping Mouse, Little Brown Myotis, Bushy-tailed Wood Rat and Mule Deer. Grizzly bears, wolves and wolverine are relatively common. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Birds

Common waterbirds breeding on low elevation rivers, lakes, and wetlands include Pacific and Common Loons, Horned Grebe, Trumpeter Swan, Canada Goose, American Widgeon, Mallard, Northern Pintail, Surf Scoter, Long-tailed Duck, and Common Merganser. Typical shorebirds and gulls include Lesser Yellowlegs, Solitary Sandpiper, Least Sandpiper, Common Snipe, Bonaparte's and Mew Gulls, and Arctic Tern (Dennington *et al.*, 1983; Theberge *et al.*, 1986; McKelvey and Hawkings, 1990). Alder Flycatcher, Tree and Cliff Swallows, Yellow Warbler, Northern Waterthrush, Lincoln's Sparrow, and Rusty Blackbird are among the many songbirds that breed in association with these wetland areas (Theberge *et al.*, 1986).

Low elevation forests support a variety of breeding songbirds including Olive-sided and Yellow-bellied Flycatchers; Ruby-crowned Kinglet; Gray-cheeked and Swainson's Thrushes; Yellow-rumped, Blackpoll, and Tennessee Warblers at its northern limit; Chipping Sparrow; Dark-eyed Junco; and Pine Grosbeak (Theberge *et al.*, 1986). These forests are probably inhabited year round by species such as Gray Jay, Common Raven, and Black-capped and Boreal Chickadees (Godfrey, 1986).

Dwarf birch and shrub willow in the subalpine provide breeding habitat for Willow Ptarmigan and a number of migrant songbirds such as Wilson's Warbler, and American Tree, Savannah, White-crowned, and Golden-crowned Sparrows (Rand, 1946; Godfrey, 1986; Theberge *et al.*, 1986). Blue Grouse, Northern Shrike, and Townsend's Solitaire inhabit open subalpine forests (Rand, 1946; Theberge *et al.*, 1986). Scattered lakes and ponds in these subalpine areas support nesting Red-throated Loons (Theberge *et al.*, 1986).

Despite the apparent abundance of suitable nesting habitat for Golden Eagle and Gyrfalcon, only very low densities of Golden Eagles and a few Gyrfalcons have been reported (Theberge *et al.*, 1986). These areas of rock outcrops, boulder fields and talus slopes do support Rock Ptarmigan and, rarely, White-tailed Ptarmigan. Other breeding species in these high alpine areas are Wandering Tattler, Short-eared Owl, Horned Lark, American Pipit, and Gray-crowned Rosy Finch (Theberge *et al.*, 1986). Snow Buntings breed in areas of permanent snow, usually on north-facing slopes of these mountains (Theberge *et al.*, 1986).

BOREAL CORDILLERA ECOZONE

This ecozone is located in the midsection of the western cordilleran system of Canada. It covers sections of northern British Columbia and the southern Yukon. Ecologically, it is an extension of the boreal forest zone that stretches across the continent from the Atlantic coast in Labrador. The boreal zone is modified within the cordillera by strong gradients of elevation, temperature and precipitation over short distances.

Hydrology: This ecozone encompasses portions of three major drainage systems: the Yukon, Liard and Alsek (Fig. 7). Most of the ecozone experiences a rapid increase in streamflow discharge in May due to snowmelt, with high flow continuing for a few weeks maintained by summer rainfall. Streams in the southwest can have peak flows in July or August due to snowfield and glacier melt. Lying south of the continuous permafrost zone, there is more ground water flow than in the Taiga Cordillera Ecozone and ground water discharge generally continues throughout winter.

Climate: The cold climate ranges from sub-humid to semi-arid. It is marked by long, cold winters and short, warm summers as modified by elevation and aspect. Mean annual temperature ranges from 1 to 5.5°C. The coldest average annual temperatures occur in the Yukon portion of the ecozone. The mean summer temperatures range from 9.5 to 11.5°C. Mean winter temperatures range from –13 to –23°C. The Pacific maritime influence moderates temperatures over most of the ecozone. Mean annual

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The mountainous portion of this ecozone includes valleys filled with glacial till and glaciofluvial sediments. These support a diversity of wildlife habitats such as this wetland beside the Watson River in the Yukon Southern Lakes Ecoregion. Beaver (shown above) are common throughout the ecozone.

precipitation is lowest in valleys within the rain shadow of the coastal ranges, at less than 300 mm, and increases in the interior ranges farther east, where up to 1000 mm of precipitation is received at higher elevations. Precipitation in the intermontane plateau areas is 300 to 500 mm annually.

Vegetation: In the central Yukon portion of this ecozone, there are grasslands on south-facing slopes with boreal forest vegetation on the north-facing slopes, a feature unique within the boreal forests of Canada. The vegetative cover varies from closed to open canopies over most plateaus and valleys. Tree species include white and black spruce, subalpine fir, lodgepole pine, trembling aspen, balsam poplar, and paper birch. In the northwest, the stands are generally open, and lodgepole pine and subalpine fir are usually absent. At higher elevations, extensive areas of rolling alpine tundra are characterized by sedge-dominated meadows, and lichen-colonized rock fields are common.

Landforms and soils: This ecozone is characterized by mountain ranges, which contain numerous high peaks and extensive plateaus, separated by wide valleys and lowlands. These have been modified as a result of glaciation, erosion, solifluction, and tephra deposition. Glacial drift, colluvium, and bedrock outcrops constitute the main surface materials. A small portion of this ecozone in the northwest was unglaciated. Permafrost and associated landscape features tend to be widespread in the more northerly areas and at higher elevations; soils are Cryosolic in these regions. In the warmer, lower elevations in the southern half, Brunisols and Luvisols are common.

Wildlife: Characteristic mammals of the Boreal Cordillera ecozone include woodland caribou, moose, Dall sheep, mountain goats, black and grizzly bears, marten, lynx, American pika, hoary marmots and Arctic ground squirrels. Representative bird species include Willow, Rock and White-tailed Ptarmigan, and Spruce Grouse, along with a variety of migratory songbirds and waterfowl.

Human activities: The zone is rich in mineral resources. In addition, the large river systems that drain this ecozone have fostered forestry, tourism and some localized agriculture. The total population of the ecozone is approximately 30,800 within the Yukon portion of the ecozone. The major communities are Whitehorse, Dawson, Faro, Haines Junction, and Mayo. Between 1951 and 1996, the Greater Whitehorse population increased from less than one-third to over two-thirds of the total Yukon population. In 1998, the population of Whitehorse stood at 23,310, the territorial population at 31,768 (Yukon Bureau of Statistics, 1999).

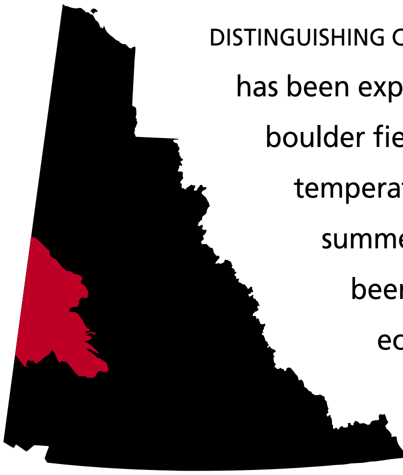
J. Meikle, Yukon Government

Much of this ecozone is plateau where forest fire is a dominant ecosystem element. Here, a young forest of lodgepole pine, white spruce and aspen has regenerated following an unusually widespread fire in 1958. The undulating topography results from drumlinized till of McConnell age and ice-sculpted bedrock outcrops. View southwest over Braeburn Lake in Yukon Plateau–Central Ecoregion.

Klondike Plateau

Boreal Cordillera Ecozone

ECOREGION 172



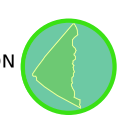
DISTINGUISHING CHARACTERISTICS: As part of easternmost Beringia, this ecoregion has been exposed to long periods of weathering, resulting in extensive upland boulder fields, V-shaped valleys and deep soil weathering. Extreme annual temperature variation occurs in valley bottoms, from –60°C in winter to 35°C in summer. Portions of the Fortymile, South Klondike and Sixtymile rivers have been dredged for gold. Two major bird migration corridors exist in this ecoregion: the Shakwak Trench in the south and the Tintina Trench in the north. The ecoregion marks the northern limit of lodgepole pine in North America.

J. Meikle, Yukon Government

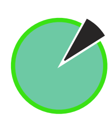
Figure 172-1. The braided floodplain of the White River (entering from the right side of the photo) is shown at its confluence with the Yukon River. The ecoregion is an area of dissected plateau as shown in the undulating upland surface in this photo. South- and west-facing slopes support grasslands while north-facing slopes are forested and are underlain by near-surface permafrost. The fluvial terraces are composed of sands and gravels and support well-drained Brunisolic soils.

APPROXIMATE LAND COVER
boreal coniferous forest, 60%
mixed forest, 15%
alpine tundra, 20%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
38,471 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
38,471 km^2



ECOREGION AREA AS A PROPORTION OF THE YUKON
8%

Metres above sea level

ELEVATIONAL RANGE
290–2,000 m asl
mean elevation 850 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to combined **Klondike River and Wesley Lake ecoregions** and western portion of **Dawson Range Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Portion of **Interior Yukon/Alaska Alpine Tundra** (Ricketts et al., 1999) • Contiguous with the **Yukon–Tanana Uplands Ecoregion** (Nowacki *et al.*, 2001)

PHYSIOGRAPHY

The Klondike Plateau Ecoregion conforms fairly well to the Klondike Plateau physiographic subdivision of the Yukon Plateau (Bostock, 1948; Matthews, 1986), although north of the Willow Hills it does not extend as far eastward. It also includes the Wellesley Depression in the southwest and part of the Tintina Trench where the Klondike and Yukon rivers flow through it. The ecoregion extends into east-central Alaska.

The ecoregion is uniform in character with smooth topped ridges dissected by deep, narrow, V-shaped valleys. These valleys, characteristic of an area that has not been glaciated in the recent past, distinguish the Klondike Plateau from adjacent ecoregions.

The Dawson Range, which trends northwest–southeast between the Yukon River to the north and the Nisling River to the south, is the most distinct feature of the plateau. Apex Mountain, at 2,026 m asl, is the highest in the Dawson Range and in the ecoregion. Most ridges are 1,200 to 1,700 m asl. Local relief ranges from 450 to 700 m. The lowest point in the ecoregion is less than 300 m asl, where the Yukon River flows into Alaska, downstream from Dawson City.

Major rivers have cut deeply into the plateau surface. The Nisling River drains the southern part of the Dawson Range as it flows westward along the southern boundary of the ecoregion before joining the Donjek and White rivers. The White River (Fig. 172-1) flows north to the Yukon River, which is included in the ecoregion from just downstream of the mouth of the Pelly, past the mouth of the Stewart, Klondike, Chandindu, and Fortymile, to the Alaska border at 64°40'N. The only significant lakes in the Klondike Plateau Ecoregion are in the southeast corner in the glaciated Wellesley Depression. The largest of these is Wellesley Lake.

BEDROCK GEOLOGY

Rocks of this region (regionally mapped by Green, 1972; Bostock, 1973; Tempelman-Kluit, 1974; Ryan and Gordey, 2002) constitute a large part of the Yukon–Tanana Terrane, a composite of crust blocks including former volcanic island arc and continental shelf depositional environments (Mortensen, 1992). The metasedimentary rocks are intruded and overlapped by granitic and volcanic rocks, and overlain by fault-bounded slices of serpentinized ultramafic rock of Slide Mountain Terrane. This area was exposed and deeply weathered for at least 15 million years. Consequently, the sparse outcrops are tors (solitary pillars and knolls; Fig. 172-2) atop broad ridges mantled with felsenmeer (fields of large angular, frost-heaved rock fragments).

In the northwest part of the ecoregion to the west of Dawson, medium grey and brown quartz muscovite

J. Meikle, Yukon Government

Figure 172-2. High elevation ridges of the Klondike Plateau Ecoregion show characteristic spines and towers (tors) which are bedrock remnants left after long periods of weathering. The valleys are deep and narrow because this area escaped scouring by Pleistocene glaciers.

schist predominates, accompanied by prominent bands of quartzite and marble that are up to 100 m thick and several kilometres long (Green, 1972). In the Sixtymile River area, 60-million-year-old porphyritic andesite flows and coal horizons (Glasmacher and Freidrich, 1984) overlie these older rocks. The Klondike placer mining district and the area to the northwest are underlain by chlorite and muscovite schist, commonly known as Klondike Schist (resulting from a Permian felsic volcanic event), and a schist containing thumb-sized feldspar phenocrysts — the 260 Ma Sulphur Creek granitic batholith (Mortensen, 1988). The Fiftymile batholith (Tempelman-Kluit, 1974) of quartz–feldspar–biotite gneiss and hornblende granodiorite underlies a 50 km^2 area in the White River area. Rock outcrops are non-existent in the Wellesley Lake–Snag area, but the area is mostly underlain by silica tuff and volcanic breccia of the 60 Ma Donjek Formation (Muller, 1967).

Portions of the Fortymile, South Klondike and Sixtymile drainages have been sluiced and dredged for gold for more than a century. Most of the placer gold is derived from quartz veins (Knight *et al.*, 1994) that have been eroded and the gold concentrated by pre-Ice Age rivers (>3 Ma). The principal formation containing placer gold is the White Channel gravel (Fig. 172-3), although a few bedrock gold veins have been located in the district (Mortensen *et al.*, 1992). Serpentine and chrysotile asbestos are found in the Slide Mountain Terrane and were mined at Clinton Creek and near Cassiar Dome. Placer gold is seasonally mined in the Moosehorn Range near the southwest corner of the ecoregion. The Coffee Creek granite contains large amounts of copper and gold at low concentrations, and the Casino deposit, at the head of Canadian Creek, has been intensely trenched and drilled. Sparse gold and copper mineralization at Mount Nansen, near the southeast tip of the ecoregion, was mined by open-pit, heap-leach methods between 1996 and 1998.

SURFICIAL GEOLOGY AND GLACIAL HISTORY

This ecoregion is largely unglaciated, except for local glaciers that emanated from the headwaters of the Sixtymile River Valley, local peaks in the eastern Dawson Range and the Kluane Ranges into the Wellesley Basin. Surface deposits over much of the ecoregion are composed of colluvium, with alluvium and glacial outwash terraces found along major

A. Duk-Rodkin, Geological Survey of Canada

Figure 172-3. Stratified gravel of the White Channel formation in the lower Klondike River valley. This gravel deposit is more than 5 million years old and precedes the Ice Age. At the top of the section is the brown glacial drift called Klondike Gravel, about 3 million years old.

river systems. Many of the tributary valleys in the Klondike Plateau proper are blanketed with thick colluvial deposits consisting of silts several metres thick covered by several metres of peat and mucky silt. Uplands are covered with colluvium rubble derived from underlying fractured bedrock. A veneer of wind-blown silt covers most of the ecoregion.

Periglacial features, such as cryoplanation terraces, patterned ground and solifluction lobes, can be found at higher elevations. Active slope processes include soil creep and debris flows.

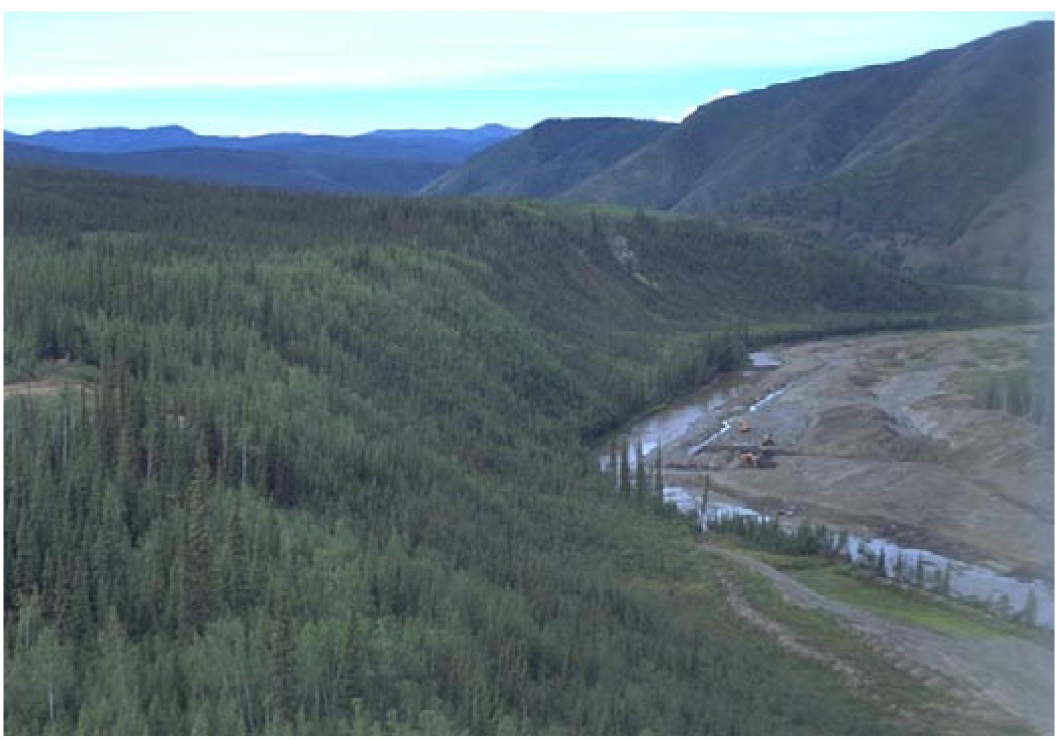
The Dawson Range was affected by diversion of the pre-glacial Yukon River during the first glaciation of the west-central Yukon Territory about 3 Ma ago (Duk-Rodkin, 1997; Duk-Rodkin and Barendregt, 1997; Froese *et al.*, 2001). It is postulated that the preglacial Yukon River headwaters were located in the Ogilvie Mountains, with a southerly drainage likely entering the Pacific Ocean south of the St. Elias Mountains. The Fifteenmile River, now a tributary to the Yukon River, formed part of this ancestral river system. High fluvial terraces containing Ogilvie Mountain rock types are found above the Fifteenmile River at the confluence of the Yukon River, and extend south to near the mouth of Stewart River (Duk-Rodkin *et al.*, 2001). The earliest glaciation blocked drainage to the south and east, surrounded the Klondike Plateau to near Dawson and flowed along the Tintina Trench to coalesce with glaciers exiting the Ogilvie Mountains. A large but likely short-lived glacial lake, informally called Glacial Lake Yukon, was formed with an outlet cut west of the mouth of Fifteenmile River at 720 m asl. This resulted in diversion of drainage towards the northwest, and incision of the Klondike Plateau south of the trench. It also greatly expanded the basin of preglacial Kwikhpak River that occupied the trench and flowed northwest into Alaska. Farther south, in the eastern Dawson Range south of the Stewart River, drainage was diverted across a local divide enabling meltwater to drain across to Indian River (Fig. 172-4). The Klondike River became a tributary to the newly established Yukon River. Glaciers flowing north in the Alaska Range extended across Tanana Valley cutting off the headwater of the Tanana River, now the Nisling River, and diverting it to the Yukon River across the Yukon–Tanana upland, forming what is now the Dawson Range.

During the Reid Glaciation, a glacier in the Fifteenmile River valley blocked the Yukon River forming a temporary glacial lake, informally called Glacial Lake Dawson. Catastrophic flood deposits on Reid outwash deposits, found near the Fortymile River, could record drainage of the former glacial lake. McConnell Glaciation was restricted to mountain valleys beyond this ecoregion. However, small patches of McConnell outwash surfaces are found in the lower Klondike River Valley.

CLIMATE

The climate of the ecoregion is strongly continental with warm summers and very cold winters. Precipitation amounts are from 300 to 500 mm annually. There is a gradual increase in precipitation from the southeast to the northwest. The lightest precipitation is from February through April with monthly means of 10 to 20 mm. The wettest period is from June through August with monthly means of 50 to 90 mm. The heaviest precipitation is in the uplands of the northwestern section of the ecoregion west of Dawson and along the Alaska boundary. Most summer precipitation originates from convective rainshowers and thunderstorms.

Mean annual temperatures are near –5°C. These temperatures show a strong seasonal variation with mean January temperatures of –23 to –32°C and in July from 10 to 15°C. The coldest January and warmest July temperatures are recorded in the lowest topographic settings in the ecoregion — the Yukon, lower Klondike, and lower Stewart valleys. Extreme temperatures in the lower valleys range from –60 to 35°C. Note that Snag, which lies in this ecoregion, has had the coldest recorded temperature in North America at –62.8°C. Frost can occur at any time of the year, although it is relatively infrequent in July. Because of the warm summer temperatures, agriculture is practiced in many valley bottoms throughout the ecoregion.



G. Lowey, Yukon Government

Figure 172-4. Placer mining has been the economic mainstay of the ecoregion for over 100 years. Valley-bottom gravels here have been reworked by the Indian River from a complex set of terraces that reflect the changed drainage gradient in this part of the ecoregion. The forest cover is a mix of black and white spruce.

J. Meikle, Yukon Government

Figure 172-5. Wellesley Lake lies in a glaciated basin in the southwestern part of the ecoregion.

Winds are generally light, but can occasionally become moderate in association with an individual weather system or thunderstorms.

Representative climatic data are available from Snag, Beaver Creek, Fort Selkirk and Dawson.

HYDROLOGY

With a total area of >38,000 km^2, the ecoregion is relatively large leading to some hydrologic diversity. The major streams are the Yukon River corridor between the Pelly River confluence and the Alaska boundary, the White River below the Alaska Highway, the lower Donjek, and the lower reaches of the Stewart River. Wellesley Lake is the only major lake (Fig. 172-5), while wetlands cover significant portions of the general Wellesley Basin and Scottie Creek drainage. Streamflow within this portion of the ecoregion is characterized by a rapid increase in streamflow discharge in May due to snowmelt, rising to a peak in June, after which summer rainfall maintains high flow for a few weeks. Though not representative of the ecoregion as a whole, the White and Donjek rivers experience peak flows slightly later in the summer due to glacier melt in the upper reaches of these streams. Summer rains produce secondary peaks and sometimes the annual maximum, especially from mountainous regions.

There are three representative continuous active or historical hydrometric stations: Fortymile and Indian rivers, and Snag Creek. The three seasonal stations are Clinton, Thistle and Scroggie creeks. Mean annual runoff is moderately low with values ranging from 85 to 295 mm and an ecoregion mean of 175 mm, while mean seasonal and summer flows are relatively low with values of 7.4 X 10^{-3} and 7.1 X 10^{-3} m^3/s/km^2, respectively. The mean annual flood and mean maximum summer flow are moderately low and moderate, with values of 52 X 10^{-3} and 43 X 10^{-3} m^3/s/km^2, respectively. Minimum streamflow generally occurs during March, with the relative magnitude generally lower than the western portion due to lower winter temperatures limiting groundwater contributions. The mean annual minimum and mean summer minimum flows are relatively high and relatively low with values of 1.8 X 10^{-3} and 1.8 X 10^{-3} m^3/s/km^2 (identical values are correct), respectively. Some small streams may experience zero winter flows.

PERMAFROST

Permafrost is discontinuous, but widespread, in the Klondike Plateau Ecoregion. It is absent from well-drained, dry slopes of any aspect (EBA, 1989a), but valley-bottom deposits and upland soils usually contain ice-rich horizons. As in other parts of the central Yukon, soil moisture content and organic-layer thickness are critical variables controlling the occurrence of permafrost (EBA, 1988; Williams and Burn, 1996). Much of the ecoregion was not glaciated during the Quaternary period and substantial loess deposits accumulated in many valleys during the McConnell advance (Fraser and Burn, 1997). These host some of the largest ground ice masses in subarctic Canada (French and Pollard, 1986). Organic matter-rich accumulations above the loess also contain ice (Fig. 172-6).

The thickness of permafrost near Dawson varies up to 60 m (McConnell, 1905), with near-surface annual mean ground temperatures of between –3 and –1°C (EBA, 1983). The active layer in alluvial sediments is up to 1.5 m thick, and up to 2 m in dry sand (EBA, 1983, 1989b), but in ice-rich peat may be only 30 or 40 cm, and only a little deeper in alpine tundra above treeline. To the south, near Beaver Creek, permafrost remains widespread, but is thaw-stable in gravelly terrain (Horel, 1988a). The active layer above perennially frozen gravel is usually about 1.2 m thick, but thicknesses up to 2 m have been recorded during geotechnical drilling (Geotechnical Services, 1992). The till in southern parts of the ecoregion is ice-rich (Horel, 1988a). In geotechnical drill holes along the Alaska Highway east of Beaver Creek, 62% indicated permafrost, with the base of permafrost at between 11.5 and 15 m depth (Geotechnical Services, 1993).

Valley-bottom deposits comprise five general units: (1) alluvial sediments, which are unfrozen close to present river courses (EBA, 1977); (2) colluvial materials, both organic and mineral sediments, which usually contain aggrading ice (Fraser and Burn, 1997); (3) gravel, which acts as a conduit for groundwater and is often unfrozen; (4) loess, mostly perennially frozen, containing ice wedges 1 m or more in cross-section and up to 5 m tall (Fraser and Burn, 1997); and (5) organic horizons, containing ice masses in horizontal beds and ice wedges distinct from, and smaller than, similar features in the loess (Naldrett, 1982). The narrow widths of many large ice wedges in the loess suggest they formed syngenetically with deposition. In lower portions of the loess, tabular bodies of ground ice occur, which may have been preserved by burial or grown later (French and Pollard,

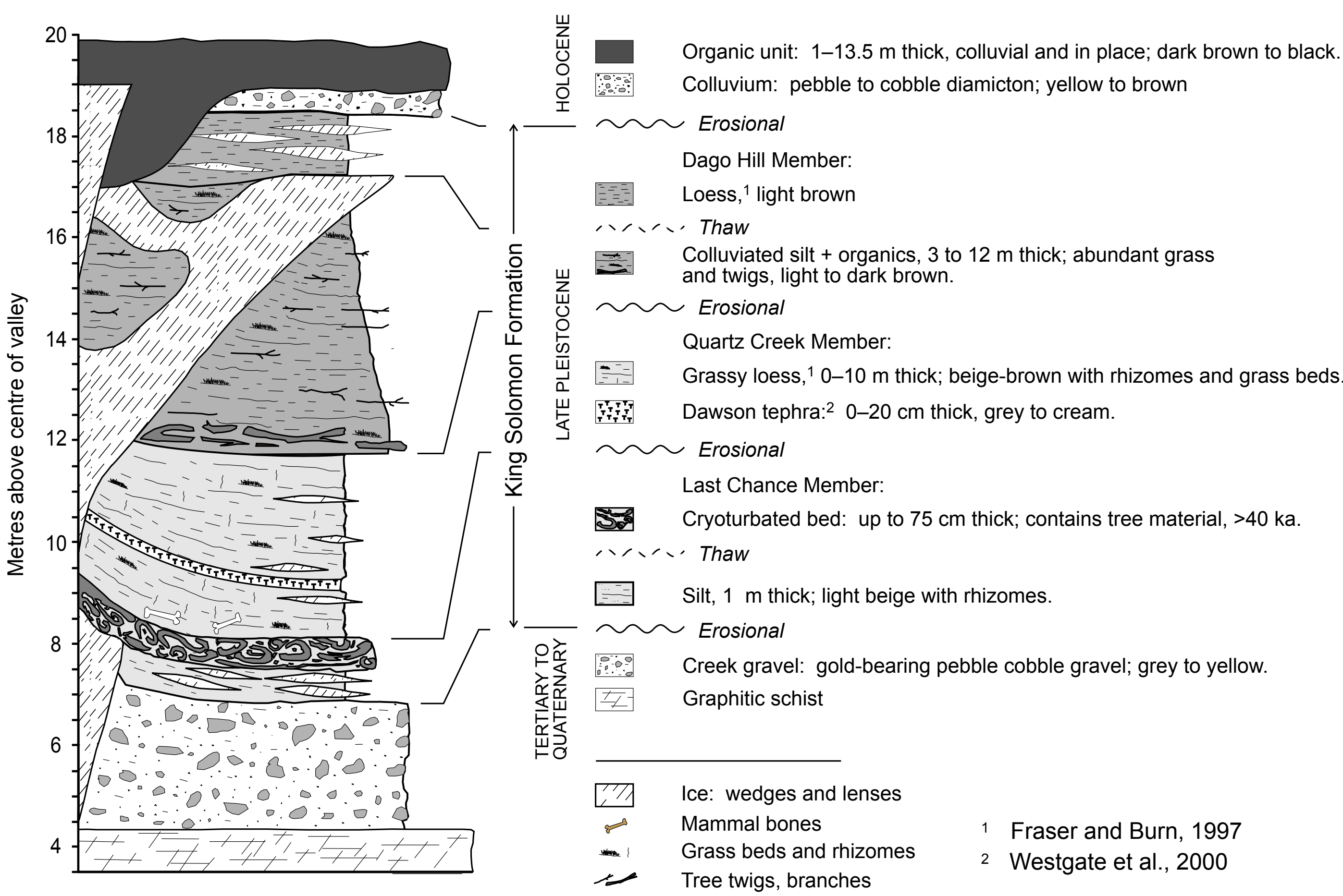


Figure 172-6. An idealized cross-section of "muck" (King Solomon Formation) overlying older gravels in the valleys of the Klondike Plateau Ecoregion.

1986). The ice wedges in the deposits formed in three periods: Holocene wedges are found in the surficial organic material; ice from the end of Late Wisconsinan (McConnell) glaciation is in the near-surface loess; and, in a few locations, wedges formed before McConnell glaciation at the base of the loess deposits (Kotler and Burn, 1998). These demonstrate that permafrost has been present in the area for at least 35,000 years. Overall, the valley-bottom sediments in the Klondike area are nearly 70% ice by volume. Extensive ice forms in creek bottoms each winter, growing as groundwater issues from the gravel units. Numerous open-system pingos at the base of slopes were mapped in the ecoregion by Hughes (1969a).

The accordant ridge tops of the plateau support a range of periglacial features. Some, such as sorted circles, are a product of seasonal freezing and thawing, while others, such as cryoplanation terraces, tors, stone nets and stripes, suggest periods of periglacial activity stretching over millennia (French *et al.*, 1983).

SOILS

This plateau-dominated ecoregion has a strongly continental climate with warm summers and very cold winters. As a result, a mosaic exists of permafrost-free soils on well-drained uplands and slopes, with Cryosols associated with extensive discontinuous permafrost on lower slopes and valley

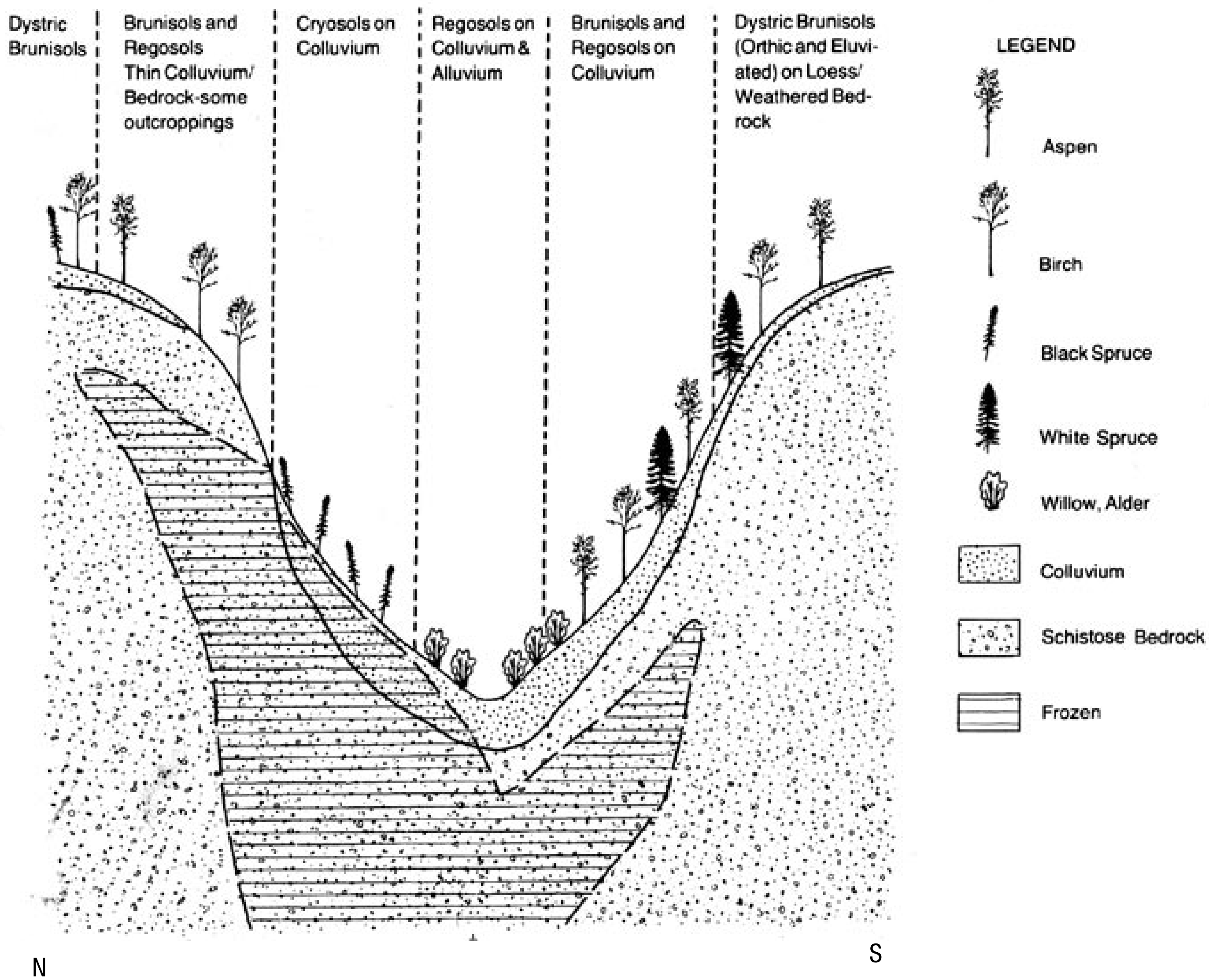


Figure 172-7. A landscape cross-section showing the influence of aspect on soil and vegetation development in the ecoregion.

bottoms (Fig. 172-7). Eutric Brunisols developed on loamy colluvial materials dominate well-drained ridge crests, south-facing slopes and glaciofluvial terraces. Most soils have formed under boreal forest and woodlands. Alpine environments are limited to the highest elevations of the Dawson Range and the Klondike Plateau proper.

As the ecoregion is largely unglaciated, the dominant parent materials are stony residual materials along ridge tops and summits, coarse colluvium on upper slopes, and silty colluvium and loess, rich in organic matter, often referred to as "muck" by placer miners, on lower slopes (Fraser and Burn, 1997). Muck deposits are usually capped with peat (Fig. 172-6) and are always underlain by permafrost, so Mesic Organic Cryosols are most common in undisturbed valley-bottom settings. Even on upland positions, active cryoturbation may occur and be expressed as sorted patterned ground and Orthic Turbic Cryosol development (site 32 *in* Tarnocai *et al.*, 1993).

Along the major rivers of the ecoregion, the lower White, Stewart and Yukon, warm summer climates and coarse alluvial or glaciofluvial materials on terraces limit organic matter accumulation and Orthic Eutric Brunisols are most common (Fig. 172-1). Most of these soils are very gravelly, but are often overlain by loess to produce soils with stone-free silt loam textures that support productive stands of boreal forest (Rostad *et al.*, 1977). Alluvial soils in the Klondike Valley consist mainly of 30 to 150 cm of silty sand capping coarse sands and gravels. Fluvial fans support wetlands composed of both fen and peat plateaus. A complex of Cryosols, Regosols and Eutric or Dystric Brunisols composed of highly contrasting soil textures has been mapped in the valley (Walmsley *et al.*, 1987).

Upland soils are dominated by micaceous residual soils that reflect the mineralogy of the underlying bedrock. Most of these well-drained soils are permafrost-free, neutral in reaction and non-calcareous. These soils may thaw to a depth of 2 m in the summer season, particularly following forest fires; those covered by thick mats of moss and forest floor materials may only thaw to 50 cm depth each year. These Turbic Cryosols may form earth hummocks and are widespread on lower slopes and depressions. Wetlands are not extensive in the north part of the ecoregion, but in the south occupy major valley floors and the Wellesley Basin (Fig. 172-5). Wetland soils tend to be composed of frozen sphagnum peat, but are without permafrost under fen vegetation growing in areas of surface water through-flow. The permafrost portions of wetland support soils are most often classified as Fibric or Mesic Organic Cryosols.

VEGETATION

Much of the Klondike Plateau Ecoregion straddles the treeline with vegetation ranging from boreal forest in the valleys and on lower slopes, to alpine tundra on ridge crests. Treeline is close to 1,000 m asl in the northern part of the ecoregion and around 1,200 m asl in the south. Below treeline, the vegetation pattern reflects the discontinuous distribution of permafrost. Stunted black spruce woodlands on cold, north-facing sites contrast with mixed forests on warm south-facing slopes.

Black and white spruce forests dominate the ecoregion in both pure and mixed stands with balsam poplar, paper birch and trembling aspen. Lodgepole pine and larch are largely absent from the area.

Black spruce–sphagnum communities exist in poorly drained depressions and at the toe of slopes on fine-textured Cryosols or with a thick organic mat as Organic Cryosols. On gently sloping, fine-textured sediments, black spruce–sedge tussock communities with an understory of ericaceous shrubs predominate. These communities are also associated with permafrost and Turbic Cryosols. Open-canopied black spruce–lichen communities are common on better drained, coarse-textured upland sites. Shrub birch, willow, Labrador tea, alpine blueberry and ericaceous ground shrubs dominate the shrub layer, overlying extensive foliose lichens and feathermoss (Kennedy and Staniforth, 1995). Paper birch and trembling aspen occur with black spruce where disturbance such as fire has happened within about 100 years (Foote, 1993). This ecoregion includes the area with the highest frequency of lightning strikes in the Yukon. Forest stands are a mosaic of fire disturbance, with seral stands more common than mature stands over much of the ecoregion.

Mixed forests are common on warmer sites and gentle to steep south-facing slopes of unfrozen, coarse surface materials. Paper birch, trembling aspen, balsam poplar, white spruce, willow and water birch preside over an understory of ground shrubs, diverse forbs and feathermoss (Kennedy and Smith, 1999). These are mid-successional communities that will gradually become conifer stands in time. As this ecoregion has frequent fires, young, mixed forests are more common.

Mixed black and white spruce forests are common through parts of the ecoregion, such as the Klondike Valley. The driest sites support spruce forests underlain by *Cladina* lichen; intermediate moisture regime stands are characterized by an understory of feathermoss; moist sites are associated with an understory dominated by horsetail (Kennedy and Staniforth, 1995; Kojima, 1996).

Along major rivers, white spruce–feathermoss communities are found on stable terraces. Balsam poplar is often mixed with white spruce on younger fluvial sites. Willow, alder and balsam poplar with a rich forb and herb understory occupy smaller drainages and large river riparian sites subject to frequent flooding (Kennedy and Smith, 1999).

WILDLIFE

Mammals

Historically, this was one of the more biologically productive Boreal Cordillera ecoregions of the Yukon. The Fortymile barren-ground caribou herd in the mid-nineteenth century is estimated to have been as large as 500,000 and ranged between Fairbanks, Alaska, and Whitehorse, Yukon (U.S. Bureau of Land Management *et al.*, 1995). This population declined through the 1930s to a low of about 6500. In 2001, the herd was estimated at about 40,200 individuals. Many factors have contributed to this decline, including wildfires, food limitations, and overharvesting. An international management plan is attempting to rebuild the herd and restore biological productivity to the ecosystem. Part of the Nelchina barren-ground caribou herd from Alaska, estimated at 33,000, began wintering in the Beaver Creek area in the 1990s. The Klaza and Aishihik woodland caribou herds, with >600 and 1,500 animals, respectively, range into this ecoregion from the east (Farnell and MacDonald, 1987; Farnell *et al.*, 1991). Also, the Chisana and Mentasta herds, 500 and 700 caribou, respectively, enter from Alaska. Dall sheep are found in the southern Dawson Range.

The wildfire regime supplies plentiful early successional moose and snowshoe hare browse. Moose are also abundant in the gold fields south of Dawson City due either to overharvesting of bears that come into conflict with humans (Larsen and Ward, 1991a) or to riparian willow habitat enhancement as a byproduct of placer gold mining. Snowshoe hares are abundant within their 10-year cycles. Snowshoe hare refugia, areas densely vegetated with browse and cover, are present in the Klondike River Valley. Hare refugia are critical for snowshoe hare specialists, such as lynx, during cyclic hare lows.

Marten are abundant, even occupying recent patchy burns and riparian areas often associated with lynx. Wolverines are also abundant, reflecting the diversity of prey and carrion left by large carnivores. Wolves are less abundant here than elsewhere in the southern Yukon. This is the northern extent of coyote, mule deer and woodchuck in the Yukon (Youngman, 1975). Black bear reach their highest Yukon densities here (MacHutcheon and Smith, 1990). Standing water and the associated semi-aquatic mammals are sparse in this ecoregion, except in the southwest, where muskrats are abundant in the Scottie Creek wetlands (Slough and Jessup, 1984). The house mouse, originating in mid-eastern Asia and now a world traveler, has taken up residence around habitations in Dawson City. A newly described species from the lower Yukon basin in Alaska, the tiny shrew, may occur in the Yukon in this ecoregion (Alaska Geographic Society, 1996; D. Nagorsen, pers. comm., 2000). A complete list of mammal species known or expected to occur in this ecoregion is given in Table 4.

Birds

Spruce-dominated forests are used by raptors such as Northern Goshawk, Red-tailed Hawk, Great Horned Owl, and Northern Hawk Owl (Mossop, 1978; Frisch, 1987). Bald eagles and some ospreys nest near forested wetlands while Peregrine Falcon nests along steep riverbanks such as those of the Yukon River (Mossop, 1978; Department of Renewable Resources, 1994). Year-round residents of these coniferous forests include Spruce Grouse, Three-toed Woodpecker, Gray Jay, Common Raven, Black-capped Chickadee, Boreal Chickadee, and Pine Grosbeak while Northern Goshawk and Common Redpoll winter here in milder years (Frisch, 1987). Coniferous forests provide breeding habitat for Northern Flicker, Western Wood-Pewee, Ruby-crowned Kinglet, Varied Thrush, Yellow-rumped Warbler, Dark-eyed Junco, and White-winged Crossbill (Grinnell, 1909; Frisch, 1978). Townsend's Warbler, a species with a limited distribution in the Yukon, also breeds in these forests (Frisch, 1978). Ruffed Grouse, Yellow-bellied Sapsucker, and Orange-crowned Warbler occur in deciduous forests along river courses (Frisch, 1975; Canadian Wildlife Service, unpubl.), while Blue Grouse, which reaches its northwestern limit here, inhabits mixed forests on slopes (Frisch, 1987). Sharp-tailed Grouse, uncommon in the Yukon, inhabits brushy forest openings near alpine areas, floodplains, and old burns (Department of Public Works and U.S. Department of Transportation, 1977; Brown, 1979; Frisch, 1987). These forest openings also support Northern Shrike and Townsend's Solitaire, with Common Nighthawk and Savannah Sparrow occurring at lower elevations. Western Wood-Pewee, Alder Flycatcher, Say's Phoebe, Mountain Bluebird, Hermit Thrush, American Robin, and Dark-eyed Junco inhabit the shrubby borders (Betts, 1940; Frisch, 1975; Frisch, 1987; Canadian Wildlife Service, unpubl.). American Kestrels hunt in these openings throughout spring and summer (Canadian Wildlife Service, unpubl.).

Extensive alpine areas provide breeding habitat for Rock Ptarmigan, Horned Lark, American Pipit, and possibly Long-tailed Jaeger (Fig. 172-8). Subalpine shrub areas are inhabited by nesting Willow Ptarmigan, American Tree Sparrow, White-crowned Sparrow, and Common Redpoll (Canadian Wildlife Service, unpubl.).

This ecoregion has two major migration corridors: the Shakwak Trench in the south and the Tintina Trench in the north. The Shakwak Trench funnels spring and fall migrations of swans, geese, ducks, and shorebirds (Department of Renewable Resources, 1994). It also offers important breeding and moulting areas for many species including Trumpeter Swan, American Widgeon, Mallard, Northern Shoveler, Northern Pintail, Green-winged Teal, Ring-necked Duck, Bufflehead, Northern Harrier, Lesser Yellowlegs, and Solitary and Spotted Sandpipers (Grinnell, 1909; Canadian Wildlife Service, 1979a, unpubl.; Hawkings, 1994; Department of Renewable Resources, 1994). The Tintina Trench is a major migration corridor for swans, geese, and Sandhill Crane traveling to and from their Alaskan breeding grounds (Soper, 1954; McKelvey, 1977). Other key wetlands are the Sanpete Wetlands, Scottie Creek Flats, Swede Johnson Wetlands, and Enger Lakes. These wetlands are important breeding and staging areas for grebes, Mallard, Northern Shoveler, Green-winged Teal, Canvasback, Bufflehead, scaup, scoters, and goldeneyes (Canadian Wildlife Service, 1979b; Hawkings, 1994). Rivers and lakes support Common Merganser, Mew and Herring Gulls, and Belted Kingfisher, with Yellow Warbler, Northern Waterthrush, Wilson's Warbler, and Lincoln Sparrow breeding in shrubby riparian habitat, while American Dippers inhabit swift flowing streams (Canadian Wildlife Service, unpubl.).

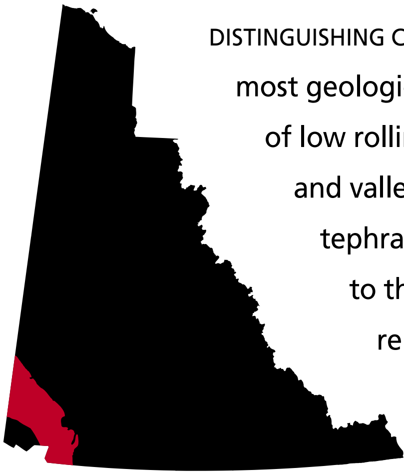
J. Meikle, Yukon Government

Figure 172-8. Tors are used by birds of prey as perches and nest sites. Bird feces and pellets supply ample nutrients that produce luxuriant grass-dominated plant communities at the base of such prominent rocks.

St. Elias Mountains

Boreal Cordillera Ecozone

ECOREGION 173



DISTINGUISHING CHARACTERISTICS: This landscape has been, and continues to be, the most geologically dynamic in the Yukon. Less than 15 million years ago it consisted of low rolling hills partly flooded by lava; now there are steep-sided mountains and valleys choked by glaciers and fast-flowing torrents. A 1,200-year-old tephra blanket supports a forest atop the Klutlan Glacier and contributes to the silt load in the White River. The ecoregion is distinguished by relatively high precipitation, almost all of which falls as snow at higher elevations. Yukon's highest densities of Dall sheep and mountain goat are found here.

J. Meikle, Yukon Government

Figure 173-1. The St. Elias Mountains, viewed westward toward Mount Bona–Churchill, were uplifted over the last 14 million years and are the youngest mountains in Canada. Orographic precipitation results in large snow accumulations at higher elevations in the ecoregion and the development of numerous large valley glaciers. The Klutlan Glacier, shown above, has two medial moraines.

APPROXIMATE LAND COVER
glacial ice and snow, 50%
rocklands, 25%
alpine tundra, 15%
boreal coniferous forest, 10%

TOTAL AREA OF ECOREGION IN CANADA
24,220 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
19,245 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
4%

Metres above sea level

ELEVATIONAL RANGE
580–5,220 m asl
mean elevation 1,920 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **St. Elias Mountains Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Portion of **Alaska/St. Elias Alpine Tundra Ecoregion** (Ricketts et al., 1999) • Contiguous with the **Kluane Range Ecoregion** (Nowacki *et al.*, 2001)

PHYSIOGRAPHY

The St. Elias Mountains Ecoregion consists of the Icefield Ranges — high, rugged, glaciated peaks surrounded by glaciers; the Duke Depression, with the broad smooth slopes of a network of river valleys; and the northern part of the Kluane Ranges, a narrow front ridge to the St. Elias Mountains. The Kluane Ranges form a wall rising from the Shakwak Valley, marking a major geological boundary, a fault line scarp, and the eastern boundary of the ecoregion (Mathews, 1986).

Mean elevation ranges from near 3,000 m asl in the southwest portion of the ecoregion to <1,000 m asl along the southeastern, eastern and northern boundaries. However, there are many mountain peaks of 4,000 to 5,000 m asl throughout the western and central portions of this ecoregion. Numerous peaks over 3,600 m elevation include Mount Lucania (5,226 m), Mount Steele (5,073 m), Mount Wood (4,841 m), Mount Hubbard (4,576 m), Mount Kennedy (4,238 m), Mount Badham (3,733 m), Mount Queen Mary (3,886 m) and Pinnacle Peak (3,713 m).

This ecoregion has a relatively less extensive ice surface than the Mount Logan Ecoregion. Intermontane glaciers form the core, grading into valley glaciers that radiate to the west, north and east. The Walsh, Chitina and Anderson glaciers flow west to Alaska. From the north, the largest glaciers flowing north and east are the Klutlan, Steele, Donjek, Kluane, Kaskawulsh, Dusty, Lowell and Fisher glaciers. These glaciers are drained by broad, braided rivers: the White, Generc, Donjek, Duke, Slims, Kaskawulsh, Dusty and Alsek.

BEDROCK GEOLOGY

The rocks of this ecoregion are part of the Insular morphogeologic belt (Gabrielse and Yorath [editors], 1991) and are separated from the rest of the Yukon by the Denali Fault system that underlies the Shakwak Valley. The region consists of deformed sedimentary and volcanic rocks of two terranes, Wrangellia and Alexander. About 20% of the exposed rock is granitic intrusions. The Late Miocene Wrangell lavas were flood basalts that formerly covered large areas; now they are exposed northwest of Donjek River and north of Mush Lake. The area is well mapped (Read and Monger, 1976; Campbell and Dodds, 1982a,b,c), with both traditional descriptive reports (Kindle, 1953; Muller, 1967) and modern tectonic syntheses (Gabrielse and Yorath [editors], 1991).

Alexander Terrane, which lies between the Duke River and Hubbard faults, consists of moderately metamorphosed Cambrian through Triassic clastic and lesser carbonate, as well as mafic volcanic rocks. Wrangellia, northeast of Duke River and southwest of the Denali Fault, contains weakly metamorphosed volcanic and sedimentary rocks of Late Paleozoic and Triassic age, notably the Skolai and Nikolai mafic volcanic rocks. These terranes are overlapped by Jurassic–Cretaceous Dezadeash Group (Eisbacher, 1976), although they may have been juxtaposed as early as late Paleozoic time, as suggested by the intrusion of 270 to 290 Ma granitic plutons in both terranes (Gardner *et al.*, 1988). Additional granitic suites, 130 to 160 Ma in Alexander Terrane and 106 to 117 Ma in Wrangellia, form northwest-trending belts (Dodds and Campbell, 1988). The latter include ultramafic intrusions 15 km west of Haines Junction and in the Burwash Uplands. The Wrangell lavas are extensive subaerial basalt and andesite flows that erupted 11 to 13 million years ago (Souther and Stanciu, 1975; Skulski *et al.*, 1992). They are part of a magmatic episode indicated by widespread occurrences of felsic dykes, as well as granitic and ultramafic intrusions as young as 9 Ma, such as the Mount Steele pluton (Dodds and Campbell, 1988).

The evolution of the St. Elias landscape is geologically young and stems from oblique subduction of the Pacific oceanic plate with the continental margin of North America (Plafker, 1969). Regional compression resulted in a thickened crust, whose surface is rising, as well as transcurrent faults with more than 300 km of dextral displacement (although most seismic activity is currently localized southwest of the area; Horner, 1983). The rocks are shattered along numerous fault strands in the Kluane Ranges. Mid-Tertiary trunk streams eroded the fault zones and localized coarse clastic material in small depositional basins. Remnants of these basins, called the Amphitheatre Formation (Eisbacher and Hopkins, 1977), are poorly consolidated and a common source of landslides and slips in the Cement Creek, Sheep Creek and Bates Lake areas. The dacite White River Ash, which is up to 50 m thick on level ground near the Klutlan Glacier and more than 2.5 cm thick across the central Yukon, erupted about

AD 803 (Clague *et al.*, 1995) from Mount Churchill (Fig. 173-1), 10 km west of the Alaska–Yukon border (Richter *et al.*, 1995). The eruptions apparently had profound effects on the lives and migration of the ancestral Athapaskan Indians of the region (Moodie *et al.*, 1992).

Upper Triassic rocks of the Insular Belt are richly mineralized and most deposits mentioned below occur within the Nikolai Group. Volcanogenic massive sulphide and skarn deposits occur in these rocks in northwestern British Columbia, while numerous silver–lead and copper–silver veins are found along the northeast side of the ecoregion. More than 5,000 tonnes of copper and silver ore were extracted from the Johobo mine, 7 km west of Kathleen Lake. The Kluane Ranges contain a 130 km long belt of nickel–copper platinum group element (PGE) showings spatially related to ultramafic rocks, including the former Wellgreen mine and Canalask deposit (Hulbert, 1997). This mineralization is unique in the world for its high proportion of platinum group elements and Upper Triassic age. Copper sulphide and native copper showings are common in the vesicular basalt in the upper White River and Quill Creek drainages. Tertiary granite plutons in adjacent Alaska contain significant molybdenum porphyry deposits and a showing of similar type occurs at the head of Burwash Creek. Lignite seams are present in the Amphitheatre Formation. Placer gold has been mined from Sheep and Bullion creeks in the Slims River drainage; Squirrel, Ptarmigan and Granite creeks in the Duke River drainage; and tributaries of Quill, Wade, Tatamagouche and Burwash creeks.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

Alpine glaciers have probably existed within the St. Elias Mountains Ecoregion since the Late Tertiary. Most surface geology units at the present surface result from the last major glacial expansion, the Kluane Glaciations (29 to 12.5 ka) and from more recent alpine glacial events 2,800 years ago, between 1,250 and 1,050 years ago and during the last 450 years (Rampton, 1971). Rampton (1981b) described the area as "a complex of steep slopes and cliffs, which have been modified by mass wastage, stream erosion and glacial scouring, and which have a veneer of unconsolidated materials. High relief, steep slopes and moderately competent rock have led to the formation of talus fans and aprons and the occurrence of landslides." Large glaciers, like the Donjek, Lowell, Kaskawulsh, Kluane and Fisher, occupy valleys in the western part of this ecoregion and can be as thick as 450 m (Fig. 173-2).

M. Hoefs

Figure 173-2. The Lowell Glacier, shown above, has a complex history of advance and retreat. The lateral moraines seen on valley walls (arrows) clearly show the extent of recent recession. Such recent retreat is widespread among alpine glaciers in the western Cordillera of Canada over the last 20 years.

Numerous smaller glaciers, hanging glaciers, cirque glaciers or small mountain ice caps, are present at high elevation and can be as thick as 90 m. Several debris-covered glaciers and rock glaciers have been mapped at high elevation, particularly in the eastern part of the ecoregion.

Glaciers, bedrock exposures on steep valley walls, cirque headwalls, and colluvium dominate the higher elevations of this ecoregion. The mid- to low elevations are commonly covered by colluvium, moraines and glaciofluvial terraces. Glaciofluvial plains, the toes of alluvial or colluvial fans and fluvial sediments from modern streams cover valley floors (Rampton, 1980a,b,c,d,e).

Colluvium deposits, rock falls, landslides, soil creep and solifluction lobes are common on mountainsides. Steeper slopes usually have talus and fans, with the gentler slopes often covered by blankets of colluvium with solifluction or soil creep features, and occasionally non-sorted polygons or stripes. Moraine originates from the large valley glaciers or as part of a complex network of small moraines associated with cirque glaciers. Moraines often partially mixed with colluvium and glaciofluvial material. Glaciofluvial deposits occur either as kames — terraces on valley sides — or as outwash plains on valley floors. These gravelly surfaces are usually well drained and stable unless they are overlain by thick loess and peat, which fosters the formation of ice-rich permafrost at shallow depth (Rampton, 1981b).

Fluvial deposits in floodplains and alluvial fans are mostly graveled except for the Slims River floodplain, which is composed of fine-grained sediments. Fluvial deposits can be as thick as 45 m, and probably average 15 m. Some terraces overlain by loess or thick peat may contain ice-rich permafrost at shallow depth. Several floodplains of braided rivers are still actively eroding and modifying their beds and are subjected to seasonal flooding and highly variable discharge rate. The larger rivers, like the Donjek, Slims, Kaskawulsh, Alsek and Dusty rivers, have sections of braided and shifting channels, mostly unvegetated and unstable.

Geological processes active in the St. Elias Mountains Ecoregion that present the most immediate hazard to human activity are related to the extreme topography of the Kluane Ranges. Slope failures resulting in rock slides and slumps are commonly associated with the Amphitheatre Formation and the Saint Clare Group, particularly when these formations outcrop near the Duke River Fault. Several large slumps were mapped in the Sheep Creek area and to the south of Kluane Lake (Yukon GEOPROCESS file, 2002).

GLACIAL HISTORY

This ecoregion comprises the northern slopes of the glacier-covered St. Elias Mountains and the northwestern part of the Kluane Range. The distribution of modern glaciers indicates a network of valley glaciers that becomes a discontinuous ice cover towards the main divides (Fig. 173-1). The Kluane Range now presents local cirque glaciers. During pre-Reid, Reid and McConnell glaciations, these valley glaciers formed piedmont glaciers that extended north near the confluence of the Nisling and Donjek rivers in the Klondike Plateau Ecoregion (Rampton, 1969; Duk-Rodkin *et al.*, 2001). They merged with glaciers emanating from the Kluane Ranges. During the earliest pre-Reid Glaciation (ca. 3 Ma), the piedmont ice front blocked the drainage of White and Nisling rivers to the west and diverted it across the Yukon–Tanana upland, where it entered the Yukon River drainage system.

CLIMATE

This ecoregion's climate is complex. The topographical divide of the St. Elias–Coast mountains, closely aligned with the divide between the coastal moist climate and the interior drier climate, extends from its southwestern border near Mount Logan, southeastward to bisect this ecoregion along its southern border west of the Tatshenshini and Alsek rivers. Precipitation is heavy in the southeast, particularly along southwestern and southern slopes, amounting up to 1,000 mm, most of which occurs in the fall and early winter. Precipitation decreases rapidly to the north and east with annual amounts of only 300 to 400 mm along the eastern and northern boundary of this ecoregion. The precipitation falls as snow except at elevations below 1,500 to 2,500 m asl during the summer and early autumn. The result is massive icefields with the glaciers spilling out the lower valleys.

Temperatures are affected both by season and elevation (Table 173-1). Generally, there is a decrease in temperature, during the summer months of

Table 173-1. Probable mean temperatures by elevation, season and location for St. Elias Mountains Ecoregion.

Coastal slopes over southeastern portion			
	1,500 m	**2,500 m**	**5,000 m**
Annual	–5°C	–10°C	–25°C
December	–12°C	–18°C	–30°C
June	6°C	–1°C	–22°C
Interior slopes over extreme eastern and northern portions			
	1,500 m	**2,500 m**	**5,000 m**
Annual	–3°C	–8°C	–22°C
December	–20°C	–20°C	–30°C
June	10°C	–1°C	–21°C

5 to 8°C for every 1,000 m increase in elevation. During the winter, this can be dramatically reversed at elevations below 1,500 m due to intrusions of cold arctic air and strong radiation cooling. Temperatures of the valley floors of the eastern and northern portion of this ecoregion can fall between –30 and –60°C. However, with temperatures at 1,500 to 2,000 m asl of only –10 to –20°C, it may be almost isothermal between 2,000 to 3,000 m asl and then decrease above 3,000 m asl at a rate of 5°C per 1,000 m.

Winds are frequently moderate to strong due to proximity of active storms in the Gulf of Alaska. During the fall and winter, and occasionally in the spring, extreme winds can occur that may cause structural damage. These severe winds are most frequently funnelled through well-defined valleys.

No long-term climate stations exist within this ecosystem. Burwash Landing, Haines Junction and Dezadeash can be used as indicators for lower elevations in the extreme northern and eastern sections. Haines Apps#2 weather site could be used as an indicator for lower sections in the coastal southeast portion of this ecoregion. Extensive meteorological data were taken at a divide, 60°46'N, 139°40'W, elevation 2,652 m, but only for June through August in 1961, 1963, 1964, 1965, 1968 and 1969.

HYDROLOGY

The ecoregion drains the northern and eastern slopes of the St. Elias Mountains. Primarily a high altitude source region, the few major streams are relatively short because of the significant coverage by icefields and valley glaciers that dominate the ecoregion. The largest stream is the White River which flows east out of Alaska before turning and flowing out of the ecoregion. Other major streams are the Generc, a tributary of the White, and the Donjek and Duke rivers. The Slims and Alsek rivers form portions of the eastern boundary. The ecoregion has few waterbodies and no major lakes. Wetlands are largely absent. Annual streamflow is characterized by a rapid increase in discharge in May due to snowmelt at lower elevations, then rising to a peak in July or August due to high elevation snowfield and glacier melt. Because the majority of the stream channels are steep and relatively short, streamflow response tends to be rapid and flashy. Maximum annual flows on larger streams are generated by high-elevation snow and glacier melting, while on smaller streams approximately 40% of the annual maximum flows are due to intense summer rain storm events. The small steep streams draining the northeastern-facing slopes of the front ranges of the St. Elias Mountains are susceptible to mud flows and debris torrents triggered by these summer rainstorms.

There are three representative continuous active or historical hydrometric stations: White and Duke rivers and Burwash Creek. The mean annual runoff is high at a rate of 493 mm, while mean seasonal and mean summer flows are high with values of 31 X 10^{-3} and 32.2 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are relatively and extremely high with values of 94 X 10^{-3} and 138 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March, with the relative magnitude higher than most other ecoregions due to the moderating influence of the Gulf of Alaska on winter temperatures and subsequent groundwater contributions. The mean annual minimum and mean summer minimum flows are relatively high, with values of 1.6 X 10^{-3} and 6.1 X 10^{-3} $m^3/s/km^2$, respectively.

PERMAFROST

The St. Elias Mountains Ecoregion straddles the widespread and sporadic discontinuous permafrost zones. Permafrost is generally found above about 1,600 m asl in the mountains, but the active layer depth is not controlled as much by elevation as by surficial materials (Harris, 1987). Within the mountains, permafrost occurs at high elevation, and the upland surfaces exhibit frost action features, particularly solifluction lobes and patterned ground. Rock glaciers, with interstitial ice, dominate many slopes (Johnson, 1988). Debris-covered glaciers, relict from Neoglacial ice advances, are found in cirques and valley bottoms (Rampton, 1981a). Near the snout of Klutlan Glacier, much glacier ice has been covered by the recent (AD 803; Clague *et al.*, 1995) White River tephra (Fig. 173-3).

In valleys, ice-rich permafrost is associated with organic soils, colluvial deposits, lacustrine sediments, and some moraine (Rampton, 1981b). Networks of ice wedges are apparent in some colluvial settings, and have been observed in trench walls (Rampton, 1981b; Rampton *et al.*, 1983). Considerable accumulations of aggradational ice have formed during the Holocene in organic deposits and mineral sediments at sites of active deposition (Rampton *et al.*, 1983). Ground ice in the region is also associated with the emergence of groundwater into near-surface materials (Rampton *et al.*, 1983). Discharge of groundwater draining from the Kluane Front Range creates frequent icing along the Alaska Highway (van Everdingen, 1982).

SOILS

Soil development in the ecoregion is controlled by elevation and by a marked climatic gradient moving from relatively mild and humid in the south to relatively cold and dry conditions at its northern limit.

J. Meikle, Yukon Government

Figure 173-3. The terminus of the Klutlan Glacier is covered by about 1 m of volcanic tephra (ash and pumice) from the White River volcanic eruption in AD 803. This tephra blanket supports white spruce with a willow understory — a unique situation of a forest growing on a glacier!

Orthic Regosols are the dominant soil formed primarily on active colluvial surfaces and moraine in alpine environments that lie above 1,500 m asl. In the northern portion of the ecoregion, Regosolic Static Cryosols are most common. Within the subalpine zone, at elevations between 1,100 and 1,500 m asl, a wider range of materials and soils are found. Dystric and Eutric Brunisols commonly occur on moraine and glaciofluvial landforms within the major valley systems of the Kluane Ranges. Near the active snouts of valley glaciers such as the Kaskawulsh, Donjek, Steele, Kluane and Lowell, Regosols can be found on a variety of neo-glacial moraines and outwash (Gray, 1984).

Below 1,100 m asl, boreal forest occurs on Dystric and Eutric Brunisols, and Gleysols in areas of poor drainage. Wetlands within this zone are underlain for the most part with permafrost, so Mesic and Fibric Organic Cryosols are found here.

A few unique soils occur within this ecoregion. A well-expressed Brunisolic paleosol formed during the early Holocene can be seen in the Slims River Valley and near the Donjek Glacier in the Donjek Valley. The soil is thought to have formed during the period of climatic amelioration following the end of the Pleistocene glaciations. During the Neoglacial period, about 3,000 to 2,500 years ago, the glaciers re-advanced and loess deposition began again, burying the former Slims soil profile over many years. The thickest deposits of the White River eruption lie in the northern portions of the ecoregion. Pumice and ash up to 2 m thick occur on and adjacent to the Klutan Glacier (Fig. 173-3). Within the ecoregion, the thickness of the ash thins rapidly to less than 75 cm moving directly northward and eastward from this point (Lerbekmo and Campbell, 1969). In many locations, this tephra has been invaded by permafrost. There has been little soil development (weathering) in this volcanic parent material.

VEGETATION

The vegetation of the St. Elias Mountains is mainly alpine and subalpine (Fig. 173-4). Treeline is close to 1,080 m asl. Below treeline, which is restricted to the eastern border of the ecoregion and river valleys, white spruce forms the climax plant community. Black spruce, larch, and pine are absent from the forest canopy except for a few isolated individuals. Broad zones of tall and medium shrubs dominate the subalpine between 1,040 and 1,400 m elevation. Subalpine meadows are common. Above 1,400 m asl, the cover is mostly alpine tundra with lichens, prostrate willows and ericaceous shrubs.

The most common mature forest community is white spruce and willow, with a moss and ground shrub groundcover. On drier sites in the southern part of the ecoregion, white spruce is often associated with soapberry, grass and ground shrubs. On cool, moist, north and east slopes, white spruce is found with a shrub birch and crowberry understory. On poorly drained sites, white spruce is associated with willow, or with shrub birch and *Carex* forming a rich fen community. On younger sites (less than about 130 years old) disturbed by fire in the southern and central parts of the region, aspen may compose part or all of the canopy. The willow *Salix scouleriana* also typically colonizes burned areas.

J. Meikle, Yukon Government

Figure 173-4. This groundsel species (*Senecio kjellmannii)* is amphi-Beringian (i.e. endemic to British Columbia, the Yukon, Alaska and Siberia). In the Yukon, it is known to occur in three areas: the Richardson Mountains, the Tombstone area, and the St. Elias Mountains Ecoregion in the Wolverine Plateau area north of Kluane National Park Reserve.

Salix glauca and shrub birch dominate the subalpine zone. In the south, alder is found along some of the creeks. Interspersed in the shrublands are frequent subalpine meadows. These are usually well drained, but persistent snowpacks provide moisture throughout much of the summer. In the south, these meadows are lush, containing numerous coastal species, and are typical of meadows further south. The easten side of the ecoregion contains dry meadows dominated by *Oxytropis* and *Calamagrostis*.

The alpine areas of the St. Elias Mountains Ecoregion consist of extensive glaciers of ice and very sparsely vegetated steep rock and rubble. Any relatively sheltered sites are host to a great diversity of plant life. Flowering plants have been collected at over 2,200 m asl, where such sites allow individual plants to survive (Murray and Douglas, 1980).

On alpine slopes below 1,600 m asl, low shrubs, shrub birch, willow, and ericaceous shrubs such as heather, Labrador tea and alpine blueberry are the dominant groundcover. A short growing season and cold soils limit snowbed sites. These communities are dominated by *Salix polaris*, or, in the south by *Phippsia algida*, *Ranunculus pygmaeus* or *Saxifraga* spp. and *Cassiope stelleriana* (Environment Canada, 1987). Seepage zones downslope from persistent snowbeds are rich, wet sites usually dominated by sedges and colourful herbs. Above 1,600 m asl, the pattern of vegetation distribution is related to the time of snowmelt, the available soil moisture and aspect (Douglas, 1974a). The most common alpine communities are those dominated by *Salix polaris* and *Salix reticulata* on moister sites, white mountain heather in sheltered sites, *Festuca altaica* on drier slopes, and *Dryas octopetala* and *Kobresia myosuroides* on exposed ridge crests. Lichen is prominent in all of these communities (Environment Canada, 1987).

WILDLIFE

Mammals

The St. Elias Mountains Ecoregion supports a great diversity of wildlife species. The Chisana and Mentasta woodland caribou herds, estimated at 500 and 700, respectively, and the Nelchina barren-ground herd, at about 35,000, enter the ecoregion from Alaska, usually in winter. Dall sheep populations reach high densities (Fig. 173-5). Mountain goats inhabit Goatherd and other mountains of the southern part of the ecoregion, reaching their highest numbers in the Yukon (Barichello and Carey, 1988). Small, isolated goat populations are found further north. These ungulates, along with moose, support numerous wolves and wolverine (Banci, 1987). Coyotes are abundant along the arid rain shadow in the north of the ecoregion, possibly displacing the red fox during 20th century colonization. Marten are notably rare due to naturally fragmented habitat and mountains as barriers to movement (Slough, 1989). This region is noted for its high density of grizzly bears, which feed on the numerous prey species and diverse plant communities at all elevations (Fig. 176-6).

Dall sheep, mountain goats, arctic ground squirrels, collared pikas and singing voles have colonized nunataks, or unglaciated islands in the glaciers. Predators, such as wolverine and grizzly bears, make occasional forays to the nunataks. Migrating little brown myotis may perish crossing the St. Elias Mountains in unfavourable weather. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Birds

Pacific and Common Loons, Greater Scaup, Bufflehead, Lesser Yellowlegs, Spotted Sandpiper, Red-necked Phalarope, Mew and Bonaparte's Gulls, Arctic Tern, and Rusty Blackbird can be found in and around the few lakes and ponds that exist in the ecoregion (Kluane National Park, 1951; Hoefs, 1972).

White spruce forests on lower slopes and valleys (Fig. 173-5) provide habitat for year-round residents such as Three-toed and Black-backed Woodpeckers, Gray Jay, Boreal Chickadee, and Red-breasted Nuthatch (Hoefs, 1972; Stelfox, 1972). Other breeding species include Northern Flicker, Swainson's and Hermit Thrushes, Yellow-rumped Warbler and Chipping Sparrow (Kluane National Park, 1951).

Species that breed at treeline include Northern Shrike, Townsend's Solitaire, Wilson's Warbler, White-crowned Sparrow, and Dark-eyed Junco (Kluane National Park, 1951). Higher elevation mountain ridges and exposed talus slopes support year-round populations of Rock and White-tailed Ptarmigan (Theberge *et al.*, 1986). Summer brings migrant Horned Lark, Northern Wheatear, American

M. Hoefs

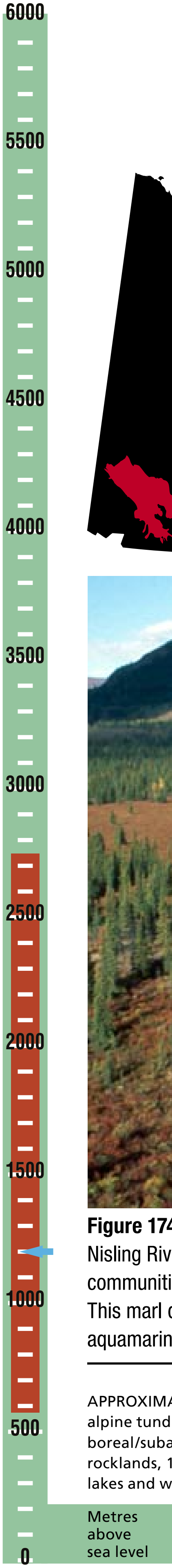
Figure 173-5. A bachelor herd of Dall sheep *(Ovis dalli)* in springtime on the Front Ranges of the St. Elias Mountains along the eastern edge of the ecoregion. White spruce and grassland communities are common on southerly and western aspects at low elevation.

J. Meikle, Yukon Government

Figure 173-6. Not of all the ecoregion is characterized by rugged mountain ranges and glaciers. The northern portion of the ecoregion is dominated by the high elevation Wolverine Plateau supporting shrub tundra vegetation that provides habitat for a range of wildlife species.

Pipit, and Gray-crowned Rosy Finch to these ridges to breed (Theberge *et al.*, 1986; CWS, Birds of the Yukon Database), while snow-covered cirques on north-facing slopes attract breeding Snow Bunting (Hoefs, 1972). Species nesting in alpine tundra and shrub areas (Fig. 173-6) include Northern Harrier, Willow Ptarmigan, American Tree, Brewer's, Savannah, White-crowned and Golden-crowned Sparrows, and Common Redpoll (Drury, 1953; Theberge, 1974; CWS, Birds of the Yukon Database). The numerous south-facing cliffs and canyon walls provide nesting habitat for a large population of Golden Eagle and smaller numbers of Gyrfalcon (Hoefs, 1972). Peregrine Falcon may also use this habitat (Hoefs, 1972).

Numerous migrants have been found dead at very high elevations on the St. Elias Icefields. These include Horned and Red-necked Grebes, Mallard, Green-winged Teal, Solitary and Least Sandpipers, Red-necked Phalarope, Rufous Hummingbird, Tree Swallow, Ruby-crowned Kinglet, Bohemian Waxwing, Blackpoll Warbler, and White-crowned Sparrow (D. Hik, unpubl. data). While some of these, such as Red-necked Grebe and Red-necked Phalarope, may have been on their regular migration to the Pacific Coast, others such as Solitary Sandpiper and Blackpoll Warbler were likely blown off course.



Ruby Ranges

Boreal Cordillera Ecozone

ECOREGION 174

DISTINGUISHING CHARACTERISTICS: Margins of three Pleistocene glaciations emanating from the St. Elias Mountains are visible in the Ruby Ranges. This ecoregion is one of Yukon's driest, as it lies in the rain shadow of the St. Elias Mountains. Kluane Lake, the largest lake in the Yukon, lies in the Shakwak Trench along the southwest edge of this ecoregion. Dall sheep, wolves and grizzly bears are relatively abundant. Swans, geese and ducks use the wetlands in the Shakwak Trench for nesting while other migratory birds use the wetlands for staging enroute to and from breeding grounds in Alaska.

M. Berkman

Figure 174-1. An open canopy, mid-elevation white spruce forest with dwarf birch and willow understory occupies the upper Nisling River valley near the northern boundary of the ecoregion. Scant precipitation in the ecoregion fosters grassland communities on south and westerly aspects. Lakes tend to be alkaline and encourage marl (biogenic calcium carbonate) formation. This marl deposit preferentially absorbs higher wavelengths of the visible light spectrum, so that shallow water appears to have an aquamarine tint.

APPROXIMATE LAND COVER
alpine tundra, 50%
boreal/subalpine coniferous forest, 35%
rocklands, 10%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
22,737 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
22,737 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
5%

ELEVATIONAL RANGE
575–2,745 m asl
mean elevation 1,200 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Ruby Range Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Portion of **Interior Yukon/Alaska Alpine Tundra Ecoregion** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Ruby Ranges Ecoregion occupies the Kluane Plateau physiographic unit, a subdivision of the Yukon Plateau, the Shakwak Trench, and the Kluane Ranges south of Kluane Lake (Mathews, 1986). The Kluane Plateau is a wide, undulating, dissected upland consisting of the Nisling and Ruby ranges and the slightly lower area around Aishihik Lake and the Nisling River valley (Fig. 174-1). The Kluane Plateau is higher than the Lewes Plateau to the east, and higher than the Klondike Plateau to the north.

The Shakwak Trench is a major longitudinal valley marking the Denali Fault, which runs from Haines, Alaska, to the south end of Kluane Lake and on to eastern Alaska. It separates the tectonically active rugged mountains to the west from the lower mountains and broad valleys east of the fault. The Kluane Ranges form a wall rising from the Shakwak Trench to the east marking the fault line scarp (Fig. 174-2). They are uniformly steep-sided mountains with talus slopes. Glaciers occur north of Dezadeash Lake.

Mount Cairnes and Mount Vulcan are over 2,700 m asl; numerous others are over 2,200 m asl. Maximum elevations decrease toward the north and west. Only a couple of peaks in the Ruby Range top 2,200 m asl, and the Nisling Range is less than 2,000 m asl. Most of the Aishihik area is less than 1,400 m asl, but the Sifton Range and Mount Creedon reach 2,100 m asl. The lowest elevation is in the south, where the Alsek River Valley is less than 600 m asl.

BEDROCK GEOLOGY

Three geological terranes separated by two northwest-trending faults lie within this ecoregion. Highly metamorphosed sedimentary and granitic rocks comprise most of the area, regionally mapped by Kindle (1953), Wheeler (1963), Muller (1967) and Tempelman-Kluit (1974).

In the southwest of the ecoregion, the lowlands and some mountains are mantled by 6 to 17 Ma iron mafic lavas and breccias (Wrangell volcanics). Paleozoic greywacke, argillite and limestone are interleaved by closely spaced faults in the Mount Cairnes area. The seismically active Duke River Fault (Clague, 1979; Horner, 1983) separates these rocks of the Alexander Terrane (e.g. Monger and Berg, 1984) from the Gravina–Nutzotin Belt (Berg *et al.*, 1972). The latter includes the Auriol Range, where biotite schist, granitic gneiss, with lesser quartzite and marble comprise the Mesozoic Dezadeash Formation (Eisbacher, 1976). The geological reason for the abrupt mountain front, where the Shakwak Valley (Fig. 174-2) truncates these rocks, remains unclear. The colluvium and glacial deposits in the valley hide a major

C.F. Roots, Geological Survey of Canada

Figure 174-2. Kluane Lake occupies the broad Shakwak Trench, an ancient fault separating the sedimentary Front Ranges of the St. Elias Mountains Ecoregion (left) from the metamorphic rocks of the Ruby Ranges Ecoregion (in the background). This northward view from Outpost Mountain shows the Alaska Highway near the research station of the Arctic Institute of North America on the southern shore of the Kluane lake.

transcurrent fault — the Denali, although this segment of the fault is currently inactive.

Northeast of the Shakwak Valley lies the Yukon Crystalline Belt (Tempelman-Kluit, 1976), a southwestern extension of the Yukon–Tanana Terrane, which is a broad zone of metamorphosed rocks in central Alaska and western Yukon (Mortensen, 1992). Foliated granodiorite and biotite quartz diorite constitute the Aishihik and Ruby Range batholiths, which trend north and northwest, parallel to the long axis of the ecoregion. The latter batholith is notable for local pods of 10 cm long pink feldspar crystals, easily visible near the portal of the hydroelectric installation at Canyon Lake. Northeast of Kluane Lake, and structurally below the Ruby Range batholith, are sericite–biotite schist, muscovite-–chlorite schist, gneiss and amphibolite (Kluane Assemblage; Erdmer, 1991). Between the Ruby Range and Aishihik Lake, and extending southeast to Mount Bratnober and northwest to the White River, is biotite schist, granitic gneiss with lesser quartzite and marble of the Aishihik Assemblage (Johnston and Timmerman, 1994). Isolated occurrences of granite, fine-grained siliceous intrusive alaskite and volcanic rock perforate the metamorphic terrane. Granite around Taye and Moraine lakes in the southeast is part of the Coast Plutonic Complex (60 Ma). North of the Ruby Range, the metamorphic rocks are overlain by 50-million-year-old tuff and breccia, the Donjek volcanics (Muller, 1967; Tempelman-Kluit, 1974), which are mainly visible where incised by streams.

An important mineral occurrence near Killermun Lake, 48 km northeast of Haines Junction, consists of native gold and gold-bearing arsenopyrite in quartz veins (Burke and Abbott, 1995). Numerous skarns, where carbonate is metamorphosed by intruding granite, with molybdenite, copper-bearing chalcopyrite, and magnetite have been examined (Morin, 1981) in the Hopkins Lake–Giltana Lake area. The construction of the Aishihik hydroelectric facility, one of the Yukon's largest rock-moving projects, was undertaken near the mouth of Canyon Lake from 1975 to 1978.

SURFICIAL GEOLOGY

Information on the Quaternary geology of this area is provided by a 1990 report and a set of four maps at the 1:100,000 scale by Hughes (1989a,b,c,d). Most of this ecoregion was included in the terrain hazards mapping by Thurber Consultants Ltd. (1989). The steep bedrock exposures at high elevation are often mantled with colluvial fans and steep talus slopes covered by coarse, angular, bedrock rubble.

At mid-elevation, most slopes are covered by moraine ridges and blankets, ice contact deposits, and meltwater channels. Moraine deposits are common and consist mainly of gravelly diamicton with a silty to sandy matrix with a low clay content, and clast contents of 20 to 40%. Solifluction lobes, frost-shattered rocks, and sorted polygons are common on moraine and colluvium-covered slopes. Glaciofluvial gravelly sands are well drained and provide stable surfaces, as they are usually free of ice-rich permafrost. They often form large surfaces with gentle to rolling topography, such as the outwash plain north of Aishihik Lake.

Lake Sekulmun–Aishihik, a large glacial lake in the area, formed during the retreat of McConnell ice. The highest elevation of shoreline related to this lake is believed to be 1,130 m asl, which is 196 m above present lake level. Well-sorted silt and clay deposits of this lake are up to 40 m thick. They are found at the north shore of present-day Aishihik Lake and in the West Aishihik River. Thick organic deposits often cover floodplain deposits and are very likely underlain by permafrost. Ice content is expected to be low to nil in well-drained, coarse, fluvial and glaciofluvial deposits. There is no permafrost under large waterbodies, such as lakes and rivers.

GLACIAL HISTORY

The eastern part of this ecoregion was affected by the Cordilleran Ice Sheet and the southern part by piedmont glaciers from the St. Elias Mountains. The highest parts of the Ruby Range supported ice caps and cirque glaciers (Hughes, 1990). A complex network of ice tongues invaded the valleys. Smaller ice bodies from cirque and ice cap glaciers occupying the higher elevations occasionally merged with the valley glaciers. Approximately 90% of the ecoregion was glaciated during pre-Reid glaciation. Approximately 60% of the area was covered by the Reid, and close to 50% was covered by the McConnell, glaciations (Duk-Rodkin, 1999). Numerous drainage diversions took place and many glacial lakes were formed during both the advance and retreat of ice during the glaciations that have affected the area. Glacial Lake Nisling was formed during the Reid Glaciation (Geurts and Dewez,

1993) in the upper Nisling Valley to a maximum elevation of 1,219 m asl. This lake drained north into the Klaza River. Glacial Lake Sekulmun–Aishihik was the most important glacial lake formed in the area during the Late Wisconsinan (Hughes, 1990).

Most recently, Glacial Lake Alsek formed as a result of several incidences of glacial blockage of the Alsek River. The valley where present-day Haines Junction is located has been inundated several times in the last few hundred years.

CLIMATE

This ecoregion is one of the driest within the Yukon because it lies in the rain shadow of the St. Elias Mountains. Precipitation amounts are only 250 to 300 mm annually. Monthly means are only 10 to 20 mm from January to May and are greatest in June and July with means of 30 to 70 mm. This heavier summer precipitation is primarily created by convection with fairly extensive thunderstorm activity, particularly over western portions of this region. The precipitation is mainly snow from October through April.

Mean annual temperatures are from –3 to –7°C with the lower temperatures in the western portion. Mean January temperatures range from –30 to –35°C in the lower elevations of the Shakwak Valley to –25°C over the higher terrain. Mean July temperatures range from 12°C in the lower valleys to 7°C over the higher terrain. Extreme temperatures, from –62 to 32°C, occur in the lower valley floors. Frost can be expected anytime of the year.

Winds tend to be moderate, but are often strong. Gale force winds have caused structural damage. These gale winds are usually southerly and associated with active storms in the Gulf of Alaska. Strong northwesterly winds can occur, generally in the winter, associated with outbreaks of Arctic air.

Representative weather stations are Burwash, Aishihik and Haines Junction. Burwash and the now closed Aishihik station have extensive data on wind.

HYDROLOGY

The ecoregion drains the Ruby and Nisling ranges immediately east of the Shakwak Trench. As a minor exception, a small pocket to the west of the Shakwak Trench (Haines Highway) that includes the Kluane Ranges is situated within the Western Hydrologic Region (Fig. 8). Hydrologic response from this pocket differs from the rest of the ecoregion because of higher relief, steeper slopes and glaciers. The most representative streams are the Dezadeash River and its tributaries and the Aishihik and Kathleen rivers. The Donjek and Kluane rivers are other large streams within the ecoregion, though not representative of the hydrologic response because their headwaters are outside the ecoregion. The southern boundary is formed by the Alsek and Kaskawulsh rivers, while the northern boundary is formed by the Nisling River. The largest stream is the White River, which flows east out of Alaska before turning and flowing out of the ecoregion. The ecoregion contains Kluane Lake (Fig. 174-2), the largest lake entirely within the Yukon. Other major lakes include Sekulmun and Aishihik lakes to the east of Kluane Lake, and Dezadeash, Kathleen, Mush and Bates lakes to the south. Wetlands are generally associated with these lakes.

There are six representative active and historical continuous and seasonal hydrometric stations: Dezadeash, Aishihik (two) and Sekulmun rivers, and Giltana and Christmas creeks. Annual streamflow is characterized by a rapid increase in snowmelt discharge to a peak in May or June. On smaller streams, approximately 40% of the annual maximum flows are due to intense summer rainstorm events. Streamflow response is unique due to a rain shadow effect provided by the St. Elias Mountains. Not only does the ecoregion have extremely low peak flows, and low runoff and summer flows in general, but it also has low winter flows as well. This is unusual considering the proximity of the ecoregion to the Gulf of Alaska and its moderating influence on winter temperatures and subsequent groundwater contributions. Mean annual runoff is low with values ranging from 97 to 161 mm, with an ecosystem average of 120 mm. Mean seasonal and summer flows are low with values of 6.7×10^{-3} and 5.9×10^{-3} $m^3/s/km^2$, respectively. The mean annual flood is the lowest of all Yukon ecoregions and the mean maximum summer flow is also relatively low with values of 23×10^{-3} and 21×10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March with values considerably lower than would be expected due to the proximity of the ecoregion to the Gulf of Alaska. The minimum annual and summer flows are moderately low and low with values of 0.75×10^{-3} and 1.6×10^{-3} $m^3/s/km^2$, respectively.

PERMAFROST

Permafrost is widespread within most of the Ruby Ranges Ecoregion, although it becomes sporadic in southern parts, as around Haines Junction (Boreal Engineering Services, 1985). The maximum thickness recorded at Haines Junction is 12 m, with mean near-surface ground temperature of –0.4°C (Burgess *et al.*, 1982). However, Brown (1967) recorded a thickness of 27 m at Aishihik airfield, and Burn (1995) found a maximum thickness of more than 22 m near Aishihik village, beneath a variable active layer. At sites in the forest, near the village, the active layer was recorded consistently at about 70 cm, but on south-facing, grass-covered slopes, the active layer depth ranged up to 2.2 m. Slumping of banks at the north end of Aishihik Lake is due to thawing of ice-rich ground. Considerable aggradational ice has grown in alluvial fan sediments throughout the ecoregion (Hughes, 1990; Burn, 1995).

In the Shakwak Trench, permafrost is widespread northwest of Kluane Lake, where 60 to 80% of boreholes drilled during geotechnical investigations along the Alaska Highway have encountered permafrost (Rampton *et al.*, 1983; Geotechnical Services, 1993). Near Burwash Landing, permafrost up to 18 m thick has been encountered beneath an active layer of 1.3 to 1.5 m (Ellwood and Nixon, 1983; Nairne, 1989). Southeast of Kluane Lake, only 20% of boreholes drilled along the Alaska Highway pipeline alignment encountered permafrost (Rampton *et al.*, 1983). At Haines Junction, permafrost has been recorded to depths of 7.3 m in two holes drilled for Water Tower construction (EBA, 1974), but most ground nearby is only frozen seasonally (Klohn Leonoff, 1987). The active layer in the dry valley floor is 1 to 2 m thick.

Hughes (1990) indicates that glaciolacustrine and alluvial deposits throughout the ecoregion are ice-rich, and ground ice is also frequently found in peat and other organic accumulations (Wang and Geurts, 1991). A small closed-system pingo northeast of Aishihik airfield is remarkable in its location in the southern Yukon Territory. Relict ice-wedge polygons have been described from select locations along the Nisling River and MacGregor Creek (Hughes, 1990).

Permafrost appears to be variably distributed beneath hillsides, with frozen ground more common on north-facing slopes, particularly in southern portions of the ecoregion (Peddle and Franklin, 1993). Most of the ground in the alpine zone is probably underlain by permafrost, the active layer is from 50 cm to more than 150 cm thick, and there is abundant patterned ground (Price, 1971). North of and above the glacial limits tors and cryoplanation terraces indicate an extended period of frost weathering (Hughes, 1990).

SOILS

Soil development in this ecoregion reflects the somewhat moderated continental climate and the rain shadow of the St. Elias Mountains, which produce the cool, dry conditions typical of the southwestern Yukon. The ecoregion is characterized by either rolling plateau or subdued mountainous topography overlain by a variety of parent materials including moraine, colluvium and glaciofluvial materials. Higher elevations are unglaciated and have been subjected to intense periglacial weathering (Hughes, 1990). Soils tend to be colder and moister in the northern portions of the ecoregion.

In the major valleys around Haines Junction, Eutric Brunisols are the most common soils on all parent materials (Day, 1962; Rostad *et al.*, 1977). These soils tend to be alkaline in reaction, calcareous and, in some locations on glaciolacustrine material, saline. In the area of the Nisling Range, lower annual air temperatures lead to the presence of discontinuous permafrost, so that Turbic Cryosols are also common. Soils have formed within residual materials above the glacial limit through much of the ecoregion. Sorted nets and stripes are common and associated soils are classified as Orthic Turbic Cryosols. Throughout the northern portion of the ecoregion, and particularly in the area between the White River and the Donjek River, an extensive blanket of the White River tephra up to 50 cm thick is present. The ash overlies the former soil surface and is not strongly weathered. In some locations, cryoturbation and tree throw have mixed the ash with underlying mineral and organic soil leading to some unique soil morphologies, including the only Cryosols dominated by tephra in Canada (Smith *et al.*, 1999). Cryosols become much more common in the Shakwak Trench north of Kluane Lake. Ellwood and Nixon (1983) described soils with common massive ground ice between 1 and 2 m depth. Estimates on the rate of peat accumulation in the northern wetlands of the Trench are about 50 cm in the last 1,200 years (Zoltai *et al.*, 1988).

Another unique soil forming process in this ecoregion is the active deposition of loess in the vicinity of the Slims, Donjek and White rivers. Loess deposition along the southern end of Kluane Lake has been shown to enhance vegetative productivity in the area (Laxton *et al.*, 1996), particularly native grasses on glaciofluvial terraces and south-facing slopes. Regosols or Gleysols are associated with the large outwash plains developed along these glacier rivers; these may even be saline in some locations, such as the Slims River Delta (Harris, 1990).

J. Meikle, Yukon Government

Figure 174-3. White spruce forest gives way upslope to aspen (bright yellow), with shrub birch (dark green) and willow higher upslope. The extensive alpine and subalpine ecosystems support the Burwash and Aishihik caribou herds. Here in the snow shadow of the St. Elias Mountains, winter range is more plentiful than it is for woodland caribou herds farther east in the Yukon. View is northward from Gladstone Creek in early September.

VEGETATION

The vegetation of the Ruby Ranges is mainly boreal forest. White spruce dominates the landscape below treeline, which is near 1,200 m asl. Broad zones of tall and medium shrubs dominate the subalpine between 1,040 and 1,400 m asl. Subalpine meadows are common. Above 1,400 m asl, alpine tundra with lichens and ground shrubs predominates.

In the montane zone of the ecoregion, white spruce is the dominant tree species on well-drained sites (Fig. 174-1). Black spruce, larch, and pine are absent from the forest canopy except for a few isolated individuals. Pine is restricted to the southeastern fringe of the ecoregion. Trembling aspen occurs mixed with white spruce in younger stands on warmer sites (Fig. 174-3). Balsam poplar occurs along streams and on some moister slopes in the south of the ecoregion, where the precipitation is higher. Black spruce dominates poorly drained areas north of Kluane Lake, usually associated with Turbic Cryosolic soils associated with near-surface permafrost. Paper birch is also found in the northern part of the ecoregion, established in early successional stands on cooler sites.

The most common mature forest community in the ecoregion is white spruce and willow with a moss and ground shrub groundcover. On drier sites in the southern part of the ecoregion, white spruce is often associated with soapberry, grass and ground shrubs. On cool, moist, north and east slopes, white spruce with a shrub birch and crowberry understory is found. On poorly drained sites, white spruce is associated with willow, or with shrub birch and *Carex* forming a rich fen community. Aspen and *Salix scouleriana* typically colonize burned sites.

Salix glauca and shrub birch dominate the subalpine. In the alpine, prostrate willows, ericaceous shrubs such as mountain blueberry, crowberry and lingonberry, lichen and herbs predominate.

The Ruby Ranges Ecoregion includes some interesting vegetation features. The saline delta of the Slims River is the only silty floodplain in the Yukon emerging from the St. Elias Mountains. Where Glacial Lake Alsek retreated less than 200 years ago, a primary forest succession occurs. The Haines Junction area has also experienced periodic forest infestation by spruce beetles in the 1940s and 1990s (Environment Canada, 1987).

WILDLIFE

Mammals

The Ruby Ranges support a vast diversity and abundance of wildlife. The Nelchina barren-ground caribou herd, and Chisana and Mentasta woodland caribou herds enter from Alaska, primarily in winter. This is the core area of the Aishihik herd, numbering 1,500 caribou. Possible natural factors and heavy human harvest of caribou made intensive management for the Aishihik herd necessary (Carey *et al.*, 1994), through reduction of harvests and wolf populations between 1993 and 1997. Moose populations had also been depleted (Larsen and Ward, 1991b).

The Kluane caribou herd is one of the smallest in the Yukon at about 200 animals. The Chisana and Mentasta woodland caribou herds are estimated at 500 and 700, respectively and about 3,500 caribou comprise the Nelchina barren-ground herd. Woodland caribou in the more arid regions such as the Mentasta, Kluane and Aishihik herds are not restricted to winter ranges by snowfall (R. Farnell, pers. comm.). These wider ranging herds are more vulnerable to wolf predation than herds with concentrated winter ranges.

Dall sheep reach their greatest numbers here and in the St. Elias Mountains and Yukon Southern Lakes ecoregions (Barichello *et al.*, 1989a). Populations of mountain goats are found in the Alsek Mountain Range. Coyote, wolf and wolverine (Banci, 1987) densities are among the highest in the Yukon. Grizzly bears are also abundant, particularly south of the Dezadeash River, where they reach some of the highest densities found in the Yukon. Red fox numbers have likely decreased since coyotes invaded the area in the 20th century.

Marten, historically rare, were transplanted to the Dezadeash basin in the 1980s, where small populations have been established (Slough, 1989). Wood bison, introduced to the upper Nisling River basin of the Yukon Plateau–Central and Yukon Southern Lakes ecoregions in 1986, are now established in the Aishihik Lake and Nisling areas (Fig. 174-4) and number about 400.

Elk, introduced in the 1950s and 1990s to enhance biodiversity and hunting opportunities, have established two small but stable herds (M. Hoefs, pers. comm.). One herd of at least 50 elk resides in the Hutshi Lake area and a herd near the Takhini River has about 60 members. Elk are not endemic to the area.

Several muskrat marshes are worthy of note, including Pickhandle Lakes, Kloo Lake–Jarvis River, Hutshi Lakes and Taye Lake wetlands (Slough and Jessup, 1984). The little brown myotis is abundant in the upper Dezadeash Basin. The bushy-tailed wood rat is an uncommon resident. Arctic ground squirrels and least chipmunks thrive in the many meadows of this arid region. The deer mouse, the most widespread mammal in North America, is found only in the southern half of the Yukon, and is most abundant in the Ruby Range and Yukon Southern Lakes ecoregions. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

M. Berkman

Figure 174-4. Wood bison were introduced to the upper Nisling watershed in 1979. Part of the species recovery strategy included creating isolated populations to reduce vulnerability to species-wide diseases. Oral history and fossil remains reveal bison were present in central Yukon until the late 18th century.

Birds

Swans, geese, and ducks migrating to and from their Alaskan breeding grounds use wetlands in the Shakwak Trench, a significant migration corridor running along the southwest edge of this ecoregion. Open water in early spring at the outlets of Dezadeash Lake and Kluane Lake create important spring staging sites for Tundra and Trumpeter Swans, Greater White-fronted Goose, and dabbling and diving ducks, while the lakes are used as staging areas in fall (Dennington, 1985; Nixon, 1989). Other important staging areas include Kloo, Sulphur, Aishihik, Hutshi and Taye lakes.

Common waterbirds include breeding Pacific Loon, Horned and Red-necked Grebes, Trumpeter Swan, Canada Goose, American Widgeon, Mallard, Northern Shoveler, Northern Pintail, scaup, scoters, goldeneyes, and several shorebirds (Soper, 1954; Dennington, 1985; Hawkings, 1994).

Larger streams and rivers support breeding Red-breasted and Common Mergansers along with Belted Kingfisher and American Dipper (Department of Public Works and U.S. Department of Transportation, 1977). Mew Gull and Arctic Tern breed on virtually all of the larger lakes, while Herring Gull occurs more sporadically on lakes and rivers (Godfrey, 1951).

Tree, Violet-green, Bank, and Cliff Swallows commonly breed adjacent to most lakes and rivers, while species such as Yellow and Wilson's Warblers, Common Yellowthroat, Fox and Lincoln's Sparrows, and Red-winged Blackbird are common in marshy areas (Hoefs, 1972; Johnston and Eftoda, 1990). Floodplains of large rivers, lakeshores, and marshes provide breeding habitat for shorebirds such as Lesser Yellowlegs, Solitary Sandpiper, Spotted Sandpiper, Least Sandpiper, and Common Snipe (Godfrey, 1951). Killdeer may breed on lakeside gravel beds and river deltas (Hoefs, 1972).

Mature white spruce forests provide breeding habitat for some species found only in the southern Yukon, such as Red-breasted Nuthatch and Golden-crowned Kinglet (Godfrey, 1951; Hoefs, 1972; Eckert *et al.*, 1998; CWS, Birds of the Yukon Database). Common breeding songbirds include Swainson's Thrush, Yellow-rumped Warbler, Wilson's Warbler, Dark-eyed Junco (Department of Public Works and U.S. Department of Transportation, 1977), Ruby-crowned Kinglet, Varied Thrush, and Pine Siskin (Theberge *et al.*, 1986). Common raptors include Sharp-shinned Hawk and Red-tailed Hawk (Theberge *et al.*, 1986).

Year-round residents include Northern Goshawk, Spruce Grouse, Great Horned Owl, Boreal Owl, Three-toed and Black-backed Woodpeckers, Gray Jay, Common Raven, and Black-capped and Boreal Chickadees (Theberge *et al.*, 1986). Open white and black spruce forests with extensive patches of willow and alder support Northern Hawk Owl, Northern Flicker, Olive-sided Flycatcher, Western Wood-Pewee, Hermit Thrush, American Robin, MacGillvray's Warbler, and American Tree Sparrow, as well as the uncommon Great Gray Owl (Theberge *et al.*, 1986). Breeding Downy Woodpecker, Least Flycatcher, Blackpoll Warbler, American Redstart, and Chipping Sparrow inhabit open mixed forests (Drury, 1953). Grassy openings in forests regularly found on dry, south-facing slopes provide breeding habitat for American Kestrel, Say's Phoebe, and Mountain Bluebird (Drury, 1953).

Sharp-tailed Grouse inhabit early successional trembling aspen and balsam poplar, while Upland Sandpipers breed in meadows and subalpine bogs (Stelfox, 1972; Department of Public Works and U.S. Department of Transportation, 1977).

Open subalpine forests support breeding Townsend's Solitaire, White-crowned Sparrow (Godfrey, 1951), and Dusky Flycatcher, which is at the northwestern edge of its range here. Breeding species that inhabit the extensive areas of alder and willow shrub at treeline include Northern Shrike, Alder Flycatcher, American Robin, Golden-crowned Sparrow, Common Redpoll (Godfrey, 1951; Vakil, 1981), and the "Timberline" race of Brewer's Sparrow (CWS, Birds of the Yukon Database).

At higher elevations, rock ridges and slopes provide nesting habitat for Golden Eagle, Gyrfalcon, Horned Lark, Gray-crowned Rosy Finch, and occasionally Peregrine Falcon (Theberge *et al.*, 1986). Other alpine species include White-tailed Ptarmigan, Snow Bunting (Theberge *et al.*, 1986), Northern Harrier, Willow and Rock Ptarmigan, American Tree Sparrow, and Savannah Sparrow (Vakil, 1981). Alpine tundra provides breeding habitat for American Golden-Plover, some Long-tailed Jaeger, and American Pipit (Price, 1969), as well as Red-necked Phalarope (Hoefs, 1972).

Yukon Plateau-Central

Boreal Cordillera Ecozone

ECOREGION 175

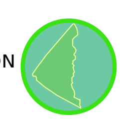
DISTINGUISHING CHARACTERISTICS: The western portions of the ecoregion are very dry with annual precipitation amounts of only 250 to 275 mm. The south-facing slopes that support extensive grassland communities are a notable feature of this ecoregion. The wetlands associated with the Tintina Trench flyway, such as Reid Lakes and the Needle Rock complex, provide important migratory and nesting habitat for waterfowl. Deeply weathered soils associated with early Pleistocene glacial deposits are unique within Canada. Very frequent forest fires maintain vast areas of relatively young aspen and lodgepole pine forests (Fig. 175-1).

J. Meikle, Yukon Government

Figure 175-1. Broad valleys in Yukon Plateau–Central Ecoregion were conduits for outwash during Cordilleran glaciations. Numerous lakes occupy potholes and hollows, with esker ridges forming long narrow points and shallows (lighter shades of blue represent shallows underlain by marl). A mixed forest of lodgepole pine with white spruce and aspen is kept at early successional stages by periodic forest fires. Islands may escape fire and be cloaked in old-growth spruce, their shores providing nesting sites for loons. Pictured are the Twin Lakes and Klondike Highway south of Carmacks.

APPROXIMATE LAND COVER
boreal/subalpine coniferous forest, 65%
alpine tundra, 30%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
26,803 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
26,803 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
6%

ELEVATIONAL RANGE
490–1,860 m asl
mean elevation 860 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Pelly River Ecoregion** and the northern portion of **Lake Laberge Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Northern portion of **Yukon Interior Dry Forests** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Yukon Plateau–Central Ecoregion incorporates part of the Yukon Plateau physiographic unit, an area of glaciated, rounded and rolling hills, plateaus and broad valleys and surrounded by higher mountain ranges. The Lewes Plateau and the northern portion of the Teslin Plateau (Mathews, 1986) are the major physiographic subdivisions of the ecoregion (Fig. 4).

Numerous lakes and smaller streams fill the network of broad valleys that characterize this ecoregion. Valleys trend northwest–southeast along faults and folds of the bedrock. The Yukon River bisects the ecoregion from south to north, from Lake Laberge and the mouth of the Teslin River to the confluence of the Pelly and Yukon rivers. The Tintina Trench forms the northern boundary of the ecoregion; the Pleistocene glacial limit forms the western and northwestern boundaries.

The base elevations of the Yukon and Stewart river valleys are less than 500 m asl. The Tatchun Hills and several peaks within the eastern portion of the Dawson Range are between 1,750 and 1,850 m asl and comprise the highest elevations in the ecoregion. Other high peaks include Mount Freegold in the Dawson Range, and Rough Top and Flat Top northwest of Pelly Crossing.

BEDROCK GEOLOGY

The Yukon Plateau–Central Ecoregion lies mostly within the Yukon–Tanana terrane with a triangular area of Stikinia extending north from Lake Laberge. The southeast corner of the ecoregion includes the Teslin structural zone, which is composed of steeply dipping, highly deformed rocks. The regional geology mapping (Bostock, 1964; Campbell, 1967; Tempelman-Kluit, 1974, 1984) differs in quality and a contemporary interpretation of rock assemblages is depicted by Gordey and Makepeace (compilers, 2000).

At least three-quarters of the ecoregion consists of igneous bedrock. Granitic batholiths, the biggest being Tatchun, Tatlmain, Glenlyon and Ice Chest, underlie one-fifth of the area. In the southwestern third of the ecoregion are volcanic breccia and augite porphyry of the Triassic Povoas Formation and Early Jurassic granitic rocks of the Big Creek, Granite Mountain and Minto batholiths aged between 192 and 188 Ma. These are covered by brown basalt of the Cretaceous Carmacks Group and intruded by the mid-Cretaceous Dawson Range batholith from 110 Ma. A remnant of the much younger Selkirk volcanics lies north and south of the mouth of the Pelly River. These lava flows are between 5,000 and 10,000 years old (Jackson and Stevens, 1992).

Northwest-trending valleys, occupied by the Nordenskiold and Big Salmon rivers, the Frenchman Lakes, and the Yukon River downstream of Minto, coincide with inactive fault zones that separate terranes and truncate rock formations. The Whitehorse Trough, which from Late Triassic to Early Cretaceous time accumulated mafic volcanic flows, alluvial fans and lagoon sediments, is folded and faulted, tapering northward from 40 km wide at Lake Laberge to its truncation by faults at Minto. Within the Trough, gritty feldspathic sandstone with minor granite–pebble conglomerate, the Tanglefoot Formation of the Jurassic Laberge Group, is the predominant rock unit. However, a reddish chert–pebble conglomerate (Fig. 175-2) and dark silty shale are typical cliff- and valley-forming rock types, respectively. Red-brown weathering volcanic flows known as Nordenskiold Dacite and white-weathering, thick-bedded limestone are prominent rock types.

Northeast of the Whitehorse Trough is a 15 km wide zone of steeply dipping mylonitic, the Teslin Suture of Tempelman-Kluit (1979). This is the western boundary of the Yukon–Tanana Terrane, an assemblage of muscovite-quartz schist with lesser amounts of quartzite, marble, amphibolite and augen gneiss. These rocks are irregularly exposed through thick glacial drift in subdued topography, except for the resistant basalt, limestone, chert and slate in the Semenof Hills.

The Dawson Range, on the western side of the ecoregion, contains over 150 mineral occurrences, primarily copper–gold with molybdenum porphyries with epithermal gold veins. Among those with calculated reserves are Minto, Cash, Mount Freegold–Antoniak, Laforma, and Williams Creek, the last with a large oxidized cap amenable to heap-leach and electrode precipitation of copper. The Carmacks basalts commonly contain traces of copper. Coal at Tantalus Butte near Carmacks has been mined and larger deposits of bituminous coal occur to the southwest, in particular at Division Mountain where the combined seams are up to 21 m thick (Carne and Gish, 1996).

Figure 175-2. South- and west-facing slopes are very dry, with grasses and sage colonizing the alkaline soil (Melanic Brunisols). Bluffs of reddish conglomerate are of the Cretaceous Tantalus Formation.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

This ecoregion is outlined to the west by the limit of Cordilleran Pleistocene glaciation (Hughes *et al.*, 1969, Duk-Rodkin, 1999). Evidence for glaciation includes disrupted drainage patterns, stream capture, streamlined hills, outwash terraces and underfit streams. The digitate western margin of the ecoregion corresponds to tongues of valley glaciers that extended along major valleys and tributary streams. Glacial drift of various ages dominates lower slopes and valley bottoms throughout. Colluvium blankets steep slopes and uplands. The higher elevations were nunataks (ridges and domes above the limit of ice) near the limit of Reid glaciation (Fig. 175-3).

GLACIAL HISTORY

This ecoregion comprises the central Yukon Plateau south of the Tintina Trench, including the eastern slopes of the Dawson Range. The present day Yukon River crosses this ecoregion from southeast to northwest. In pre-glacial times, this ecoregion was drained by the middle course of the paleo-Yukon River. The trunk stream of this ancient drainage system flowed from north to south exiting in the Gulf of Alaska (Tempelman-Kluit, 1980; Duk-Rodkin, 1997; Jackson, in press). This drainage was diverted northwestward by the first Cordilleran glaciation that occurred around 3 million years ago and covered this ecoregion almost completely (Duk-Rodkin and Barendregt, 1997). During the Reid Glaciation, the ice reached its maximum in the western part of this ecoregion, with well-defined glacial limits marked by subdued moraines and meltwater channels. The McConnell glacial maximum is traceable along the eastern part of this ecoregion (Bostock, 1966; Jackson, 1997a,b), where it reached its maximum extent approximately 24,000 years ago (Jackson and Harington, 1991). Very sharp-edged glacial features occur along this former ice frontal position, as well as around nunataks further east. The central Yukon Plateau

Figure 175-3 White Mountain, near the centre of the Yukon Plateau Ecoregion, was a nunatak during the Pre-Reid glaciations. Lower elevations are underlain by a thick blanket of glacial outwash and loess deposited when this area was ice-free during the Reid and McConnell glaciations. The foreground hills are covered in willow thickets and a reddish sphagnum bog occupies a broad level area in mid-distance.

has an extensive record of at least four Pleistocene glaciations (Bostock, 1966; Jackson *et al.*, 1996).

The Diversion Creek paleosol (Smith *et al.*, 1986) developed during the non-glacial interval between Reid and McConnell glaciations, whereas the Wounded Moose paleosol (Smith *et al.*, 1986) developed between the younger of the pre-Reid glaciations. Reid deposits (more than 200 ka) are commonly buried beneath dune sand and loess deposited by katabatic winds off the Cordilleran Ice Sheet during the McConnell Glaciation. Pre-Reid deposits in this ecoregion are 0.75 to 1.5 Ma or older, typically buried beneath colluvium. In the Fort Selkirk area, extensive volcanic eruptions occurred during the last pre-Reid glaciation (Jackson *et al.*, 1996). Volcano Mountain, north of Fort Selkirk, erupted as recently as 5,000 to 10,000 years ago (Jackson and Stevens, 1992).

CLIMATE

The orientation of the landscape is primarily south–southeast to north–northwest and lies just northeast of the main rain shadow of the St. Elias–Coast mountains. Precipitation is relatively light, ranging from 250 to 300 mm, two-thirds of which falls during the summer. Snow cover generally exists from mid-October to mid-April in the valley floors and a month longer over the higher terrain.

Mean annual temperatures are near –4°C. Mean January temperatures vary from –30°C in the lowest valleys to a more moderate –20°C over the higher terrain due to inversions. Mean July temperatures range from near 15°C in the valleys to 10°C over the heights. The most extreme daily temperatures occur in the lowest valley floors and can range from extreme minimums of –60 to –65°C, to extreme maximums near 35°C. The period with mean daily temperatures above 0°C is from late April to mid-October, although frost can occur at any time of the year. Winds are generally light, but can also be moderate to strong in association with individual storm situations.

Climatic information is available for Carmacks and Fort Selkirk with limited data from Braeburn. The annual climate graph for Carmacks is shown in Figure 175-4, a schematic cross-section that depicts the major landscape elements that make up the ecoregion.

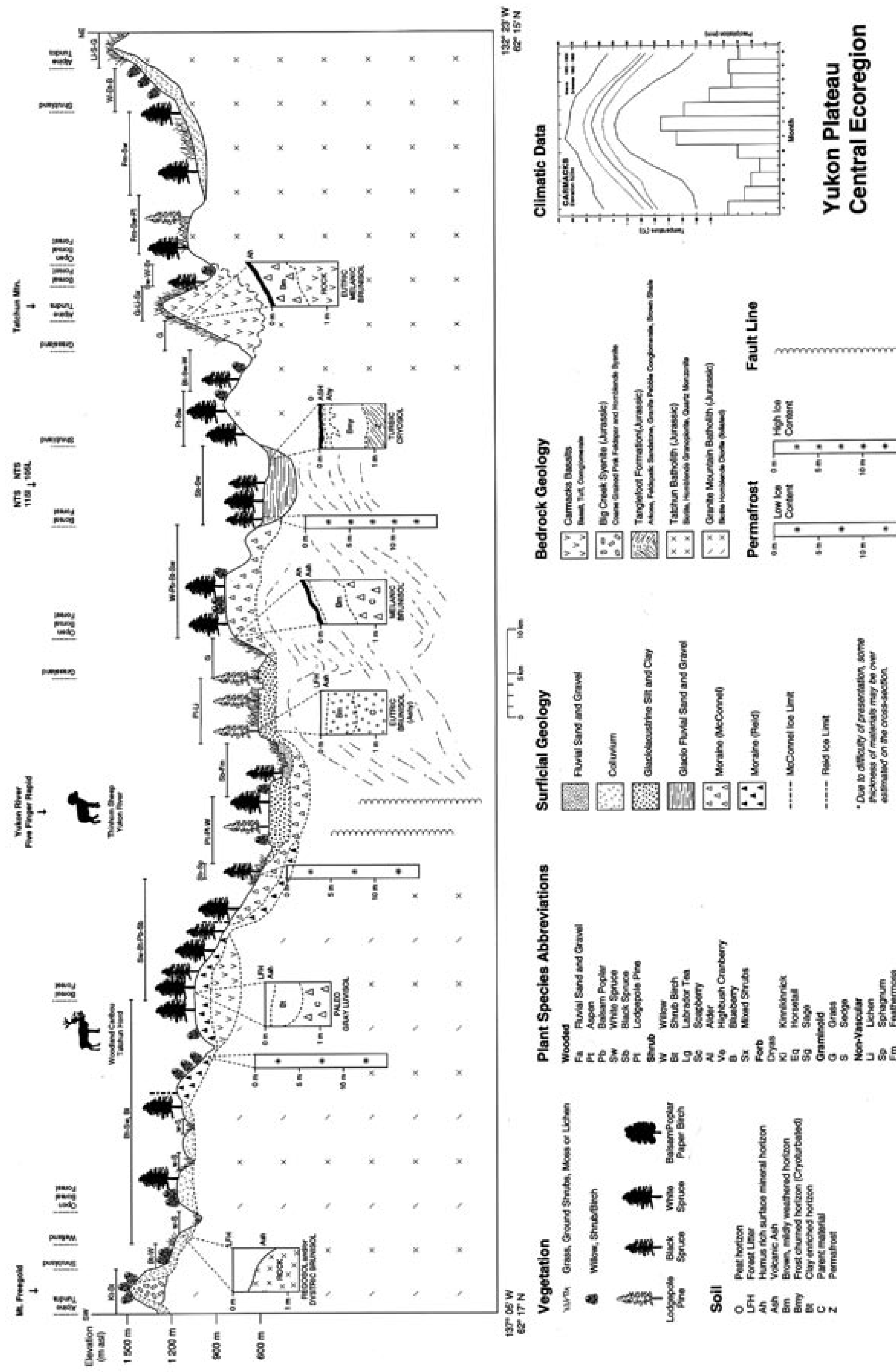


Figure 175-4. Schematic cross-section of the Yukon Plateau–Central Ecoregion at approximately 62° N latitude. Due to the scale of presentation, some vertical thicknesses of materials may be out of proportion.

HYDROLOGY

The Yukon Plateau–Central ecoregion is situated exclusively within the Interior Hydrologic region (Fig. 8). With a total area of approximately 27,000 km^2, drainage of the largely undulating plateau complex with little significant relief is primarily from the south and east. Several large river valleys traverse the ecoregion including the Yukon, Stewart, Pelly (Fig. 175-5) and Teslin rivers. The most representative intermediate stream is the Nordenskiold River. Tatlmain Lake is the largest lake in the ecoregion. There are numerous smaller lakes, which include Tatchun, Frenchman, Diamain, and von Wilczek. Wetlands are an important component of the landscape, including Needlerock wetlands, the largest wetland complex on the Yukon Plateau, and the Nordenskiold wetland (Fig. 28) complex, both of which have been recently designated as Habitat Protected areas.

There are two active representative hydrometric stations: Nordenskiold River and Big Creek. Annual streamflow is characterized by a rapid increase in snowmelt discharge to a peak in May or June. On smaller streams, approximately 40% of the annual maximum flows are due to intense summer rainstorm events. The nearby Big Salmon River and Nisling River hydrometric data were used to augment available data for streamflow characterization purposes. The mean annual runoff based on the available hydrometric record is low, with values ranging from 76 to 139 mm with an extremely low ecosystem average value of 107 mm. Mean seasonal and summer flows are likewise low, with values of 6.1×10^{-3} and 5.7×10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are also low, with values of 36×10^{-3} and 17×10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during February or March, with relatively low values due to low winter temperatures. The minimum annual and summer flows are also low, with values of 0.25×10^{-3} and 1.2×10^{-3} $m^3/s/km^2$, respectively.

PERMAFROST

The Yukon Plateau–Central Ecoregion spans both widespread and sporadic discontinuous permafrost zones. A large portion of the ecoregion lies west of the limits of McConnell glaciation, so the surficial deposits are coarse and dry, and largely free of ground ice. However, fine-grained and moist sediments in valleys are prone to perennial freezing and occurrence of ground ice. Permafrost was recorded in two of three instrument holes at Rink Rapids, north of Carmacks, with a maximum thickness greater than 18.3 m, and temperatures at 9 m ranging between –0.9 and 3.2°C (Burgess *et al.*, 1982). The plateau surfaces in the ecoregion are too low to support alpine permafrost and most ice-rich ground is in valleys. In northern portions, permafrost is found in various terrain types, even in relatively dry till under deciduous forest near Pelly Crossing (Klohn Leonoff, 1988). Hughes (1969a) mapped many open-system pingos in the northern valleys, where surficial deposits permit downslope groundwater movement yet valley bottoms may be very cold in winter.

J. Meikle, Yukon Government

Figure 175-5. The valley of the Pelly River occupies the Tintina Trench through much of its course in the Yukon Plateau–Central Ecoregion. Note the wide floodplain and meander scars in the foreground. Dark patches of spruce represent older stands that have escaped recent fire.

The importance of soil moisture and organic accumulation on the specific location of permafrost develops southward. No permafrost has been reported during excavations in relatively coarse materials near Carmacks (e.g. EBA, 1990c) and there is little along the Robert Campbell Highway in the ecoregion (Hoggan, 1992a). However, in the Nordenskiold Valley to the south, moist glaciolacustrine sediments are ice-rich. Occasionally, ground ice forms in slopes that are prone to slumping when the ice is disturbed, as along the Klondike Highway at Tatchun Creek and near Fox Lake (Brown, 1967; Paine, 1984).

SOILS

The ecoregion generally consists of undulating plateau landscapes with a few isolated mountain summits. The climate is strongly continental and semi-arid with warm summers, developing large soil moisture deficits early in the growing season. Soils have been mapped in detail only in the major valley bottoms near Carmacks and Pelly Crossing (Rostad *et al.*, 1977). The south-facing slopes that support extensive grassland communities are a notable feature of this ecoregion. These are common on low elevation sidehills in the Yukon River and Nordenskiold River Valleys around Carmacks. While such grasslands exist throughout the southern Yukon, they are best expressed here. A second notable feature is the layer of tephra up to 35 cm thick that blankets most of the soils of the ecoregion (Fig. 25). While the maximum thickness of the ash is less than that found in the Ruby Ranges Ecoregion to the west, the ash is most ubiquitous throughout.

Mildly weathered, alkaline soils form on a variety of calcareous glacial parent materials. Open meadows on south-facing slopes have soils with dark A horizons typical of grasslands. Soils are classified as Melanic Brunisols (Figs. 175-2, 175-4). Surrounding aspen stands have thick moder humus forms with alkaline forest soils classified as Eutric Brunisols. Northern and eastern aspects support mixed forests underlain by Eutric Brunisols with mor humus forms. Wetlands are associated with thermokarst of large ice masses in the silty alluvial deposits of major floodplains where Organic Cryosols and Gleysolic Turbic Cryosols form. Higher elevation uplands and north-facing slopes may also lie on permafrost. These are most commonly Orthic Turbic Cryosols, occasionally with patterned ground features in alpine areas.

Some soils in this ecoregion formed with unique features. In association with various ages of Pleistocene glacial drift, a series of paleosols exhibit deep soil development and strong reddish colours that relate to long periods of weathering under interglacial climatic conditions in the central Yukon (Smith *et al.*, 1986; Tarnocai, 1987a). These paleosols are also formed in glacial deposits in the adjacent Klondike Plateau and Yukon Plateau–North ecoregions. There are no other soils like them in Canada (Fig. 175-6).

S. Smith, Agriculture and Agri-Food Canada

Figure 175-6. Relict soils are found in the Yukon Plateau–Central Ecoregion on glaciofluvial terraces that have been relatively undisturbed since early pre-Reid glaciations. One of these soils associated with the oldest drift surfaces is the Wounded Moose Paleosol. The involutions of sand (sand wedges) outlined on the photo are thought to have formed during the last glacial interval when this soil was exposed to polar desert-like conditions that existed in unglaciated regions near to the ice front.

VEGETATION

The montane boreal forest dominates the Yukon Plateau–Central Ecoregion below 1,200 m asl. Above 1,200 m asl is the subalpine zone. Treeline near 1,370 m asl separates the subalpine from the alpine (Oswald and Senyk, 1977).

The boreal zone contains many plant communities because of the diverse habitats provided by mixed glacial landforms and fire (Oswald *et al.*, 1983). Fires are frequent and large due to the high incidence of thunderstorms concentrated along the north part of the Tintina Trench and the generally dry summer conditions. Most forest stands are less than 100 years old (Fig. 175-1, 175-5). The dominant community on undisturbed moraine soils, which blanket lower slopes of the ecoregion, is white spruce and feathermoss with few shrubs or herbs. On recent alluvial floodplains, the white spruce–feathermoss forest typically contains rose, horsetail, willow and alder. A mixture of kinnikinnick, grass and lichen replaces the feathermoss understory vegetation on coarse outwash deposits, which are extensive on the valley floor. Succession is also important on fluvial deposits. The first species to colonize recent floodplains is horsetail, which is followed by willow and then balsam poplar.

Due to the frequency of fire, lodgepole pine and trembling aspen are prevalent at low elevations. Pine is more common on better-drained, warmer, coarse soils; aspen grows on sites with finer soil and on steep south-facing slopes. On drier sites, the understory is predominantly lichen, kinnikinnick and grass. The moister sites commonly contain more shrubs, such as alder, willow, lingonberry and soapberry, as well as moss. White spruce slowly invades these post-fire communities. Paper birch is a successional species usually found colonizing moister sites in the ecoregion.

On undisturbed, colder, north-facing lower slopes and alluvial floodplain sites, white spruce–feathermoss forests are slowly invaded by black spruce and permafrost as the dominance of brown mosses increases on the forest floor. Grasslands are an important feature of this ecoregion. They occur on steep south- and west-facing slopes throughout the ecoregion and sometimes extend from the valley floor to the alpine. Sagewort, rose, juniper and kinnikinnick are typical species of these grasslands. Willows and aspens invade moister sites, such as the bases of slopes.

Wetlands are significant in the ecoregion. Shallow open water with *Carex aquatilis* and aquatic plants and shore marshes dominated by graminoid species are common along the shores of lakes and ponds. Willows with shrub birch, Labrador tea and shrubby cinquefoil, with a moss and sedge groundcover, commonly occur in bogs through the ecoregion.

Subalpine trees include subalpine fir, white spruce and sometimes stunted lodgepole pine. Shrub birch and willow dominate the subalpine, commonly with mountain blueberry and crowberry; on moister sites, they are underlain by moss and Labrador tea, and on drier sites by lichen (Oswald *et al.*, 1983; Oswald and Brown, 1986).

Figure 175-4 illustrates the vegetation, soil and terrain relations in the ecoregion.

G. Mowat, Yukon Government

Figure 175-7. The combination of relatively dry summers and a high incidence of lightning strikes results in both frequent and extensive forest fires. One result is consistently good habitat for snowshoe hare and its main predator, lynx.

WILDLIFE

Mammals

The Yukon Plateau–Central supports moderate densities of moose and woodland caribou in the Aishihik, Tatchun, and Klaza herds (Markel and Larsen, 1988; Farnell *et al.*, 1991). The Aishihik herd was intensively managed in the 1990s, primarily through wolf reduction (Carey *et al.*, 1994), and has increased to 1,500. In 2000, the Tatchun and Klaza herds were estimated at 500 and less than 600, respectively.

Grizzly bears and predators such as wolverine and marten are not as abundant as in surrounding ecoregions. River otter densities are probably highest along salmon-bearing streams in the Yukon River drainage. The area supports healthy populations of snowshoe hare and lynx (Fig. 175-7). The juxtaposition of suitable wetlands and fire-induced aspen and willow stands supports large numbers of beaver colonies locally (Slough and Jessup, 1984). The introduced herd of wood bison, now about 400 individuals, and Hutshi Lake elk, of at least 50 individuals, range from the Ruby Ranges Ecoregion into the upper Nordenskiold River drainage. Recently, range-expanding mule deer, more abundant following a succession of mild winters in the 1980s and 1990s, wander in small herds of 12 to 15 individuals. The occasional cougar is sighted near mule deer range; such sightings are unusual and not necessarily indicative of a self-sustaining population. Mammal species known or expected to occur in this ecoregion are listed in Table 4.


J. Meikle, Yukon Government

Figure 175-8. The Von Wilczek Lakes wetland south of Pelly Crossing consists of extensive emergent graminoids and open water, protected by a thick fringe of dense alder–willow thicket. One of the most biologically productive wetlands in Yukon Plateau–Central Ecoregion, this wetland is the northern extent of the range for the Ruddy Duck.

Birds

The northeast border of the Yukon Plateau–Central Ecoregion includes part of the Tintina Trench, which is the Yukon's major migration corridor for thousands of Sandhill Cranes that nest in Alaska. Important and productive wetlands include the Needlerock complex, the Willow Creek complex, the Nordenskiold River system, and Von Wilczek Lakes (Fig. 175-8). Loons, Horned and Red-necked Grebes, American Widgeon, Mallard, Green-winged Teal, scaup, scoters, Long-tailed Duck, Bufflehead, goldeneyes, and American Coot breed and moult in these wetlands (Dennington, 1985; Hawkings, 1994). Ruddy Duck breeds on some of these wetlands (Fig. 175-8) along with songbirds such as Red-winged and Rusty Blackbirds (Hawkings, 1994).

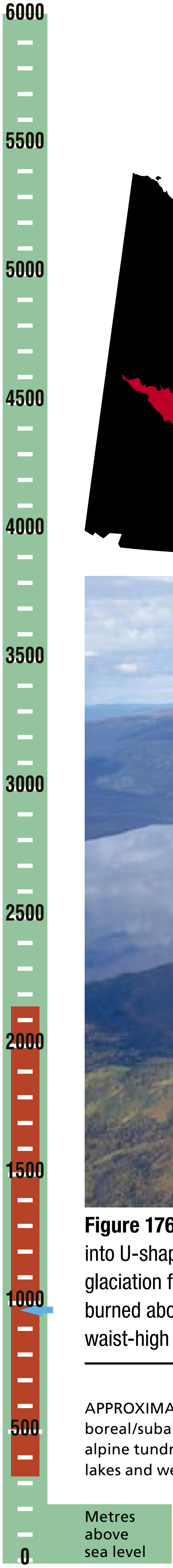
The Yukon River itself, running north through this ecoregion, contains limited nesting areas on bays and backwaters for Canada Goose while the north section of the river provides open flats and sandbars used as resting areas by Sandhill Crane during spring and fall migration through the Tintina Trench (Soper, 1954). Peregrine Falcon nest along steep banks of the Yukon, Stewart, and Pelly rivers (Stelfox, 1972; Mossop, 1978). Other raptors include Bald Eagle and Golden Eagle (Mossop, 1978). Rivers are also inhabited by breeding Common Merganser and Belted Kingfisher with Bank Swallow colonies in the riverbanks (Rand, 1946). Scattered marshes, lakes, and rivers support breeding shorebirds and gulls including Semipalmated Plover, Lesser Yellowlegs, Spotted Sandpiper, Red-necked

Phalarope, Bonaparte's Gull, and Mew Gull (Stelfox, 1972).

Sharp-tailed Grouse inhabit young deciduous forests throughout the region (Stelfox, 1972). Songbirds breeding in wetland shrubs include Alder Flycatcher, Orange-crowned Warbler, Yellow Warbler, Northern Waterthrush, Common Yellowthroat, and Savannah and Lincoln's Sparrows (Soper, 1954; Stelfox, 1972).

Year-round residents include Great Horned Owl, Three-toed Woodpecker, Gray Jay, Black-billed Magpie, Common Raven, and Boreal Chickadee (Godfrey, 1986). Coniferous forests provide breeding habitat for Sharp-shinned and Red-tailed Hawks, Olive-sided Flycatcher, Ruby-crowned Kinglet, Yellow-rumped Warbler, and White-winged Crossbill (Stelfox, 1972). Deciduous forests support breeding Ruffed Grouse, Northern Flicker and Least Flycatcher. Species such as American Kestrel, Common Nighthawk, Say's Phoebe, American Robin, White-crowned Sparrow, and Dark-eyed Junco inhabit open treed habitats (CWS, Birds of the Yukon Database).

There are few records of bird species for alpine areas, but breeders include Gyrfalcon, Horned Lark, and American Pipit. Subalpine areas provide habitat for resident Willow Ptarmigan, Townsend's Solitaire, Wilson's Warbler, and American Tree Sparrow.



Yukon Plateau-North

Boreal Cordillera Ecozone

ECOREGION 176

DISTINGUISHING CHARACTERISTICS: This is the largest ecoregion entirely within the Yukon. It includes a 450 km length of the Tintina Trench, an ancient fault trace within which deposits of at least seven Pleistocene glaciations are recognized. Several large river valleys traverse the ecoregion, including the Pelly, Ross, Macmillan, Stewart, Hess, McQuesten and Klondike. The Fannin sheep of the McArthur, Russell and Anvil ranges may be a relict of isolation during the last glaciation. The glaciated valleys host numerous important wetlands, including the Sheldon Lake complex and Horseshoe Slough.

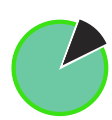
J. Meikle, Yukon Government

Figure 176-1. The Stewart Plateau in the northern portion of the ecoregion consists of rolling uplands with steep slopes leading into U-shaped valleys about 1,000 m below the upland surface. Above Ethel Lake (shown above), the highest deposits of Reid glaciation form low eroded embankments on the upper slopes (arrow). The white spruce forest on the crest of the plateau was burned about 15 years before this photograph was taken and among the dead timbers are scattered spruce, alder thickets and waist-high drawf birch.

APPROXIMATE LAND COVER
boreal/subalpine coniferous forest, 75%
alpine tundra, 20%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
57,091 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
57,091 km^2



ECOREGION AREA AS A PROPORTION OF THE YUKON
12%

ELEVATIONAL RANGE
320–2,160 m asl
mean elevation 995 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Mayo Lake–Ross River Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Southwest portion of **Interior Alaska/Yukon Alpine Tundra** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Yukon Plateau–North Ecoregion encompasses, from the north, the Stewart Plateau, the Macmillan Highland and the Ross Lowland (Mathews, 1986) (Fig. 4) or the Stewart, Macmillan and Pelly plateaus (Bostock, 1948). It is located northeast of the Tintina Trench.

The Stewart Plateau is a series of tablelands separated by a network of broad, deeply cut valleys (Fig. 176-1). The Macmillan Highland consists of small mountain ranges: the Anvil (north of Faro), South Fork, Wilkinson and Russell ranges, also separated by broad valleys. The Ross Lowland, as its name implies, is slightly lower in elevation with rolling, rounded hills separated by broad valleys.

Several summits in the ecoregion are over 2100 m asl. Grey Hunter Peak in the McArthur Range is the highest at 2,200 m asl. Most of the area is between 900 and 1,500 m asl. Local relief is typically 300 to 900 m.

BEDROCK GEOLOGY

This ecoregion includes parts of two geological provinces consisting of metamorphosed sedimentary rock; less than one-tenth of the area is granitic. The northern half of the ecoregion is underlain by variably deformed sedimentary rocks deposited on the outer continental shelf of ancestral North America, called the Selwyn Basin, between 530 and 200 Ma. The regional distribution of rock units in the northern half of the ecoregion is shown on geological maps (Bostock, 1964; Campbell, 1967; Green, 1972; Roots *et al.*, 1995; Roots, 1997). In contrast, rocks in the southeast part of the ecoregion include siliceous sedimentary and volcanic rocks of the Yukon–Tanana terrane and metabasaltic flows of the Slide Mountain terrane. The origin of these rocks is obscure because they were deformed before and during transport onto the telescoped Selwyn Basin strata. Their distribution is shown on regional geological maps (Tempelman-Kluit, 1984; Gordey and Irwin, 1987). A contemporary interpretation of the regional assemblages is shown in Gordey and Makepeace (compilers, 2001). The regional distribution of metals, trace elements and fluorine are represented by stream sediment and water geochemical surveys.

Rocks of the Selwyn Basin underlie a broad expanse of the east-central Yukon. The oldest strata are a great thickness of brown sandstone and grit and minor white limestone, overlain by maroon shale, all of which constitute the Late Proterozoic to Middle Cambrian Hyland Group (570 to 520 Ma; Gordey and Anderson, 1993). Within the ecoregion, the Hyland Group is exposed in a 35 km wide swath extending from Partridge Creek to Mount Selous. The quartz-rich rocks in the Mayo area were extensively recrystallized during deformation and metamorphism about 100 million years ago and now contain considerable white mica and green clay minerals, commonly chlorite. South of this belt, ridges are more subdued and covered with vegetation, although bare patches and stream cuts reveal a nondescript succession of dark-coloured, thinly bedded siltstone and shale of the Cambrian Gull Lake Formation and the Ordovician to Middle Devonian Road River Group. Within this succession, which is repeated by folds and thrust faults, are more resistant outcrops that reveal scattered pods or horizons of white limestone, including the Cambrian Rabbitkettle Formation, mafic volcanic flows and breccias with abundant calcite of the Ordovician Menzie Creek Formation (Goodfellow *et al.*, 1995) and grey to multicoloured chert. The formation locally produces crumbling walls with angular, treacherous talus beneath.

In the northern Anvil Range, and near McEvoy Lake, extensive areas of the Devonian Earn Group are characterized by jet-black or gunsteel-blue weathering siliceous siltstone and conglomerate containing abundant chert pebbles. Underlying Earn strata releases high background levels of barium, zinc, lead and cadmium to streams, vegetation and local ungulates (M. Gamberg, pers. comm., 1993). Along the north boundary of the Yukon Plateau–North Ecoregion, scarp-like hills lie on blocky rubble of the Carboniferous Keno Hill quartzite, a distinctive substrate commonly indicated by luxuriant lichen and moss cover.

North of the Macmillan River are numerous sub-circular granitic intrusions of the Tombstone suite, uniformly 92 Ma. These form the core of the Syenite, Lansing and Armstrong ranges, as well as Mount Selous, because they are surrounded by baked sedimentary rocks that are resistant to erosion. The Anvil and McArthur ranges are also underlain by granitic batholiths. Between the Rogue and South Macmillan rivers are two large, semi-circular areas underlain by dark brown weathering, locally columnar-jointed, biotite–quartz–hornblende–feldspar crystal tuff. This rock is poorly exposed and resembles a porous granite, but represents the pyroclastic fill of enormous calderas formed 80 million years ago (South Fork volcanics; Wood and Armstrong, 1982).

The southeast part of the ecoregion, the Campbell Range, contains quartz–feldspar–mica schist and black argillite similar to Earn Group, but with higher metamorphic grade, while higher ground is dominated by several varieties of granite (e.g. Murphy, 1998), as well as chlorite–actinolite phyllite and chloritic metavolcanic rocks. The latter dark-green rocks are considered to be part of Slide Mountain Terrane, which formed at the edge of a continent in Permian time and was thrust over the continental rocks (Tempelman-Kluit, 1979) about 100 million years ago.

This ecoregion also includes a 450 km length of the Tintina Trench, an ancient fault trace covered by Pleistocene glacial deposits. River and stream cutbanks expose Tertiary sandstone with coal seams along its length (Hughes and Long, 1980), as well as rhyolite and olivine basalt between Faro and Ross River (Jackson *et al.*, 1986; Pride, 1988).

This ecoregion contains considerable potential for metallic mineral deposits. Open-pit mines have extracted zinc and lead in Cambrian sediments of the Anvil Range at Faro and adjacent ore bodies (Pigage, 1990), gold from veins at Grew Creek in Tintina Trench (Duke, 1990), and gold from altered granitic dykes and black shale at Brewery Creek by heap-leach pad extraction (e.g. Diment, 1996). Another large volume of gold veins amenable to stripping and heap-leach extraction is at Dublin Gulch (Smit *et al.*, 1996). Other explorations have been directed toward stratiform zinc–lead in Earn Group black shale prospects at Dromedary Mountain and Rogue River and to strata-bound lead–copper–zinc–gold–silver in felsic volcanics near Wolverine and Fire lakes (e.g. Schultze, 1996; Foreman, 1998). Tungsten, tin, molybdenum, copper and gold showings are known in and around many granitic intrusions (e.g. Poulsen, 1996) although none are yet recognized as large deposits.

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

Surficial geology maps by Hughes (1982a,b; 1983a,b), Jackson (1986), Jackson and Morison (1984), Ward and Jackson (1993a,b,c) and Bond (1998, 1999, 2001) cover the area. The Selwyn Lobe of the Cordilleran Ice Sheet (McConnell Glaciation), which flowed in a west–northwest direction, covered this ecoregion, with the exception of unglaciated summits or nunataks. In some areas, a complex of ice caps and cirque glaciers was active at high elevations.

Deglaciation in this ecoregion consisted mainly of melting large stagnant ice blocks, a complex system of glaciofluvial deposition, and glacial lake resultant formation and drainage disruptions.

At high elevations, thin blankets of weathered and mass-wasted bedrock partially cover the bedrock. At middle to low elevations, valley walls are dominantly covered by till with numerous drumlins or streamlined landforms indicative of north and westward flowing ice of the Selwyn Lobe. The general composition of the till matrix in this area has a wide range of sand (20 to 70%), silt (20 to 80%), and a usually lower clay content (5 to 30%). Permafrost is common, and ice content is estimated as low to moderate in colluvial and moraine deposits. Ice-wedge polygons, solifluction lobes, blockfields and rock glaciers are common in most of the ecoregion.

Glaciofluvial sand and gravel often blanket the valley floors. The Pelly River Valley, for example, is often terraced and covered by glaciofluvial sand and gravel, and in its western part, by glaciolacustrine deposits. The glaciofluvial sand and gravel have variable thickness and composition and are usually from stable surfaces. The glaciolacustrine sediments can be up to 18 m thick. Such deposits are found in several locations in the ecoregion, for example, in No-Gold Creek, Upper Kalzas River and the Keno–Ladue River valleys, as well as in the Stewart River valley. Ice-rich permafrost is very common in these deposits and can sometimes be indicated by the presence of well-developed thermokarst lakes.

Valley floors contain discontinuous permafrost in the silty sediments overlain by organic deposits. Alluvial areas can be flooded seasonally within the lower reaches of major rivers such as the Pelly and Stewart. In some years, low-level terraces up to 3 m above the stream channel are flooded as a result of the snow melt or ice jams during breakup.

Landslides have occurred in a variety of lithologies in the area (Jackson, 1994). Large rock avalanches and rock falls still take place, as indicated by the large number and volume of talus cones and aprons throughout the mountainous portions of the ecoregion. Snow avalanches are common and can contain large volumes of boulders and debris. Solifluction lobes and slope creep are very common. The Surprise Rapids landslide, located south of the Macmillan River, is one of the largest debris flows recognized in the Yukon (Ward *et al.*, 1992). The failure may have been initiated by permafrost degradation due to a forest fire in the late 1800s.

Two hot springs have been found in the southern part of the Ddhaw Ghro Habitat Protection Area.

GLACIAL HISTORY

This ecoregion was intensely glaciated by the Cordilleran Ice Sheet, local glaciers that emanated from the South Ogilvie Mountains, and local cirque glaciers from the highest peaks in the ecoregion at different glacial periods (Hughes *et al.*, 1969; Jackson *et al.*, 1991; Jackson, 1994; Duk-Rodkin, 1996). As in other parts of the northern Cordillera, the same pattern of glaciation occurred where more recent glaciations were less extensive than their precursors were. Most of the glacial features of this ecoregion were left by the last glaciation, the McConnell (Bostock, 1966). However, glacial features and erratics of older Reid and pre-Reid glaciations are found above (Fig. 176-1), and beyond the western limit of McConnell Glaciation. Deposits of older Cordilleran ice sheets that existed during the Reid Glaciation and at least six pre-Reid glaciations can be found in sections in the Tintina Trench (Bostock, 1966; Duk-Rodkin, 1996; Jackson *et al.*, 1996; Duk-Rodkin and Barendregt, 1997). The oldest pre-Reid Glaciation occurred about 3 million years ago (Duk-Rodkin and Barendregt, 1997) and was responsible for the diversion of the south flowing paleo-Yukon River towards the northwest into Alaska (Duk-Rodkin, 1997). The most important diversion within this ecoregion involved the Klondike River, formerly a northern tributary to the paleo-Yukon River, which drained south into the Stewart River area. Stratigraphic records of the earliest glaciation can be also found south of the Trench. Cirque glaciers on Stewart Plateau were developed during pre-Reid, Reid and McConnell glaciations. Minor drainage diversions in the Stewart Plateau occurred during these glaciations (Figure 176-2) (Bond, 1997; Bond and Duk-Rodkin, in press). Alpine glaciers were present in the McArthur Group mountains during the Little Ice Age.

The floors of major valleys and low relief uplands, such as the Tintina Trench, were extensively fluted or eroded into whalebacks or rock drumlins by the glacial flow. Expansion of glaciers in divide areas could have been underway by 29,000 years ago, but these did not merge to form the ice sheet until after 24,000 years ago (Matthews *et al.*, 1990; Jackson and Harington, 1991). The firn line fell to approximately 1,500 m asl at the climax of McConnell Glaciation. Flow within the ice sheet was more analogous to a complex of merged valley glaciers than to that of extant ice sheets; topographic relief was typically equal to, or exceeded, ice thickness and strongly influenced ice flow. Surface gradients on the ice sheet were fractions of a degree. The ice sheet terminated along the western margin of this ecoregion. Retreat from the terminal moraine was initially gradual, as indicated by recessional moraines within a few tens of kilometres of the terminal moraine. Small magnitude readvances occurred locally. The ice sheet eventually disappeared through regional stagnation and wasting. This stagnation resulted in extensive areas of kame and kettle topography and glacial lake deposits in many valleys. Regional deglaciation ended prior to about 10,000 years ago.

CLIMATE

This ecoregion consists of relatively rolling highlands with an east–west orientation. Mean annual temperatures in this ecoregion are near –5°C, but there is a strong seasonal variability accentuated by difference of elevation. Mean January temperatures range from below –30°C in the lower valleys (Fig. 176-3) to above –20°C over the higher terrain. This gradient is dramatically reversed by July as mean temperatures in the lower valley floors of 15°C drop to near 8°C over the higher terrain. Extreme temperatures in the lower valley floors have ranged from –62 to 36°C. Over higher terrain the extremes are more moderate. Frost can occur at any time of the year but is less likely from mid-June to late July.

Precipitation is relatively moderate showing an increase over eastern sections as a result of

J. Meikle, Yukon Government

Figure 176-2. Horseshoe Slough (arrow), about 40 km east of Mayo, is the most important waterfowl and migratory bird habitat in Yukon Plateau–North Ecoregion. Before the last glaciation the Stewart River flowed southwest up the valley of Nogold Creek (foreground) to Ethel Lake and drained southward from there. A moraine now dams Ethel Lake and glacial till chokes the Nogold valley, so that the river now crosses the bedrock divide at Fraser Falls and follows a northwesterly course.

C.F. Roots, Geological Survey of Canada

Figure 176-3. The deep valleys of central Yukon undergo temperature extremes. Cold air inversions may confine the temperature to 30°C for weeks in winter, while clear days with little wind in summer may result in temperatures of +30°C. Hungry Mountain (pictured above), which overlooks the Stewart River valley west of Mayo, has terraces above treeline, which represent the upper limit of Reid and Pre-Reid glaciation; the terminal moraine (farthest west) of McConnell glaciation lies near its base.

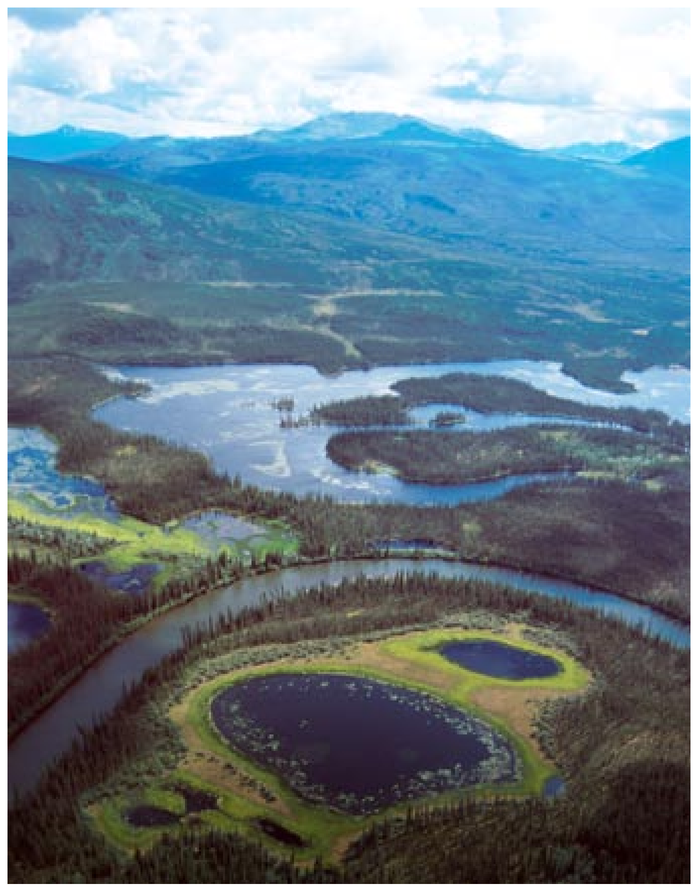
upslope conditions over the higher terrain of the east. Annual amounts range from near 300 mm in a minor rain shadow along the Tintina Trench, especially near Ross River, to near 600 mm over the higher terrain of the eastern sections. Amounts are fairly low from December through May, being only 20 to 30 mm per month. The wettest period is during July and August, with monthly amounts of 40 to 80 mm from rainshowers and thunderstorms. Winds are generally light, and only moderate to strong in association with thunderstorms or unusually active weather systems.

Mayo and Ross River are representative climate stations in the lower valley floors. Elsa and Sheldon Lake (Twin Creeks) are good indicators for the valley floors in the higher terrain.

HYDROLOGY

The Yukon Plateau–North Ecoregion is situated exclusively within the Interior Hydrologic Region (Fig. 8). Drainage of this plateau complex is primarily from the footslope regions of the Selwyn Mountains to the east. This ecoregion has somewhat greater relief than the Yukon Plateau–Central Ecoregion to the west, with subsequently greater runoff and peak flow events. Several large river valleys traverse the ecoregion including the Pelly, Ross, Macmillan, Stewart, Hess, McQuesten and Klondike. Though the headwaters and upper reaches of these streams are outside the ecoregion, the relative proportions are small enough that these streams are representative. Mayo Lake is the largest lake in the ecoregion. There are numerous intermediate-sized lakes including Finlayson, McEvoy, Earn, Stokes and Ethel, as well as many smaller lakes. Large wetland areas are primarily associated with the lower portions of the large river valleys, including the large wetland complex of the Ross River Lowland (Fig. 176-4). There are other significant wetlands within the Macmillan, Pelly and Stewart River valleys.

There are 12 representative streams with active or historical continuous or seasonal hydrometric stations: Pelly (two), Ross, Macmillan, Stewart (three), McQuesten, Klondike, and Little South Klondike rivers, and 180 Mile and Clear creeks. Annual streamflow is characterized by a rapid increase in snowmelt discharge to a peak in June with secondary rainfall-generated peaks throughout the summer. On smaller streams, approximately 40% of the annual maximum flows are due to intense summer rainstorm events. The mean annual runoff is moderately high with values ranging from 236 to 385 mm, with an ecosystem average of 309 mm. Mean seasonal and summer flows are likewise moderately high and moderate with values of 18.8 X 10^{-3} and 13.7 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flood are moderately low and moderate, with values of 70 X 10^{-3} and 40 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during February or March with relatively low values due to low winter temperatures. The mean annual minimum and mean minimum summer flows are moderate and moderately high, with values of 1.0 X 10^{-3} and 7.4 X 10^{-3} $m^3/s/km^2$, respectively. Smaller streams will occasionally experience zero flow during cold winters.



J. Meikle, Yukon Government

Figure 176-4. Valleys underlain by hummocky glacial debris typically contain meandering streams (Tay River lowland in foreground) and numerous lakes, ponds and wetlands. Anvil Range in the background is a Cretaceous granitic intrusion surrounded by sediments of the Selwyn Basin. This range harbours the largest population of Fannin Sheep in the Yukon.

PERMAFROST

Permafrost is discontinuous in the Yukon Plateau–North, where its precise location is controlled by microclimatic factors, especially ground surface moisture content and organic-layer thickness (Williams and Burn, 1996). In northern parts of the ecoregion, valley-bottom permafrost thicknesses of up to 40 m have been reported near Mayo, and high on Keno Hill the thickness is at least 135 m (Wernecke, 1932). Ground temperatures near Mayo suggest that the base of permafrost at several sites in the area is elevated by convective heat carried by groundwater, and hence ground temperature gradients are steep (0.08°C/m; Burn, 1991). These temperature profiles also indicate ground warming associated with warmer winters in the 1970s and 1980s, although in the 1990s the ground cooled when snow depths decreased (Burn, 1992, 1998a). Near-surface ground temperatures in permafrost at Mayo are between –1.3° and –1.8°C (Smith *et al.*, 1998).

In southerly portions of the ecoregion near Ross River and Faro, permafrost is thinner and less extensive. Depths to the base of permafrost of up to 24 m, but more commonly 15 to 18 m, are reported from Ross River, and are approximately 10 m near Faro (EBA, 1981; Stanley, 1986). A mean ground temperature of –0.4°C has been measured at Ross River (Hoggan, 1989). Much of the Robert Campbell Highway alignment throughout the ecoregion is over permafrost-free terrain (e.g. Community and Transportation Services, 1989).

Glaciated portions of the plateau are covered by a blanket of till, which is ice-rich below the active layer, so ground subsidence often occurs upon active-layer deepening following forest fires. Glacial lakes filled many valleys towards the end of the McConnell Glaciation; when these lakes drained, large amounts of segregated ice grew as permafrost aggraded into the lake sediments (Burn *et al.*, 1986; Stanley, 1989; EBA, 1991). Thermokarst lakes are found in these deposits throughout eastern portions of the ecoregion (Fig. 176-5; Hughes, 1983a,b; Burn and Smith, 1990). Occasionally thaw slumps are initiated in such sediments by riverbank or lakeshore erosion (Burn and Friele, 1989). Where the glaciolacustrine sediments have been replaced by alluvial material, the ground is rarely ice-rich, but recent ice wedges may be exposed in riverbanks from time to time (Burn, 1990).

West of the glacial limits, coarse glacial outwash and recent floodplain materials dominate valley-bottom deposits. The coarse deposits are generally ice-free, as in the most southerly length of the Dempster Highway (EBA, 1990a), but isolated ground ice has been found at a depth of 40 m (Burn, 1991). Numerous open-system pingos at the base of slopes in the unglaciated portion of the ecoregion were mapped by Hughes (1969a). Colluvial deposits are often ice-rich, especially if associated with

C. Burn, Carleton University

Figure 176-5. Actively expanding thaw lakes are generated as a result of melting ground ice in the underlying silty clay sediments. Black spruce trees topple into the lake as it expands.

groundwater seepage, and they subside if disturbed (EBA, 1987b).

The active layer at sites in northern portions of the ecoregion is up to 75 cm thick, but the variation in thickness increases in glacial outwash deposits (Leverington, 1995). To the south, the active layer at many sites in gravelly terrain is about 2 m thick, but depths of 60 cm or so are more common in fine-grained sediments (EBA, 1990b).

SOILS

Soil development reflects the strongly continental climate, the presence of extensive discontinuous permafrost, and the rugged topographic relief in this ecoregion. The major valleys tend to be underlain by a mixture of glacial parent materials. Soil development is largely controlled by available soil moisture on these materials, such that coarse-textured glaciofluvial materials and moraine support Eutric Brunisols (Tarnocai, 1987b). Fine-textured glaciolacustrine and the most imperfectly drained sites are underlain by near-surface permafrost and are classified as Turbic Cryosols. Regosols, Brunisols or Gleysols occur on active alluvial soils (Rostad *et al.*, 1977).

Valley bottoms are subject to strong winter inversions that promote the development of permafrost in many of these soils, which have been described in various settings within the valleys of the ecoregion by Burn (1991). The presence of near-surface permafrost and active layer thicknesses are controlled by the thickness of surface humus layers, canopy cover, aspect and soil moisture (Williams and Burn, 1996). Surface vegetation and humus layer thickness are controlled largely by forest fire history. Both Static and Turbic Cryosols occur in moraine and fluvial materials but are transitory in nature.

Upland soils are formed mainly on moraine and colluvium and their genesis has been less well studied. Generally, Eutric Brunisols occur on well-drained materials and Turbic Cryosols develop on imperfectly drained materials and in alpine environments exhibiting patterned ground formation. Some subalpine and alpine locations have formed Dystric Brunisols in association with coarse-textured, acidic bedrock types, a reflection of higher precipitation at these elevations.

The Wounded Moose paleosol has developed on glacial surfaces of pre-Reid age (Fig. 175-6). Diversion Creek paleosol (Smith *et al.*, 1986) developed during the non-glacial period between the Reid and McConnell glaciations. These paleosols are preserved sporadically beyond the limit of the McConnell Glaciation.

VEGETATION

The vegetation of the Yukon Plateau–North ranges from boreal to alpine. Northern boreal forest exists at elevations up to 1,500 m. Higher elevation vegetation is characterized by shrub and lichen tundra. Low ericaceous shrubs, prostrate willows and lichens dominate the alpine. Talus slopes common at high elevations support communities of crustose lichens. In the subalpine environment, shrub birch, with scattered pine, white spruce, subalpine fir and a lichen understory, is extensive. Moister sites support more moss and graminoids than lichen. Extensive shrublands exist at mid-elevations and on valley bottoms subject to cold air drainage.

In the boreal zone, open black spruce with a moist moss, or drier lichen understory is the dominant forest type. Black spruce dominates moister sites and cooler north-facing slopes, often mixed with subalpine fir. These sites are often associated with permafrost soils. Feathermoss dominates the understory vegetation of nearly closed coniferous stands, but as trees become less dense willows and ericaceous shrubs become prevalent. White spruce, occasionally with aspen or lodgepole pine, occurs on warmer and better-drained sites (Fig. 176-6). White and black spruce are often found together on mesic sites including alluvial sites.

Mixed canopy forests are common due to frequent forest fires. The fires are caused by a high incidence of thunderstorms along the Tintina Trench. Lodgepole pine frequently invades burned areas, occasionally forming extensive forests. Also common on disturbed sites are trembling aspen and balsam poplar. Paper birch is scattered throughout the ecoregion, usually occurring on cooler sites.

Sagewort grassland, with juniper, kinnikinnick, forbs and sometimes aspen, develops on steep, south-facing slopes. These grasslands are common along the banks of the large rivers. These

R. Gotthardt, Yukon Government

Figure 176-6. An old log deadfall trap for wolverine lies in a clearing on the south side of the McArthur Range, near Woodburn Creek. The forest consists of white spruce with an understory of tall willow and moss–lichen groundcover.

grasslands are often contiguous with unglaciated high elevation areas, which would have supported similar vegetation during the last glacial period. The elements of the grassland plant communities are considered to be relicts of the glacial period.

Willows, sedges and aquatic plants dominate wetlands on the margins of small lakes, marshes, and shallow open water (Fig. 176-4). Black spruce bogs containing sedge tussocks and sphagnum moss and underlain by permafrost, occur in lowland areas throughout the ecoregion.

WILDLIFE

Mammals

The vast Yukon Plateau–North Ecoregion supports populations of most of the Yukon's typical boreal forest mammals. Moose, woodland caribou in the Mayo, Ethel Lake, Moose Lake, Tay River, and Finlayson herds, Stone sheep, grizzly bear, black bear, wolverine and marten are all abundant. The size of the Mayo caribou herd is unknown. The Ethel Lake herd numbers about 300, the Moose Lake herd 200, the Tay River herd 4,000, and the Finlayson herd 4,100. Moose and caribou densities were high in the Finlayson Lake area in the 1990s following intensive management, including wolf reduction, from 1983 to 1989 (Larsen and Ward, 1995). The stability of these managed populations is uncertain (Hayes, 1995). The prime wintering area of the Finlayson caribou herd is between Ross River and Finlayson Lake (Farnell and MacDonald, 1987).

The Fannin sheep of the Ddhaw Ghro Habitat Protection Area are relict from the last continental glaciation (Fig. 176-7). The greatest proportion of brown-coloured black bears in the Yukon (45%) occurs between the Stewart and Pelly rivers (Yukon Department of Renewable Resources, 1988). Lynx and red fox are abundant in the Tintina Trench. Mule deer and coyotes, recent colonizers of the Yukon, also live in the Tintina Trench. Mule deer herds are about 12 to 15 individuals. Beavers are abundant in wetland complexes found in the southern Tintina Trench and Ross River Basin. One of the larger microtine rodents, the chestnut-cheeked vole, is confined to colonies in the forests north of the Stewart River. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Birds

The southwest border of this ecoregion follows the Tintina Trench, an important migration corridor for large numbers of Sandhill Crane and waterfowl breeding in Alaska. Wetlands are used for breeding and staging by Pacific, Red-throated and Common Loons; Trumpeter Swan; Canada Goose; American Widgeon; Green-winged Teal; scaup; and scoters (Dennington *et al.*, 1983; Dennington, 1985; McKelvey and Hawkings, 1990). Osprey and Bald Eagle also breed around lakes (Dennington *et al.*, 1983).

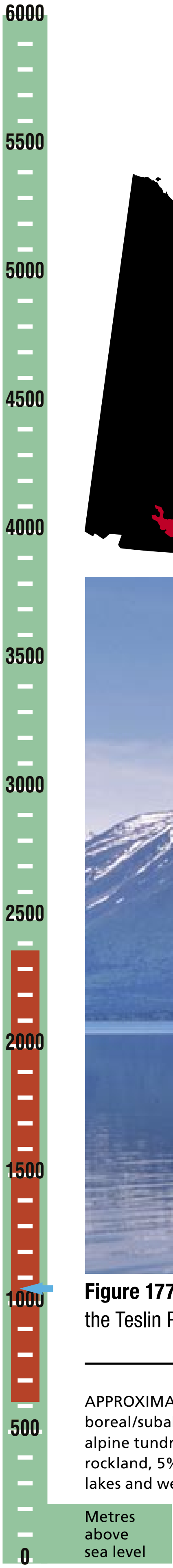
Breeding songbirds such as Alder Flycatcher, Orange-crowned Warbler, Yellow Warbler, Northern Waterthrush, Common Yellowthroat, and Fox Sparrow use alder and willow thickets adjacent to marshy lakes (Rand, 1946). Bonaparte's and Mew Gulls breed at some of these lakes, while Herring Gull more often occurs along rivers (Rand, 1946). The diverse breeding bird community associated with wetlands includes American Kestrel, Lesser Yellowlegs, Solitary Sandpiper, Common Snipe, and Red-winged and Rusty Blackbirds (Osgood, 1909; Johnston and McEwen, 1983).

Many forest bird species reach their northern limit here including Ruffed, Blue, and Sharp-tailed Grouse; Common Nighthawk; Yellow-bellied Sapsucker; Hairy Woodpecker; Western Wood-Pewee; Hermit Thrush; and Townsend's Warbler (Frisch, 1987). Common year-round residents of these forests include Spruce Grouse, Great Horned Owl, Three-toed Woodpecker, Black-capped and Boreal Chickadees, Gray Jay, and Common Raven (Osgood, 1909; Rand, 1946). Red-tailed Hawk, Northern Flicker, Olive-sided Flycatcher, Ruby-crowned Kinglet, Swainson's Thrush, Varied Thrush, Yellow-rumped Warbler, Blackpoll Warbler, and Dark-eyed Junco breed in these forests (Osgood, 1909; Johnston and McEwen, 1983).

Low densities of Gyrfalcon breed in alpine areas accompanied by Rock and White-tailed Ptarmigan, Wandering Tattler, and Gray-crowned Rosy Finch (Osgood, 1909; Beckel [editor], 1975). American Pipits breed on alpine plateaus (Osgood, 1909). At slightly lower elevations, Willow Ptarmigan, Wilson's Warbler, American Tree Sparrow, and Golden-crowned Sparrow nest in subalpine birch and willow shrubs (Osgood, 1909).

C. Kennedy, Yukon Government

Figure 176-7. The McArthur Mountains within the Ddhaw Ghro Habitat Protection Area have unglaciated ridges between 1,500 and 1,800 m in elevation. The mountains are home to Fannin sheep. The north side of the range is the winter range of the Ethel Lake caribou herd.



Yukon Southern Lakes

Boreal Cordillera Ecozone

ECOREGION 177

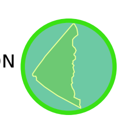
DISTINGUISHING CHARACTERISTICS: Broad valleys and large lakes characterize this ecoregion. Set within the rain shadow of the St. Elias Mountains, this ecoregion's climate is dry and cool. The Yukon Southern Lakes Ecoregion lies in the sporadic discontinuous permafrost zone, where permafrost underlies less than one-quarter of the landscape. Soils tend to be alkaline and wetlands (mainly fens) are typically dominated by marl formation. The ecoregion supports the highest mammalian diversity in the Yukon, with at least 50 of the 60 species known to occur in the Yukon at present.

J. Meikle, Yukon Government

Figure 177-1. The north end of Kusawa Lake is a broad U-shaped glacial valley. The surrounding upland is a dissected portion of the Teslin Plateau with a surface elevation 1,000 m higher than the valley floor.

APPROXIMATE LAND COVER
boreal/subalpine coniferous forest, 65%
alpine tundra, 25%
rockland, 5%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
35,650 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
29,892 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
6%

ELEVATIONAL RANGE
610–2,380 m asl
mean elevation 1,055 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Lake Labarge Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Southern portion of **Interior Yukon Dry Forests** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Yukon Southern Lakes Ecoregion, a large area of rounded summits and broad valleys, is part of the Yukon Plateau physiographic unit as defined by Bostock (1948) and Hughes (1987b). Most of this ecoregion is located in the Yukon, but a portion extends south into British Columbia to include the south end of Teslin Lake. The Teslin and Nisutlin plateaus, separated by the Teslin Fault, are the other physiographic subdivisions within this ecoregion (Bostock, 1948; Mathews, 1986). Some mountain groupings are the Sifton, Englishmans and Miners ranges. The topography consists of dissected plateaus, rolling hills and broad valleys occupied by lakes and rivers (Fig. 177-1).

Much of the terrain lies between 1,000 and 1,500 m asl. The highest peak is Mount Arkell at 2377 m asl. Other peaks over 2,000 m asl are Joe Mountain, Mount Lorne, Mount Byng, Pilot Mountain, and peaks in the Sifton and Englishman ranges. The major rivers and Lake Laberge all lie below 760 m asl.

The numerous large lakes and rivers give the ecoregion its name. Most of the lakes, such as Kusawa (Fig. 177-1), Teslin, Marsh and Laberge, and the larger rivers, the Yukon and Teslin, trend northwest–southeast or north–south. This pattern reflects the northwest-trending faults and folds of the bedrock.

BEDROCK GEOLOGY

Coarse-grained, crystalline metamorphic and granitic rocks predominate in the eastern and western thirds of this ecoregion, while mafic volcanic rocks, limestone reefs and clastic sediments characterize the central third. The regional rock units are shown by Kindle (1953), Tempelman-Kluit (1974), Wheeler (1961) and Gordey and Stevens (1994a). Certain areas have been mapped in greater detail (Hart, 1997 and references therein) and a contemporary map interpretation of the terranes is given by Gordey and Makepeace (compilers, 2000).

Within the ecoregion are parts of four terranes — Yukon–Tanana, Stikinia, Cache Creek and Dorsey — each with different rock types and origins. The exposed rocks in each are summarized below, beginning in the west.

The area generally west of the Takhini River bridge on the Alaska Highway, belongs to the western part of Yukon–Tanana Terrane, intruded by various granitic components of the Coast Plutonic Complex. The former consists of strongly metamorphosed quartzofeldspathic schist (Erdmer, 1991) flanked by quartz–biotite schist, granitic gneiss, marble and amphibolite (Johnston and Timmerman, 1994). In the Coast Plutonic Complex, the Early Jurassic Little River and the Paleocene Annie Ned batholiths consist of resistant granite, with cliffs and large talus blocks resulting from planar vertical fractures or joints (Hart, 1997).

Northern Stikinia contains sedimentary and volcanic rocks. Augite basalt flows and tuffs of the Povoas Formation of the Lewes River Group predominate on the western part of the terrane. Upper Triassic to Middle Jurassic limestone, argillite, tuffaceous sandstone and conglomerate comprise the Whitehorse Trough (Hart, 1997), which is the largest element of northern Stikinia. Upper Triassic limestone forms sparsely vegetated, light-coloured cliffs, domes and pinnacles east of Lake Laberge (Fig. 177-2), with some notable fossil reef communities (Reid and Tempelman-Kluit, 1987). Areas of thick andesite and basalt flows in the north-central part of the ecoregion include the post-accretion (after Stikinia accreted to ancient North America) mid-Cretaceous Mount Byng, the Late Cretaceous Open Creek, and Carmacks Group (Hart, 1997). The Carmacks Group is notable for its alkaline shoshonitic chemistry (e.g. Johnston *et al.*, 1996; Smuk *et al.*, 1997). Numerous mid-Cretaceous granitic plutons that intrude Stikinia are named after nearby features, including Flat Creek, Haeckel Hill, Cap Mountain and Cap Creek, M'Clintock Lakes, Byng Creek and Mount M'Clintock (Fig. 41 in Hart, 1997). Vesicular basaltic lava erupted near Alligator Lake about 3 million years ago, leaving spatter cones and scoria-covered uplands southwest of Whitehorse. The columnar-jointed basalt lava flows between Cowley Creek, McCrae and the Whitehorse Rapids flowed from vents south of the Mount Sima ski area in several episodes between 15 and 8.5 Ma (Hart and Villeneuve, 1999).

The Cache Creek terrane, east of Carcross and between Marsh and Teslin lakes, contains altered basalt greenstone (Nakina Formation), crinoid- and fusilinid-bearing limestone (Horsefeed Formation)

Figure 177-2. Carbonate cliffs (remnants of large reefs of middle Triassic age) and dense forest flank the east side of Lake Laberge. The rocky headlands and long north–south reach of the lake make small boat travel hazardous during summer stormy weather.

and ribbon chert-rich Kedahda Formation (Monger, 1975; Hart and Pelletier, 1989a,b). Pods of serpentinized peridotite up to several kilometres long (Gordey and Stevens, 1994b) weather black and, where not covered by glacial deposits, support only stunted vegetation.

Northeast of Teslin Lake are strips of Quesnel, Yukon–Tanana and Cassiar terranes (Gordey and Stevens, 1994a). Rock types include siliceous argillite, siltstone and sandstone with abundant fresh augite crystals. Quartz–mica phyllite is flanked to the northeast by sandstone, grit, chert and chert pebble conglomerate. Small hornblende–biotite quartz monzonite plutons throughout the Thirtymile Range, and biotite granite with up to 40% pink feldspar phenocrysts in the Englishman's Range and west of Quiet Lake, constitute about one-fifth of the eastern third of the ecoregion.

The central part of the ecoregion has significant mineral potential and a long mining history. Copper in limestone skarns has been mined in 13 places (Watson, 1984) immediately west of Whitehorse. Coal seams have been investigated 24 km south of the city (Bremner, 1988; Hunt and Hart, 1994). Gold in quartz veins has been explored throughout the area south of Whitehorse (Hart and Radloff, 1990). Gold also occurs in altered rocks around Cache Creek ultramafic pods (e.g. Hart, 1996). East of Teslin River is the Red Mountain molybdenum porphyry, about 20 silver–lead–zinc veins, and both copper–iron and tin–tungsten skarn deposits, all related to Cretaceous plutons. Baked mudstone (Laberge Group) in a unique occurrence west of Fish Lake has traditionally been used for cutting and scraping tools (Gotthardt and Hare, 1994).

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

The main sources of surficial geology information for the Yukon Southern Lakes Ecoregion are several surficial geology and soil maps (Rostad *et al.*, 1977; Morison and McKenna, 1981; Klassen and Morison, 1987; Morison and Klassen, 1991; Mougeot and Smith, 1992 and 1994) and maps of terrain hazards and geological information for all maps sheets (Yukon GEOPROCESS file, 2002).

The surface deposits of the Yukon Southern Lake Ecoregion are associated with the most recent Cordilleran glaciation, the McConnell, believed to have covered the south and central Yukon between 26,500 and 10,000 years ago. Most of the ecoregion was covered by ice that flowed towards the northwest from the Cassiar Mountains. Streamlined moraine deposits, primarily drumlins, are abundant west and north of Lake Laberge, all indicating a northwesterly ice flow direction. After the maximum extent of McConnell ice, deglaciation produced disrupted drainage systems and large glacial lakes as a result of a complex assemblage of ice lobes, which were restricted to valley bottoms and controlled by local topography.

Quaternary deposits are distributed in a general pattern. Representative sequences of Quaternary deposits are found in many major valleys such as the Yukon River Valley. High elevation slopes and summits are covered with a discontinuous colluvium or moraine veneer over bedrock. Where exposed, the bedrock is weathered or frost-shattered.

Glacial till, often gullied, covers most mid-elevation slopes mixed with colluvial fans or aprons. The general composition of the till matrix in adjoining map sheets (Jackson, 1994) indicates a wide range of sand content (20 to 70%), of silt (20 to 80%), and usually a lower clay content (5 to 30%). Isolated lenses of ice-rich permafrost may be present on north-facing slopes and at high elevations where thick organic deposits are present over the Quaternary sediments.

Glaciofluvial sand and gravel terraces flank the valley sides while pitted or hummocky deposits of sand and gravel line the bottom of some valleys. These deposits usually are free of permafrost and have stable surfaces, but may contain undesirable, or weak, lithologies for potential use as aggregate. In addition to the glaciofluvial gravel, the largest river floors contain alluvial deposits.

During deglaciation, large volumes of meltwater were dammed in some valleys and formed large glacial lakes. Beachlines, lake bottom sediments and many modern lakes can now be found in these valleys. In the Takhini River and Tagish River valleys, Glacial Lake Champagne deposited up to 75 m of silt and

J. Meikle, Yukon Government

Figure 177-3. The Takhini River Valley is filled with glaciolacustrine sediments that were deposited beneath glacial Lake Champagne between 9,000 and 10,000 years ago. Western portions of the Takhini Valley receive only 200 mm of precipitation annually. Light precipitation has resulted in very slow regeneration of mixed forest cover that has replaced the white spruce and lodgepole pine that was burned in 1958.

clay (Fig. 177-3). Glaciolacustrine silt and clay deposits border Teslin Lake, Little Atlin and Atlin lakes, as well as the Nisutlin River valley and the Red River valley north of Fish Lake, and can be as thick as 15 m. They commonly contain massive ice bodies and are prone to retrogressive thaw slides and thermokarst degradation when disturbed either by river erosion, forest fires, or other changes in surface conditions.

GLACIAL HISTORY

The Yukon Southern Lakes area is dominated by till, glaciofluvial gravels and glaciolacustrine clay and silt deposited during the McConnell Glaciation (Bostock, 1966; Hughes, 1969a). Ice flowed into the area from the Cassiar Mountains to the southeast and the eastern Coast Mountains to the southwest (Jackson and Mackay, 1991; Jackson *et al.*, 1991; Ryder and Maynard, 1991). Trunk glaciers followed the major valleys and flowed northwestward across this region to terminate in the central Yukon. The streamlined topography of this region was shaped by this flow. Glacial ice covered the lowland some time after 26,000 years ago and was probably gone well before 9,000 years ago (Jackson *et al.*, 1991). Blockage of meltwater drainage, possibly supplemented by isostatic depression, created extensive lakes in the ecoregion during deglaciation, so that Lowlands are often underlain by glaciolacustrine sediments (Fig. 177-3). During the postglacial period, streams incised into the thick drift of this region leaving steep-sided canyons and flights of terraces.

CLIMATE

The orientation of the topography is primarily northwest-trending over its eastern section, but has an east–west orientation over its western portion. This arid ecoregion lies in the heart of the rain shadow of the St. Elias–Coast Mountains. Precipitation ranges from 200 to 325 mm. One-third to one-half of this falls during the summer, primarily as showers. A secondary maximum occurs in the fall and early winter associated with active storm centres in the Gulf of Alaska. Snow cover is generally in place from late October to mid-April in the valley floors, and a month longer over the higher terrain.

Mean annual temperatures are near –1 to –2°C over the southeastern portion of this ecoregion, and –3 to –4°C in the northwest. Mean January temperatures range from –21°C in the southeast to –25°C in the northwest. Mean temperatures are five degrees warmer over higher terrain due to the inversion. Short periods with temperatures above zero can be expected during the winter. July mean temperatures range from 12 to 14°C and some five degrees cooler over higher terrain. Extreme temperatures have ranged from –55 to 34°C. Temperature extremes are not as great as in the Yukon interior valleys, due to the higher elevations of valley floors in this ecoregion. In the immediate vicinity of the larger lakes, spring can be delayed up to two weeks due to the persistence of the ice cover. Conversely, the onset of cold winter temperatures can be delayed from two weeks to a month due to the extensive low cloud associated with the lakes as they freeze over in November and December.

In valleys with southeast to northwest orientation, winds are common because of the proximity of storm centres in the Gulf of Alaska. Strong winds typically range from 30 to 50 km/hr and occasionally reach destructive force with gusts over 100 km/hr, primarily from a southerly direction (Fig. 177-4).

HYDROLOGY

The Yukon Southern Lakes Ecoregion is situated within the Interior Hydrologic Region, although it forms a boundary with the Western Hydrologic Region (Fig. 8). With a total area of approximately 30,000 km^2, the ecoregion primarily drains northward from the upland plateau complex consisting of the Teslin and Nisutlin plateaus. The western portion of the ecoregion consists of the footslopes of the Coast Mountains, and as such has greater relief and subsequently higher runoff and peak flows than the central and eastern portion of the ecoregion. Major streams include the Teslin River, which makes up part of the eastern boundary, the upper Yukon River, and the Takhini River. Several smaller, more representative intermediate-sized tributaries of the Yukon include the Nisutlin, Wolf and M'Clintock rivers. The Dezadeash and Aishihik rivers at the western corner flow westward into the Alsek River. Wetlands and large lakes cover approximately 5% of the ecoregion. The ecoregion contains several large lakes including Teslin, Wolf, Marsh and Laberge (Fig. 177-2). The most significant


M. Hoefs

Figure 177-4. Sand dunes near Carcross are composed of sediments reworked from nearby glaciofluviual deposits by strong winds through the coastal mountains to the southwest. The lupine *(Lupinus kuscheii)* and sedge *(Carex sabulosa)* in the foregound stabilize these dunes. These species are known in only a handful of other Yukon locations.

wetland complex is the Nisutlin River and Delta (Fig. 177-5). Other wetlands include the M'Clintock and Yukon River downstream of Marsh Lake.

There are seven representative hydrometric stations: Teslin (two), Nisutlin, Lubbock, M'Clintock and Ibex rivers, and Sidney Creek. Annual streamflow is characterized by a rapid increase in snowmelt discharge, to a peak in June, with secondary rainfall peaks later in the summer. On smaller streams, approximately 40% of the annual maximum flows are due to intense summer rainstorm events. The mean annual runoff is moderate, though variable, with a range of values of 73 to 366 mm and an ecosystem mean value of 245 mm. Mean seasonal and summer flows are moderate, with values of 14 X 10^{-3} and 11 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are moderately low with values of 44 X 10^{-3} and 29 X 10^{-3} $m^3/s/km^2$, respectively, respectively. Minimum streamflow generally occurs during April, with the relative magnitude reasonably high due to the moderating influence of the Gulf of Alaska on winter temperatures and subsequent groundwater contributions. The minimum annual and summer flows are high and moderate with values of 1.6 X 10^{-3} and 3.9 X 10^{-3} $m^3/s/km^2$, respectively. Only very small streams may experience zero winter flows during cold winters.

PERMAFROST

The Yukon Southern Lakes Ecoregion lies in the sporadic discontinuous permafrost zone, where permafrost underlies less than one-quarter of the landscape. East of Whitehorse, less than 8% of the Alaska Highway is built on permafrost (Brown, 1967) and less than 5% of holes drilled in association with the Alaska Highway gas pipeline encountered permafrost (Rampton *et al.*, 1983). Between Whitehorse and Haines Junction, however, the gas pipeline drilling encountered permafrost in 20% of holes. The active layer in mineral soil is commonly over 1.5 m thick, and so permafrost may not be identified at sites of shallow inspection. In wet, organic terrain, the active layer may be less than 1 m. In the Takhini River Valley, there is up to 15 m of permafrost (Fig. 21), and the mean near-surface temperature is –0.8°C. However, when permafrost is encountered in Whitehorse or Teslin, it is only 2 or 3 m thick (Burgess *et al.*, 1982; EBA, 1995). Permafrost is infrequent because, in the rain shadow of the Coast Mountains, the ecoregion is dry, and thus the soils are warm in summer. Permafrost has rarely been recorded in numerous excavations in coarse materials near Carcross, Teslin, or Tagish (e.g. Department of Highways and Public Works, 1981a; EBA, 1987c, 1988b, 1993), but in moist, silty soils, overlain by a peaty organic layer, ground ice is more frequent (Department of Highways and Public Works, 1981b).

Terrain features associated with permafrost degradation are more common than those associated with aggradation. As in many other ecoregions, glaciolacustrine sediments often contain substantial ground ice. Thermokarst lakes occur where the ice is melting, as in the Takhini Valley. Widespread subsidence in these terrains

Figure 177-5. The Nisutlin Delta, largest in southern Yukon, is an important staging area for migratory waterfowl and is designated a National Wildlife area. Its productivity results from mud flats and aquatic vegetation that is exposed by low water levels in fall, coinciding with southerly bird migrations.

is associated with ground thawing after forest fires (Burn, 1998b). Retrogressive thaw slumps are commonly initiated by river erosion. However, because permafrost is so scattered, the ecoregion has numerous perennial springs. Where these emerge, icings form in winter that may build up over 2 m thick. Landforms associated with permafrost aggradation are palsas, with occasional peat plateaus, restricted to wetlands and underlain by a metre or so of permafrost (e.g. Harris, 1993).

SOILS

Soils in this ecoregion have formed under a relatively mild, semi-arid climate within the rain shadow of the St. Elias Mountains. Mineral soils tend to be weakly weathered and peat accumulations are generally less than 1 m in thickness.

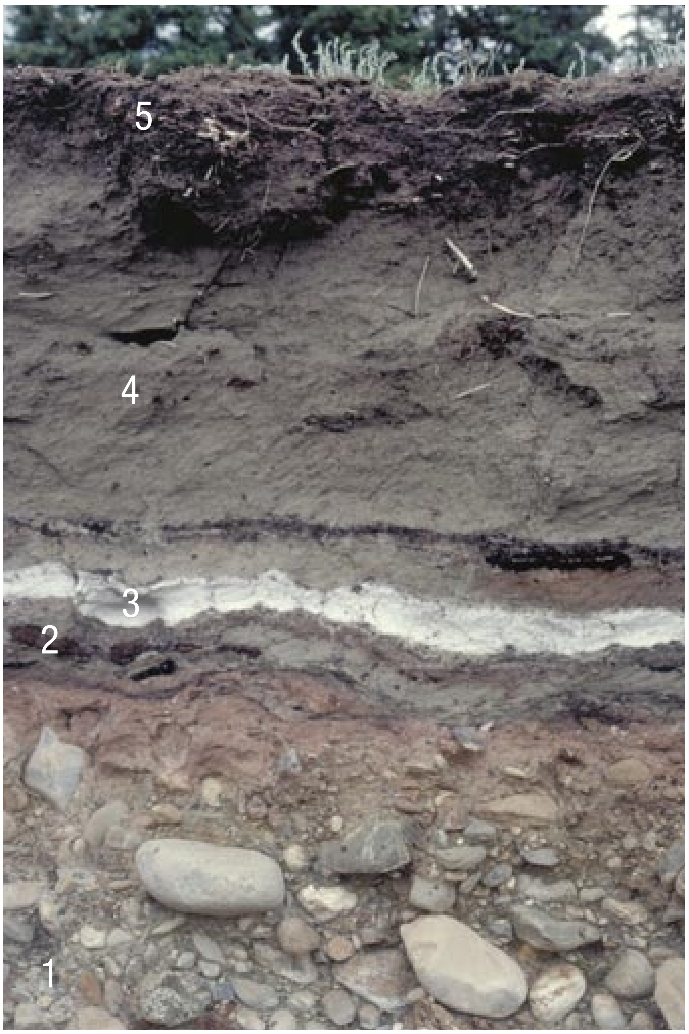
The soils are relatively well studied and numerous detailed soil surveys have been conducted in the major valleys systems of the ecoregion, including Day (1962), Rostad *et al.* (1977), Davies *et al.* (1983a), and Mougeot and Smith (1992 and 1994). Soils are predominately Eutric Brunisols formed on a variety of glacial parent materials. Soils affected by near-surface permafrost (Cryosols) are largely confined to upper elevations, moist north-facing slopes, and some wetlands.

Major valleys in the ecoregion are comprised of glaciolacustrine deposits of calcareous silt and clay. Soils are alkaline and usually classified as Eutric Brunisols. Soils are often saline in areas of groundwater discharge (Humic Gleysols, saline phase), but those exhibiting morphologies characteristic of the Solonetzic order (i.e. Alkaline Solonetz) are rare.

Soils of depressions are usually classified as Humic Gleysols or as Turbic Cryosols, if permafrost is present. Floodplain soils are classified as

Gleysolic, or as Regosolic if no soil development has yet occurred. South-facing slopes may support grassland communities and the associated soils may have surface A horizons rich in humus. These soils are classified as Melanic Brunisols. For the most part, forested lower and middle slopes are Eutric Brunisols. A thin veneer (2 to 5 cm) of White River volcanic tephra covers most stable soil surfaces in the ecoregion or can be seen buried within sediments on riverbanks or road cuts (Fig. 177-6).

Permafrost is scattered and discontinuous, and Cryosols are intermittently distributed among the Brunisols. They are most commonly associated with upper subalpine vegetation and northerly aspects. Massive ground ice is occasionally present in these fine-textured materials. Palsas have been recorded here associated with minerotrophic wetlands (Harris, 1993). Thick accumulations of peat are uncommon in the ecoregion. Most wetlands are alkaline fens due to the base-rich nature of the geologic materials and rest on mineral soil or marl at less than 50 cm depth (Mougeot and Smith, 1998). Alpine zones are typically on colluvial rubble or moraine. In well-drained locations, these soils are also classified as Eutric Brunisols. In moist locations, the presence of permafrost and active frost churning result in soils classified as Turbic Cryosols.



P. Sinclair, Canadian Wildlife Service

Figure 177-6. White River volcanic tephra is exposed in cutbanks throughout the southern Yukon. This cross-section reveals (from the bottom): (1) imbricated boulder (glaciofluvial) gravel; (2) loess and buried organics; (3) 5–10 cm layer of White River tephra, deposited about 1,200 years ago, overlain by (4) almost 1 m of loess with several charcoal horizons from forest fires; and (5) the top 30 cm is modern surface soil horizon found in loess that contains roots of alder, willow and drought-resistant grass.

VEGETATION

The vegetation of the Yukon Southern Lakes Ecoregion is dominantly open coniferous and mixed woodland, reflecting the rain shadow climate of the area and the pattern of forest fires. Medium shrubs dominate the higher elevation slopes, while mountain summits are usually dry dwarf shrub tundra (Francis *et al.*, 1999).

Pine is the dominant tree species, because it quickly regenerates in burned areas. White spruce–feathermoss forests are common on active floodplains and in small parcels of land that have not burned in the last 100 years. Pine, or mixed spruce and pine, forests are common on coarser glaciofluvial deposits and moraine. On dry upland sites, the understory vegetation is dominated by a mixture of ground shrubs including twinflower, kinnikinnick, lingonberry and lichen, with abundant litter. Gravelly river terraces that have not burned in the last 100 years are characterized by open spruce and pine forest with a *Cladina* lichen groundcover (Davis *et al.*, 1983; Applied Ecosystem Management, 1999a).

Black spruce has limited distribution in this ecoregion. It is largely restricted to the eastern portion, most commonly along the Nisutlin River. It is found on low, wet and cold sites often associated with Cryosols and near-surface permafrost.

At higher elevations, subalpine fir has a feathermoss understory where the canopy is dense, and with shrub birch and lichen in open stands.

Mixed aspen and white spruce are common on fine soils with a variable cover of ground shrubs, lichen and litter. Willow and soapberry are common. Aspen is also found on steep south-facing slopes, often with small pockets of spruce occupying the moister sites. Balsam poplar is found on roadsides and along creeks and rivers; it is an early invader and usually replaced in the successional sequence by white spruce. Paper birch is scattered on cooler, moister sites, but is neither common nor known to form pure stands.

Open areas at low elevations include grasslands on steep south-facing slopes and alkaline lacustrine depressions, such as those found in the Takhini Valley. Shrub birch is common in moist depressions subject to cold air drainage. Willows dominate fen and marsh wetlands and are common in areas subject to flooding (Oswald and Brown, 1986).

Around treeline, shrub birch, underlain by lichen and moss, takes over the drier sites. On moister and north-facing sites, willow and shrub birch with moss groundcover are more dominant. The alpine dwarf shrub tundra found at higher elevations includes willow, lingonberry, bearberry, bilberry, and mat or cushion plants such as dryas, lichen and graminoids. The vegetation cover is sparse on the most exposed sites.

WILDLIFE

Mammals

The topographically diverse Yukon Southern Lakes Ecoregion supports the highest mammalian diversity in the Yukon with at least 50 of the 60 or more Yukon species. Dall sheep (Barichello *et al.*, 1989a), grizzly bear (Larsen and Markel, 1989), wolves (Hayes *et al.*, 1991), coyotes, red fox, and wolverine (Banci, 1987) are abundant. Wolf and wolverine densities are among the highest in the Yukon. Coyotes invaded the territory in the early 20th century, probably benefiting from widespread wolf control across North America and the ability to outcompete red fox. Coyotes are most abundant in the southern Yukon and range north to the Klondike Plateau and Yukon Plateau–Central. Stone sheep are found east of Lake Laberge.

A long history of overharvesting of moose and caribou populations throughout much of this ecoregion required management programs that restricted human harvest beginning in the 1990s (Larsen *et al.*, 1986, 1989). The Carcross–Squanga, Ibex and Atlin woodland caribou herds are small and fragmented, estimated at 300, 400, and 800 caribou, respectively. The Carcross–Squanga and Ibex herds are not restricted to smaller winter ranges by snowfall, and therefore expose themselves to more wolf packs. The more remote Wolf Lake caribou herd to the east is considered healthy (Farnell and MacDonald, 1989), with 1400 animals estimated in 1998.

A small population of mountain goats was re-established on White Mountain in 1983–1984 following their extirpation in the 1960s (Barichello *et al.*, 1989b). An elk herd, introduced in the 1950s, with additions for genetic outcrossing in the 1990s, has survived in the Takhini River Valley and numbers about 60. Mule deer are common in this ecoregion and are often seen in small herds of 12 to 15 (Fig. 177-7).

The Teslin burn of 1958 supports some of the highest densities of moose, wolves, snowshoe hare and lynx in the Yukon. The lynx density in 1990–1991 of 45/100 km^2 was the highest ever reported in North America (Slough and Mowat, 1996). Beavers are also abundant where burns and wetlands meet, as in the Teslin burn (Slough and Jessup, 1984). Muskrats are still common but once thrived in the Lewes River marsh before flow control, which has altered seasonal water level fluctuations.

The cougar, with the greatest range of any mammal in the Western Hemisphere, makes infrequent movements through this area from northern British Columbia. Marten are uncommon west of the Teslin River; however, a transplant program and natural colonization in the 1980s have increased marten abundance in local climax coniferous habitats, primarily at higher elevations (Slough, 1989).

The northern flying squirrel, bushy-tailed wood rat and woodchuck are uncommonly seen residents. Arctic ground squirrels and least chipmunks flourish in the forest openings and grassy slopes common in the ecoregion. The only know location of the western jumping mouse in the Yukon is on the South Canol Road. The meadow jumping mouse is common throughout the southern Yukon (Youngman, 1975). There is abundant aquatic habitat for water shrew in the ecoregion. The house mouse, originating in mid-eastern Asia and now a world traveler, has taken up residence around the habitations of Whitehorse.

Figure 177-7. Mule deer *(Odocoileus hemionus)* spend much of the year in small herds of up to 15 animals. The deer (including occasional white-tailed deer) are increasing in numbers in the Yukon Southern Lakes Ecoregion.

The little brown myotis bat is abundant near lakes where it gleans insects on the wing. It probably winters in coastal Alaska. Bats have received little attention in the Yukon, and other species may yet be found, especially in the south and near the coast. Bat species found near the Yukon include the long-legged myotis, Keen's long-eared myotis, the silver-haired bat and the big brown bat (van Zyll de Jong, 1985; Nagorsen and Brigham, 1993; Parker *et al.*, 1997; Slough, 1998). Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Birds

The inlets and outlets of the large lakes provide some of the most important waterfowl staging areas in the Yukon (Department of Renewable Resources, 1994). Perhaps the most significant waterfowl staging area in early spring is the Marsh Lake outlet from M'Clintock Bay and the adjacent Lewes River marsh (Johnston and McEwen, 1983; Hawkings, 1994; Eckert, 1997c). Early open water and exposed mud flats and sandbars make M'Clintock Bay a spring staging site of national importance (Yukon Waterfowl Technical Committee, 1991) hosting up to 2,000 swans a day (Mossop, 1976; Hawkings, 1994).

Along with M'Clintock Bay and Lewes Marsh, Tagish Narrows between Tagish Lake and Marsh Lake are important to a variety of other waterbirds such as Red-throated, Pacific and Common Loons; Horned and Red-necked Grebes; and virtually all southern Yukon geese and ducks (Mossop, 1976; Canadian Wildlife Service, 1979b; Johnston and McEwen, 1983; Hawkings, 1986; Yukon Waterfowl Technical Committee, 1991; Eckert, 1997c). These areas are equally important to numerous shorebirds such as American Golden-Plover; Semipalmated Plover; Lesser Yellowlegs; Semipalmated, Least, and Pectoral Sandpipers; Common Snipe (Eckert, 1997c; Eckert, 1997d); and migrant songbirds such as American Robin, American Pipit, Lapland Longspur and Rusty Blackbird (Eckert, 1997c). Other important staging areas are upper Lake Laberge and the Teslin Lake outlet (Yukon Waterfowl Technical Committee, 1991).

The Nisutlin River Delta (Fig. 177-5) is a fall staging area of national importance for swans, geese, dabbling ducks, and diving ducks (Mossop and Coleman, 1984; Yukon Waterfowl Technical Committee, 1991; Hawkings, 1994). While spring water levels are high at the Nisutlin Delta, they decrease in the late summer and fall to expose extensive mud flats and dense beds of aquatic vegetation (Dennington, 1985). The exposed mud flats also provide important feeding areas for many migrant shorebirds including Semipalmated Plover; Lesser Yellowlegs; Semipalmated, Least, Baird's, and Pectoral Sandpipers; Long-billed Dowitcher; and migrant songbirds such as American Pipit and Lapland Longspur (Eckert, 1997a, 1998a). One of North America's rarest migrant shorebirds, the Sharp-tailed Sandpiper, is apparently a regular fall migrant here (Eckert, 1997a, 1998a). The large numbers of waterfowl and shorebirds in turn attract numerous predators such as Bald Eagle, Merlin, Peregrine Falcon, and Gyrfalcon (Mossop and Coleman, 1984; Eckert, 1997a, 1998a). Southbound Trumpeter Swans arrive on the delta in mid-September and by late September are greatly outnumbered by large flocks of migrating Tundra Swans, a few of which linger until freeze-up (Mossop and Coleman, 1984; Eckert, 1997a, 1998a).

The lower Nisutlin River is a rare example of a river supporting large numbers of breeding waterfowl (Hawkings, 1994). The river's abundant cut-off channels, oxbows, and sloughs harbour breeding and moulting Canada Goose, American Widgeon, Mallard, Green-winged Teal, Ring-necked Ducks, scaup, and goldeneye (Dennington, 1985; Hawkings, 1994). Since 1992, these wetlands have hosted the highest density of breeding Trumpeter Swan in the Yukon (Hawkings, 1994). During fall migration from early September to late October, large lakes and other sites that concentrate gulls witness movements of Thayer's Gull with lesser numbers of Glaucous Gull (Eckert, 1998a; Canadian Wildlife Service, unpubl.).

Larger lakes and rivers support breeding Pacific and Common Loons, Surf Scoter, Mew and Herring Gulls, Arctic Tern, and Belted Kingfisher (Rand, 1946; Godfrey, 1951; Stelfox, 1972; Canadian Wildlife Service, 1979a; Nixon *et al.*, 1992). Numerous wetlands such as Swan Lake (Grunberg, 1994), Rat Lake, Cowley Lake, McIntyre Creek, Mary Lake and Chinook Creek are important to many waterfowl as well as Pied-billed Grebe, Sora, and American Coot (CWS, Birds of the Yukon Database). McIntyre Creek wetlands are especially important to very large numbers of migrating swallows especially Tree, Violet-green, Northern Rough-winged, Bank, and Cliff Swallows (Eckert, 1997c; Canadian Wildlife Service, unpubl.).

Marshy areas associated with lakes, streams and ponds have breeding Northern Harrier, Lesser Yellowlegs, Solitary and Least Sandpipers, Common Snipe, Wilson's and Red-necked Phalaropes, Bonaparte's Gull, Rusty and Red-winged Blackbirds, Northern Waterthrush, Common Yellowthroat, and Savannah and Lincoln's Sparrows (Grunberg, 1994; Eckert, 1999b; Canadian Wildlife Service, unpubl.). Rocky and sandy lakeshores provide breeding habitat for Semipalmated Plover, Killdeer, Spotted Sandpiper, and Arctic Tern (Johnston and McEwen, 1983; Canadian Wildlife Service, unpubl.), while Harlequin Ducks and American Dippers breed on swift mountain streams (Soper, 1954). Osprey and Bald Eagle nest near lakes and rivers containing spawning fish (Yukon Wildlife Branch, 1977).

Deciduous and mixed forests in riparian areas support breeding Yellow-bellied Sapsucker, Hammond's Flycatcher, Yellow Warbler, Chipping Sparrow, and Fox Sparrow, with Least Flycatcher occurring locally in trembling aspen forests (e.g. Grunberg, 1994). Ruffed Grouse are year-round residents of trembling aspen forests, while Blue Grouse inhabit subalpine forests (Rand, 1946). Rufous Hummingbirds reach their northern limit in the Southern Lakes Ecoregion although breeding there is unconfirmed (Canadian Wildlife Service, unpubl.).

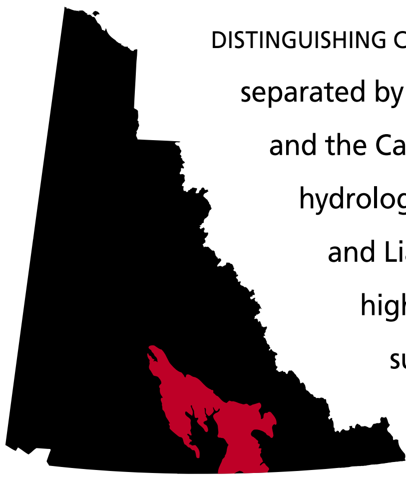
Open mixed woodland and coniferous forests support raptors such as Northern Goshawk, Red-tailed Hawk, Great Horned Owl, Northern Hawk Owl, Great Gray Owl, and Boreal Owl (Rand, 1946; Godfrey, 1951). Year-round residents include Three-toed, Black-backed, Downy, and Hairy Woodpeckers; Spruce Grouse; Gray Jay; Black-billed Magpie; Common Raven; Black-capped and Boreal Chickadees; Bohemian Waxwing; Pine Grosbeak; and White-winged Crossbill; also, Red Crossbill regularly occur at a few locations (Eckert *et al.*, 1995). Common and Hoary Redpolls occur regularly in winter (Eckert *et al.*, 1995). Common forest species include Olive-sided Flycatcher, Western Wood-Pewee, Ruby-crowned Kinglet, Swainson's Thrush, American Robin, Varied Thrush, Warbling Vireo, Yellow-rumped Warbler, Blackpoll Warbler, Dark-eyed Junco, Purple Finch, and in mature spruce forests, Golden Crowned Kinglet (Department of Renewable Resources, 1994; Grunberg, 1994; Eckert *et al.*, 1995; Canadian Wildlife Service, unpubl.). Open country species include Common Nighthawk, Say's Phoebe, Mountain Bluebird, and Brown-headed Cowbird (Eckert *et al.*, 1995), with Fox and White-crowned Sparrows in shrubby areas (Canadian Wildlife Service, unpubl.)

Alpine areas support Golden Eagle and Gyrfalcon (Foothills Pipe Lines Ltd., 1978; Department of Renewable Resources, 1994). A few Rock and White-tailed Ptarmigan inhabit these exposed rocky areas, while Willow Ptarmigan are common in subalpine willow and alder shrub (Department of Renewable Resources, 1994). Shrubby subalpine areas also provide breeding habitat for Dusky Flycatcher; Northern Shrike; Townsend's Solitaire; Wilson's Warbler; American Tree, Brewer's, and Golden-crowned Sparrows; and Common Redpoll (Department of Renewable Resources, 1994; Canadian Wildlife Service, unpubl.).

Pelly Mountains

Boreal Cordillera Ecozone

ECOREGION 178



DISTINGUISHING CHARACTERISTICS: The ecoregion includes two major mountain ranges, separated by the Dease Plateau; the more rugged Pelly Mountains in the north and the Cassiar Mountains in the south. The ecoregion encompasses a major hydrologic divide, with the Teslin and Pelly rivers of the Yukon River watershed and Liard River tributaries of the Mackenzie River watershed. The relatively high relief of this ecoregion results in high runoff and peak flows in summer. The ecoregion provides habitat to Stone sheep, mountain goats and the Pelly and Wolf Lake caribou herds.

C.F. Roots, Geological Survey of Canada

Figure 178-1. The Dorsey Range of the Pelly Mountains is composed of metamorphic and granitic rock. Steep-sided mountains with long slopes of blocky talus, typically covered with lichen, characterize the landscape. Higher slopes are frequented by woodland caribou, Stone sheep and mountain goat. This view is southeastward toward Dorsey Lake.

APPROXIMATE LAND COVER
boreal/subalpine coniferous forest, 50%
alpine tundra, 35%
alpine rockland, 10%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
35,580 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
34,258 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
7%

ELEVATIONAL RANGE
600–2,400 m asl
mean elevation 1,350 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Pelly Mountains Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Northern portion of **Northern Cordilleran Forests** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Pelly Mountains Ecoregion is comprised mainly of the Pelly Mountains, the northernmost extent of the Cassiar Mountains, the Dease Plateau, and the Simpson Ranges (Mathews, 1986). The Simpson Ranges are a southern extension of the Selwyn Mountains (Mathews, 1986). Bostock (1948) and Hughes (1987b) have included the Pelly Mountains and the Simpson Ranges as part of the Yukon Plateau and the Dease Plateau with the Cassiar Mountains. Maps of the National Topographic System place the Simpson Ranges and the smaller adjacent Campbell Range as part of the Pelly Mountains. The Saint Cyr, Big Salmon and Glenlyon ranges comprise the Pelly Mountains. A small portion of this ecoregion extends south into British Columbia.

This ecoregion is a rolling plateau topped by numerous mountain peaks and dissected in places by small rivers (Fig. 178-1). The relief is generally greater than 1,500 m asl, with a maximum elevation of 2,404 m asl in the Saint Cyr Range. Relief is greater in the Pelly Mountains than in the Cassiar Mountains to the south (Hughes, 1987b).

BEDROCK GEOLOGY

The Pelly Mountains Ecoregion is entirely within the Omineca Morphological Belt (Fig. 4), an area of uplifted sedimentary, metamorphic and granitic rocks. The northwest-trending axis of the ecoregion is the Cassiar Platform (Fig. 5), composed of continentally derived Paleozoic clastic and carbonate rocks; to the southwest are Dorsey and Yukon–Tanana (also called Kootenay) terranes. Part of the ecoregion is northeast of the Tintina Trench and provides excellent exposure of Yukon–Tanana terrane.

The types of bedrock and their distribution are shown by Poole *et al.* (1960). Gordey and Stevens (1994b). Tempelman-Kluit (1974 and 1984). Gordey and Irwin (1978) and Campbell (1967).

The metamorphic rocks of the area display multiple generations of folding with mica development and pronounced cleavage, both of which allow preferential erosion parallel to the regional structural grain. In contrast, granitic bodies, which are about 100 million years old and underlie about one-fifth of the ecoregion, post-date regional deformation. They form steep slopes and cliffs and underlie high standing areas with fields of grey-weathering boulders. The largest is the 350 km long Cassiar Batholith, of which its 90 km length in the Yukon is enclosed within the Pelly Mountains Ecoregion.

The oldest and most extensive rock unit in the Cassiar Platform is metamorphosed sandstone and shale (the Ingenika Group of Late Proterozoic age) overlain by marble (Murphy, 1988). Northeast of this expanse is an arcuate belt containing grey and black slate and phyllite with lesser amygdaloid basalt, known as Kechika Group of Upper Cambrian to Lower Ordovician age, in turn overlain to the northeast by younger black shale, chert and conglomerate. These latter rocks are similar in age and lithology to the Road River and Earn groups of the North American miogeocline, suggesting that the Cassiar Platform may be a displaced sliver of the ancient continent. However, the Platform is separated from the miogeocline by the Saint Cyr Range, between the Saint Cyr and Tintina faults, a series of Paleozoic metasedimentary rocks (platy limestone, phyllitic calcareous siltstone, green slate and blue–grey phyllite) whose origin is unknown.

The southeast prong of the ecoregion has been referred to as Kootenay terrane (Gordey and Stevens, 1994a) and Teslin Suture Zone. However, the metasedimentary and metavolcanic rocks there are comparable to the Yukon–Tanana terrane south of Finlayson Lake (Murphy, 1998; Murphy *et al.*, 2001). In both places, three broad units are recognized: at the base, quartz muscovite chlorite schist, quartzite and graphitic phyllite are intruded by Early Mississippian hornblende-bearing metamorphosed granite and orthogneiss; this is overlain by mafic schist and amphibolite, which is in turn overlain by ridge-forming quartz metasandstone and conglomerate.

South of Wolf Lake lies a portion of Dorsey terrane, which includes the deformed granite Ram stock, of Permian age, surrounded by Paleozoic metavolcanic rock, schist, quartzite and ribbon chert. Near the Swift River are numerous limestone bands 500 to 600 m thick that contain corals of Pennsylvanian age. Cretaceous biotite granite of the Seagull batholith is surrounded by an aureole of rusty- and grey-weathering hornfels more than 1 km wide (Abbott, 1981a).

This ecoregion is rich in minerals. The Ketza River mine, 40 km south of the community of Ross

River, is one of several gold-rich massive sulphide deposits in Early Cambrian limestone (Stroshein, 1996). Gold-rich magnetite occurrences and their higher-grade oxidized tops also interest prospectors. Around the Seagull Batholith are tin and iron-zinc vein systems, while the nearby Logjam Intrusion contain tungsten and molybdenum in fractures, and both metals are naturally found in nearby stream sediments.

The area south of Finlayson Lake has seen considerable exploration since the discovery of a zinc–copper massive sulphide deposit, now called Kudz Ze Kayah (Schultze, 1996). Other significant deposits were found near Wolverine and Fyre lakes. The host felsic metavolcanic layers are widely distributed in the Yukon–Tanana terrane. Similar mineralization occurs southwest of Tintina Trench near McNeil Lake. Placer gold was mined early in this century in Sayyea and Cabin creeks, which drain the eastern part of the ecoregion toward the Liard River.

SURFICIAL GEOLOGY

The uplands of the Pelly Mountains Ecoregion were major sources for glacier ice that fed the extensive anastomosing valley glaciers that composed the Cordilleran Ice Sheet during the McConnell, Reid and Pre-Reid glaciations (Jackson *et al.*, 1991; Jackson, 2000). Consequently, alpine-type glacial erosional features such as arête ridges and horn peaks dominate the highest mountains (Fig. 178-1) while high elevation plateaus feature glacial scouring (Fig. 178-2). The last (McConnell-age) ice sheet disappeared by stagnation and downward wasting so that glacial lakes and ice-marginal and englacial streams existed in major valleys during deglaciation. These filled valley bottoms with bedded lacustrine silt and sand, as well as gravel-rich kame and kettle topography (Jackson, 1994; Ward and Jackson, 2000). Valley sides are locally marked by flights of gravel terraces deposited by meltwater streams flowing along former glacier margins during down-wasting. Uplands along the western and northwestern margins of

J. Meikle, Yukon Government

Figure 178-2. Glacially scoured metamorphic bedrock at Icy Lakes is colonized by caribou lichen and dwarf birch (red foliage in late August), with pockets of subalpine fir trees in hollows where soil development and soil moisture allow.

this ecoregion, such as the Glenlyon Range, stood above Cordilleran ice as nunataks during the Reid and McConnell glaciations. Till deposited by Cordilleran ice sheets during these glaciations are well preserved around these nunataks (Ward and Jackson, 1992).

GLACIAL HISTORY

Deposits left by Cordilleran ice sheets during the last two glaciations are found within the Pelly Mountains Ecoregion. Erratics and till from the Reid Glaciation are restricted to nunataks along the west and northwest margins of this ecoregion (Ward and Jackson, 2000). Ice flow patterns during this glaciation are assumed to have been similar to the subsequent McConnell Glaciation although the Reid-age Cordillaeran ice sheet formed rapidly from the expansion of cirque and valley glaciers after about 26 ka (Jackson and Harington, 1991). The ice cap covering all but the peaks of the Pelly Mountains and Cassiar Mountains fed the Selwyn, Cassiar and Liard lobes of the Cordillaran ice sheet (Jackson and Mackay, 1991; Jackson *et al.*, 1991). Deglaciation occurred from the top down: uplands were the first to emerge while valleys remained under stagnant valley glaciers (Jackson, 1994). Deglaciation was completed before 10 ka. During the postglacial period, streams incised into glacial sediments deposited alluvial fans and cut alluvial terraces. Intense mechanical weathering and mass wasting created colluvial mantles on mountain slopes. Rock glaciers advanced from cirques and from below precipitous slopes during the Little Ice Age (about 1550 to 1850). These remain active in many areas (Jackson, 1994).

CLIMATE

This ecoregion is a relatively effective orographic barrier consisting of the Pelly Mountains and the northern extension of the Cassiar Mountains. It has a southeast–northwest orientation with elevations of 600 to 2,400 m asl. This is the first major barrier to the flow of weather systems east of the St. Elias and Coast mountains, so precipitation is relatively heavy. The higher elevations also result in cooler summers and less severe winters.

Mean annual temperatures are near –3°C, but there are moderate variations due to elevation and season. Mean temperatures are near –20°C in January and near 10°C in July. During January, the higher terrain has temperatures generally 5°C milder; conversely, the higher terrain is about 5°C colder in July but cold air drainage in valley bottoms is common (Fig. 178-3). Extreme temperatures can range from –53 to 32°C in the valley floors, but are less extreme over higher terrain. Frost can occur at any time of the year, but is less frequent in July. Spells of thawing temperatures can occur during winter, particularly in the southern valleys.

Precipitation is moderate, with mean annual amounts of 500 to 650 mm. The driest months are April through June, with monthly amounts of 20 to 40 mm. This increases in July and August, with rainfall of 40 to 60 mm, primarily as showers. The heaviest amounts, between September and January, are associated with weather systems from the Gulf of Alaska. This tends to be snow, with monthly water equivalent amounts of 60 to 80 mm. Winds are generally light but can be moderate, particularly in the fall and winter, in association with passing Pacific systems.

The climate stations representative of at least the valley floors are Quiet Lake and Swift River.

HYDROLOGY

The Pelly Mountains Ecoregion is situated within the Interior Hydrologic Region. The ecoregion drains the Pelly and Cassiar mountains. Drainage from the Pelly Mountains is to the Yukon system through the Pelly River in the east and the Teslin River in the west. Drainage from the Cassiar Mountains is to the Liard River in the east and the Yukon system through the Teslin River in the west and south. This ecoregion is a source area and as such has relatively high relief with subsequent high runoff giving the peak flows. Because the ecoregion is a mountainous source area, there are few large streams within its boundaries. The upper reaches of the Liard flow to the southeast from the Cassiar Mountains, while the upper reaches of the intermediate-sized Big Salmon River flow to the west from the Pelly Mountains. Other significant smaller streams include the Meister, Hoole, Smart, Rose, Lapie and North Big Salmon rivers. The ecoregion has relatively few waterbodies, with Little Salmon and Drury lakes as the only major ones. The coverage by wetlands is also relatively small.

C.D. Eckert

Figure 178-3. Higher elevation valleys within the Pelly Mountains Ecoregion are often subject to cold air drainage such that forest growth is suppressed on the valley floor (1000 m elevation) but vigorous on the sidehills. In this photo taken along the South Canol Road, shrub vegetation covers the glacial deposits of the valley floor, in contrast to open stands of subalpine fir and white spruce above. Alpine tundra and perennial snowpatches are seen in the distance at elevations above 1500 m.

There are four representative active and historical continuous hydrometric stations: Rancheria, Big Salmon, and South Big Salmon rivers; and Sidney Creek. Annual streamflow is characterized by a rapid increase in discharge in May, due to snowmelt at lower elevations, rising to a peak in June. Because of the mountainous topography, there are a number of streams likely to produce a streamflow response that tends to be rapid and flashy. Because this area is also susceptible to intense summer rainstorms, maximum annual flows are frequently produced by these storm events. Some steep, smaller streams are susceptible to mud flows triggered by these summer rainstorms. Mean annual runoff is moderate with a range in values of 244 to 366 mm, and an ecosystem mean value of 309 mm. Mean seasonal and summer flows are moderate with values of 19 X 10^{-3} and 15 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean summer flood are moderately low values of 70 X 10^{-3} and 35 X 10^{-3} $m^3/s/km^2$, respectively. The minimum annual and summer flows are high and moderate, with values of 1.7 X 10^{-3} and 6.1 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during April, with the relative magnitude higher than more eastern or northern ecoregions because of higher winter temperatures and subsequently greater groundwater contributions. Only very small streams may experience zero winter flows during cold winters.

PERMAFROST

Permafrost occurs regularly in the alpine zone, but at lower elevations it is more variably distributed. Permafrost was not encountered in seven exploration wells drilled on Red Mountain below 1,500 m asl, but at 1,605 m asl the permafrost thickness was 115 m (Burgess *et al.*, 1982). In northern parts of the ecoregion, most valley floors are underlain by frozen ground, such as near

Ross River and Finlayson Lake, where the base of permafrost is over 20 m below the ground surface (Burgess *et al.*, 1982; Stanley, 1986). In these parts, only some south-facing slopes and river courses are permafrost-free (Jackson, 1994).

In the southern portion of the ecoregion, dry coarse-grained deposits tend to be permafrost-free, while throughout the region fine-grained mineral soil and sites covered by organic soil support near surface ground ice. Floodplains of the larger rivers are moist, thus supporting organic accumulation over permafrost (Jackson, 1993a). The floodplain is rarely ice-rich because the sandy alluvial material is not conducive to ice segregation. The sediments are ice-bonded with local injection or wedge ice.

Ice-rich glaciolacustrine and glaciofluvial sediments, in which thermokarst lakes often develop, are found in valleys. As in other areas, the extent of ground ice in such sediments renders them susceptible to thaw slumping when exposed by river erosion. At higher elevations, there are rock- and debris-covered glaciers in north-facing cirques (Jackson, 1993b); many slopes that support a veneer of soil and organic material have solifluction lobes (Jackson, 1994). Patterned ground, comprised of sorted stone nets and fine-grained circles, develops where upland terrain is flat. Palsas and peat plateaus are common in valley floors in the southern portions of the region.

SOILS

The soils of this ecoregion have formed under the influence of relatively high precipitation, strong elevation gradients and warm summers. Mean annual precipitation is higher than that in adjacent plateau ecoregions. Soils have formed on a wide range of parent materials of varied lithology.

Precipitation tends to increase with elevation, so soils of the alpine and subalpine environments are relatively strongly leached and acidic. There are no published soil surveys in this ecoregion, but surveys in adjacent ecoregions (Rostad *et al.*, 1977; Davies *et al.*, 1983a) are useful in defining the range of soil types that exist. Strongly leached Eluviated Dystric Brunisols are found where crystalline intrusive rocks (Cassiar batholith) are predominant in northern ranges of the ecoregion. In areas of sedimentary and metamorphic rocks, and at lower elevations, Orthic Eutric Brunisols develop on sandy loam moraine or on coarse colluvium (Fig. 178-3). Soils formed under subalpine fir forests at or near treeline tend to have thick accumulations of forest floor organic layers; if they are more than 40 cm thick, they are classified as Typic Folisols.

Much of the ecoregion is above treeline. The soils of the alpine zone are acidic and often show evidence of permafrost through cryoturbation as Turbic Cryosols and patterned ground formation. Permafrost is common on north-facing slopes and under bog complexes, particularly at higher elevations. Turbic Cryosols are the common soil formed on north-facing slopes. Occasionally, Organic Cryosols are found in peat plateau wetlands on the Nisutlin Plateau.

VEGETATION

Much of the Pelly Mountains Ecoregion lies above treeline, which is between 1,350 and 1,500 m asl. Shrub and dwarf shrub tundra dominate the vegetation at higher elevations. Coniferous, and sometimes mixed, forests mantle the slopes below 1,350 m asl.

There appear to be differences in the vegetation as one travels from south to north across the ecoregion. Porsild (1951) noted a floristic break between the vegetation of the granitic intrusions that form the core of this ecoregion and the often calcareous Paleozoic rocks to the east. Also, in the northern part of the ecoregion, black spruce is common on cool wet sites and paper birch is a significant component of the canopy. These two species are much less frequent in the south.

White spruce is the dominant tree species in the ecoregion. White spruce–feathermoss forests occupy more mature sites on most soils, while white spruce–lichen is the most common forest type on well and rapidly drained soils (Fig. 178-4). Throughout most of the ecoregion, white spruce is found with pine and aspen following fire. The groundcover on these sites usually contains a significant *Peltigera* lichen, ground shrub and grass component. Further north, white spruce is found on warmer sites, often mixed with subalpine fir or black spruce. Where the canopy is denser, the groundcover is feathermoss and a shrub layer of Labrador tea is common. Where the trees are less dense, a shrub birch, ground shrub — kinnikinnick, lingonberry and twinflower — and lichen understory is common.

Figure 178-4. This open canopy spruce–lichen forest grows where sandy, well-drained Eutric Brunisols, north of Wolf Lake, hold little soil moisture. Soil organic matter accumulation is limited due to frequent removal by hot forest fires. This area is winter habitat for the Wolf Lake caribou herd.

Pine may regenerate after fire, as along the Rancheria River, but in many cases willows and aspens are the first species to colonize burned areas, followed several years later by pine and spruce (Porsild, 1951).

Black spruce occupies cooler wet sites on the valley floors and north-facing slopes. Black spruce is much less common in the south part of the Big Salmon Range and the Cassiar Mountains, and restricted to wetland habitats.

In the north part of the ecoregion, subalpine fir is common between 750 and 1,400 m asl. Here, it is often found in mixed stands with white or black spruce. In the remainder of the ecoregion, fir is confined to alpine valleys between 1,200 and 1,400 m asl. Dense stands of fir common on north-facing slopes are underlain by feathermoss. As the trees become sparser with increasing elevation and exposure, krummholz growth form is common and the abundance of shrub birch and lichen increases.

Shrub birch dominates the subalpine above subalpine fir, and in the cool, well-drained valley floors where cold air drainage restricts tree growth (Fig. 178-4). Shrub birch on drier sites is associated with lichen, grass and lingonberry, and on wetter sites with willow, horsetail, shrubby cinquefoil, grass and moss.

Mountain summits composed of granitic rocks are usually dry lichen heath. *Dryas integrifolia*, *D. octopetala*, lichen (dominantly *Cetraria* spp., *Alectoria*, *Thamnolia vermicularis*), grasses (*Hierochloe alpina*, *Poa* spp.) and ground shrubs are the most common species found. In contrast, sedimentary rocks at high elevations are dominated by *Salix reticulata*, dryas and other forbs. Alpine meadows or flower gardens develop in moist alpine locations, commonly associated with non-porous granitic rocks that cause restricted drainage or persistent snow patches.

WILDLIFE

Mammals

The Pelly Mountains are home to Stone sheep and several herds of woodland caribou including the Pelly, Wolf Lake and Little Rancheria herds (Farnell and MacDonald, 1987, 1990). The Pelly herds have not been surveyed but are believed to number about 1,000 (2001). The Wolf Lake herd numbered 1,400 in 1998, and the Little Rancheria herd 1,000. The Wolf Lake herd is thought to be the most naturally regulated herd in the territory (R. Farnell, pers. comm., 2002). The Finlayson herd, 4,100 strong in 1999, ranges into the eastern Pelly Mountains (Farnell and MacDonald, 1989). Moose and caribou densities were elevated in the 1990s following intensive management, including wolf population control, on the Finlayson caribou range. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Birds

The northeast side of this ecoregion follows the Tintina Trench, one of the major flyways for migratory birds through the Yukon. Sandhill Cranes move over the Pelly Mountains and along the Tintina Trench during migration (Theberge *et al.* [editors], 1979). Canada Goose and Common Merganser breed in small numbers along rivers. Wetlands provide breeding habitat for Red-throated and Common Loons, Horned and Red-necked Grebes, small numbers of Trumpeter Swan, American Widgeon, Mallard, Northern Shoveler, Green-winged Teal, Ring-necked Duck, Bufflehead, and goldeneyes (Johnston and McEwen, 1983; McEwen and Johnston, 1983; Nixon *et al.*, 1992). Small influxes of dabbling ducks such as Northern Pintail, diving ducks such as scoters and Long-tailed Duck, and other migrants such as Pacific Loon, Horned Grebe, swans, and Greater White-fronted and Canada Geese (Johnston and McEwen, 1983; McEwen and Johnston, 1983) are seen on the wetlands during spring and fall migrations.

Rivers and wetlands also support Harlequin Duck; Osprey; Bald Eagle; Peregrine Falcon; Semipalmated Plover; Lesser Yellowlegs; Solitary Sandpiper; Spotted Sandpiper; Common Snipe; Red-necked Phalarope; Bonaparte's, Mew, and Herring Gulls; Arctic Tern; Belted Kingfisher and American Dipper (Johnston and McEwen, 1983; McEwen and Johnston, 1983; Department of Renewable Resources, 1994). Songbirds breeding in riparian shrubs and adjacent forests include Alder Flycatcher, Yellow Warbler, Northern Waterthrush, Common Yellowthroat, Wilson's Warbler, Savannah Sparrow, Lincoln's Sparrow, Red-winged Blackbird, and Rusty Blackbird (Johnston and McEwen, 1983; McEwen and Johnston, 1983). Tree, Violet-green, Bank, Cliff, and Barn Swallows breed and forage near lakes, ponds, marsh, rivers and forest edges (Johnston and McEwen, 1983; McEwen and Johnston, 1983).

Winter inhabitants of spruce and mixed forests include Spruce Grouse, Great Horned Owl, Gray Jay, Common Raven, Boreal Chickadee, Red-breasted Nuthatch, Pine Grosbeak, White-winged Crossbill, and Common and Hoary Redpolls (Rand, 1946; Johnston and McEwen, 1983). In summer, raptors such as Sharp-shinned and Red-tailed Hawks are common inhabitants of these forests (Johnston and McEwen, 1983). Olive-sided Flycatcher, Western Wood-Pewee, Ruby-crowned Kinglet, Gray-cheeked Thrush, Hermit Thrush, Varied Thrush, Yellow-rumped and Blackpoll Warblers, and Dark-eyed Junco are some of the migrants that come to these forests to breed (Rand, 1946; Johnston and McEwen, 1983). Deciduous and mixed forests on floodplains and south-facing slopes are used by breeding Yellow-bellied Sapsucker, Hairy Woodpecker, Least Flycatcher, and Warbling Vireo (Johnston and McEwen, 1983). Songbirds found in all forests include Swainson's Thrush, American Robin, Yellow-rumped Warbler, and Dark-eyed Junco (Rand, 1946). Forest edges and other open areas provide suitable habitat for breeding and foraging Common Nighthawk, Northern Flicker, Say's Phoebe, Orange-crowned Warbler, Chipping Sparrow, and Fox Sparrow (McEwen and Johnston, 1983).

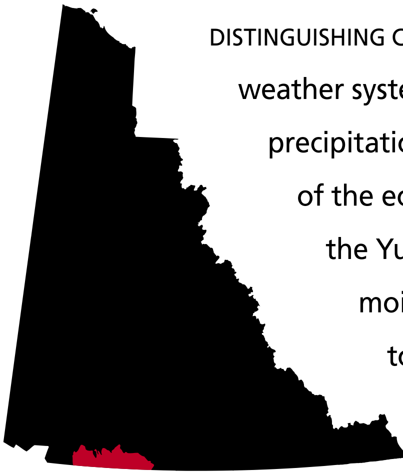
Subalpine shrubs and trees provide breeding habitat for Willow Ptarmigan, Dusky Flycatcher, Townsend's Solitaire, and American Tree, White-crowned, and Golden-crowned Sparrows (CWS, Birds of the Yukon Database).

Mountain ridges and cliffs in the extensive alpine areas support Golden Eagle, White-tailed Ptarmigan and Gray-crowned Rosy Finch (Department of Renewable Resources, 1994). Rock Ptarmigan, Horned Lark, and American Pipit breed in drier, lichen covered tundra (Canadian Wildlife Service, unpubl.).

Yukon Stikine Highlands

Boreal Cordillera Ecozone

ECOREGION 179



DISTINGUISHING CHARACTERISTICS: The ecoregion is heavily influenced by Pacific maritime weather systems, producing relatively moderate temperatures and enough precipitation to support scattered alpine glaciers. In the British Columbia portion of the ecoregion, a tributary stream to the Atlin River is deemed the source of the Yukon River. Forest vegetation does not experience the temperature and moisture stresses common elsewhere in southwestern Yukon. Adapted to steep terrain and high snowfall, mountain goats reach their highest Yukon population densities here.

C. Kennedy, Yukon Government

Figure 179-1. In the Boundary Ranges along the British Columbia–Yukon border, high precipitation, mild winters and lots of snow produce robust forests below 850 m elevation. Tree line shown here near Rainy Hollow along the Haines Road is at 1200 m elevation. These ranges support alpine glaciers.

APPROXIMATE LAND COVER
boreal/subalpine coniferous forest, 35%
boreal mixed forest, 10%
alpine tundra, 35%
alpine rockland and glaciers, 15%
lakes, 5%

TOTAL AREA OF ECOREGION IN CANADA
24,250 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
7,028 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
1%

ELEVATIONAL RANGE
460–2,700 m asl
mean elevation 1,270 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Coast Mountains Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Northwestern portion of **Northern Cordilleran Forests** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Yukon Stikine Highlands Ecoregion is part of a larger ecoregion that extends south into British Columbia. In the Yukon, it consists of the Boundary Ranges (Coast Mountains) and the Alsek Ranges (St. Elias Mountains) (Mathews, 1986; Bostock, 1948; Hughes, 1987b). The boundary of the ecoregion conforms approximately to the northern boundary of the Coast Mountains. This boundary varies from map to map due to the broad transition area from mountains to plateau.

These rugged mountain ranges support glaciers at higher elevations and are dissected by deep valleys. The relief is usually 900 to 1200 m between the broad summit areas and the valley floors lying between 760 and 900 m asl. The Tatshenshini River valley (Fig. 179-1), the lowest elevation in the southern Yukon, lies less than 450 m asl where it crosses into northern British Columbia. The highest point in the ecoregion, 2,700 m asl, is in the Alsek Ranges between the Alsek River and the upper reaches of the Tatshenshini River. The highest mountain in the Boundary Ranges, 2,522 m asl, is east of Kusawa Lake. Numerous other peaks are greater than 2,100 m asl.

Most of the Boundary Ranges drain via the Takhini, Watson and Wheaton rivers of the Yukon River system. Kusawa and Bennett lakes are the largest in the ecoregion. Other lakes include Rose and Primrose lakes. In the Alsek area, which drains via the Tatshenshini and Alsek rivers to the Pacific, Mush and Bates lakes are the only large waterbodies in this portion of the ecoregion.

BEDROCK GEOLOGY

Unlike the elongated British Columbia portion of this ecoregion, which generally coincides with the metasandstone of Nisling subterrane of Yukon–Tanana Terrane, the Yukon portion extends westward across four northwest-trending terranes. The rock types, age range, and origin contrast greatly between the terranes; only the adjacent Yukon Southern Lakes Ecoregion displays as great a diversity of rocks and structures.

The regional distribution of rock types are shown on 1:250,000 scale maps by Wheeler (1961), Kindle (1953) and Campbell and Dodds (1982b). More detailed maps exist for certain areas (referenced below) and a compilation by Gordey and Makepeace (compilers, 2001) shows updated interpretations. The Cordilleran context of the terranes is discussed in Gabrielse and Yorath (editors, 1991) and in the "Geologic Framework" introductory section of this report.

Granitic intrusions are exposed over about 60% of the ecoregion, chiefly in the Coast Plutonic Complex. In the east lies Stikinia and pendants of Nisling subterrane of Yukon–Tanana, while the Gravina–Nutzotin belt, a sliver of Wrangell terrane (Wrangellia), and eastern Alexander terrane form the western quarter. The rocks are summarized below in similar order.

Stikinia, between Carcross and the Primrose River, contains three sub-circular volcanic cauldron complexes that underlie highlands on Montana Mountain (Hart and Radloff, 1990), around the West Arm of Bennett Lake (Lambert, 1974), and Mount Skukum (Pride, 1985). Each contains cliff bands and pinnacles of dark, fine-grained andesite and dacite flows and breccia. Steep faults separate the volcanics from older sandstone, conglomerate of Jurassic Laberge Group, and augite porphyritic basalt and limestone of Upper Triassic Lewes River Group, which define Stikinia.

From Primrose River westward to the Tatshenshini River, bare rock and rubble-strewn mountains consist of grey, coarsely crystalline biotite granodiorite of the Coast Plutonic Complex (Fig. 179-2). Approximately 20% of the area is quartz–mica schist and micaceous quartzite of Yukon–Tanana Terrane, in what are termed pendants, surrounded by granitic rocks. The largest pendants lie east of Kusawa and Dezadeash lakes. Their margins are typically rusty and thermally hardened. Large expanses of plutonic rock are criss-crossed by lineaments and slots where joints formed by cooling have been preferentially plucked by glacial and fluvial erosion.

West of the Haines Highway, the Auriol and Dalton ranges are underlain by conglomerate, shale, sandstone, chert and minor coal seams of the Lower Cretaceous Dezadeash Formation, an overlap assemblage in Gravina–Nutzotin belt. The Shorty Creek pluton consists of granodiorite that is 106 million years old (Dodds and Campbell, 1988).

Between the Dalton, a south extension of the Denali or Shakwak system, and Duke River faults,

Figure 179-2. Alpine tundra and rockland make up approximately half the area of the ecoregion and are subjected to strong winds and cloud cover. Black leaf lichen *(Umilicaria sp.)* thrives on the silica-rich bedrock. North-facing cliffs result from plucking by alpine glaciers as recently as the Little Ice Age. Blond, lichen-free areas indicate recession of semi-permanent snow patches during the last century.

which are both in wide, north-trending valleys, is a 15 km wide strip of Wrangellia terrane containing weakly metamorphosed volcanic and sedimentary rocks, the Carboniferous to Permian Kaskawulsh Group, intruded by the elongate Mount Beaton quartz–diorite pluton. Southwest of Bates Lake is a significant accumulation of sandstone, conglomerate and mudstone of Upper Oligocene Amphitheatre Formation (Ridgeway *et al.*, 1992). Northeast of Mush Lake are basalt and andesite flows of the Miocene Wrangell lavas (Souther and Stanciu, 1975).

At the west edge of the ecoregion, in the Alsek Ranges and on Goatherd Mountain, are amphibolite, siliceous and micaceous schist of the Carboniferous to Permian Kaskawulsh Group (Campbell and Dodds, 1978). These rocks are part of Alexander Terrane. They are intruded by the Alsek and Shaft Creek plutons which are 130 Ma (Dodds and Campbell, 1988).

The eastern quarter of the ecoregion has significant mineral potential. Quartz veins containing gold, silver and antimony mineralization have been mined at Mount Skukum (MacDonald, 1990) and Montana Mountain (Roots, 1981). The Wheaton River area also contains many metallic mineral showings that are detailed in Hart and Radloff (1990). In contrast, the Coast Mountains have few mineral occurrences. The Station Creek volcanics in Wrangellia host copper, zinc and lead in quartz veins, and picrolite asbestos is found on islands in Bates Lake. Placer gold has been mined from Squaw (Dollis), Beloud, Sugden and Shorty creeks, and native copper nuggets, probably derived from Wrangell lavas, are found in Beloud Creek.

SURFICIAL GEOLOGY AND GLACIAL HISTORY

This ecoregion has been extensively glaciated, and its west-central portion supports modern glaciers. Clusters of cirques, often occupied by modern glaciers, are found in the Boundary Ranges and in Kluane National Park. Neoglacial and Little Ice Age moraines are only a short distance from the cirques in most valleys.

Most of the surficial materials and morphology were produced by glaciers emanating from the St. Elias Mountains, eastern Coast Ranges and the Cassiar lobe of the Cordilleran Ice Sheet (Jackson *et al.*, 1991) during the McConnell Glaciation, about 23 ka (Klassen, 1987; Jackson and Harington, 1991). These glaciers moved generally north–northwestward, and crossed Dezadeash Valley to cover most of the Aishihik area. Extensive glacial lakes were formed during deglaciation.

The southern shores of Glacial Lake Champagne (Kindle, 1953) impinged the north side of this ecoregion. This lake, formed when the glaciers had retreated to the intermontane valley between Kluane and Ruby ranges, extended along the Shakwak Trench to the southeast, and may have extended east to the Takhini River and south of Whitehorse (Wheeler, 1961). Well-defined shorelines along the Dezadeash and Takhini rivers and tributaries reach up to 1,280 m in elevation. A spectacular ice contact delta complex was deposited at the same elevation at the north end of Kusawa Lake. Glacial Lake Champagne occupied the areas of what is now Kusawa Lake valley. Minor and major deltas are found on the western side at the mouth of Bear Creek, on the south side on Tatshenshini, Klukshu and Takhanne rivers, and at the mouths of Primrose and Takhini rivers to the east.

Continued glaciation led to impoundment of Glacial Lake Carcross (Wheeler, 1961) by glaciers to the south of the Yukon–British Columbia border and by glaciers occupying the upper Wheaton and Watson valleys to the west. Shorelines located up to 760 m asl can be found along Bennett Lake, as well as along the Wheaton, Watson and nearby valleys (Wheeler, 1961; Morison and Klassen, 1991). Other minor glacial lakes were also formed as the glaciers retreated from the area.

CLIMATE

This ecoregion consists of four major south–north valleys that affect movement of weather systems: the Alsek River, the Haines Road Corridor, Kusawa Lake and the Bennett–Tutshi Lakes. The main orographic lift of maritime air and resultant heavy precipitation occurs to the south of this ecoregion in British Columbia and southeast Alaska.

This ecoregion is near enough to the Pacific Ocean to receive moderate amounts of precipitation with annual amounts of 300 to 500 mm. This precipitation is lightest from February through May and heaviest in the fall and early winter. This precipitation is generally snow from October to May, as well as at elevations above 2,000 m throughout most of the year (Fig. 179-1).

Mean annual temperatures are near –2.5°C, although seasonal temperatures show the effects of elevation. During January, the mean temperatures are near –25°C in the lower valley floors as compared with nearly –18°C over higher elevations. Short midwinter thaws can occur in the lower valleys. By July, usually the warmest month, the lower valleys have mean temperatures near 12°C decreasing to 5°C over the higher terrain. Extreme temperatures can range from –45 to 35°C in the lower valleys and from –30 to 15°C over higher terrain. Frost can occur at any time of the year but is least frequent in July.

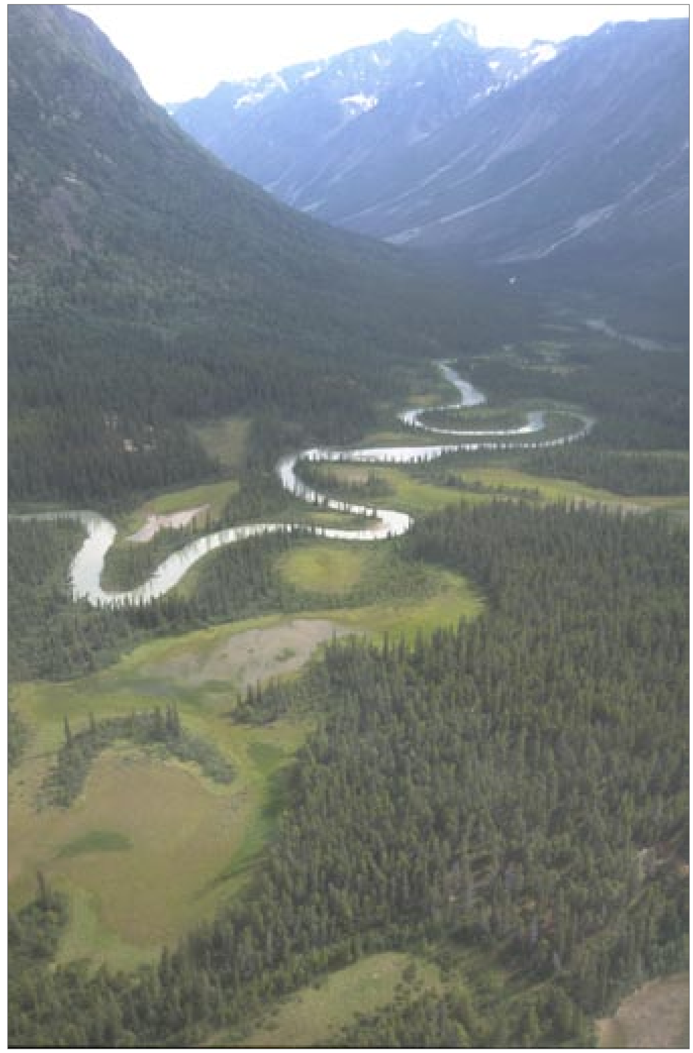
Winds are moderate to light, but can frequently reach gale force strengths in north–south oriented valleys. These gale force winds are most common from the fall through spring and occasionally reach destructive speeds, particularly from a southwesterly direction.

A representative climate station at lower elevations is Carcross, but this site receives less precipitation than most areas in this region. Precipitation amounts are more similar to those indicated at Dezadeash, Yukon, and Mule Creek, British Columbia Precipitation amounts may be up to 50% greater over higher terrain.

HYDROLOGY

The ecoregion drains the northern- and eastern-facing slopes of the Coast Mountains (Boundary Ranges). Because the ecoregion is a high altitude source region, and because of its relatively small size, there are no large representative streams within its boundaries, though a short reach of the Alsek River forms the western border. At the western limit, the ecoregion straddles the divide between the Alsek and Yukon river drainages. Major intermediate and smaller streams within the Alsek drainage include the Tatshenshini, Klukshu and Bates rivers. Major intermediate and smaller streams within the Yukon drainage include the upper Takhini, Primrose, Wheaton and Watson rivers.

Although glacier coverage of the Yukon portion of the ecoregion is small at 1.42% of the total area, the hydrologic response is dominated by glacier melt contributions. Glacier coverage, including the Llewellyn Glacier, is significantly greater within the British Columbia portion of the ecoregion. Also within the ecoregion is a small, unnamed tributary of the Atlin River, originating at the base of the Llewellyn Glacier, which has been identified as the source of the Yukon River (Parfit, 1998). The source is defined as the longest tributary of the Yukon River upstream of its confluence with the Teslin. The ecoregion has relatively high lake coverage at 4.5%. Major lakes include Bennett and Kusawa, while smaller ones are Primrose, Rose, Takhini, Mush and Bates. Wetland coverage is relatively small at 0.32% of the total Yukon area (Fig. 179-3).



J. Meikle, Yukon Government

Figure 179-3. The Hendon River meanders across its floodplain, indicating less sediment transport than in braided streams, such as the nearby Kusawa and Primrose rivers. Former oxbows are now sedge fens. Nearby ridges support white spruce and dwarf birch. Mature white spruce cloaks the lower slopes. Avalanche tracks are visible up valley.

There are four representative (active and historical, continuous and seasonal) hydrometric stations within the ecoregion: Tatshenshini, Takhanne, Wheaton and Watson rivers. Though glaciers are not present throughout, hydrologic response within the ecoregion is dominated by characteristics typical of a glacierized system. Annual streamflow within these systems is characterized by a rapid increase in discharge in May due to snowmelt at lower elevations, rising to a peak in July or August due to high elevation snowfield and glacier melt. In non-glacierized systems, peak flows occur in June as a result of snowmelt inputs. Because most stream channels are steep and relatively short, streamflow response tends to be rapid and flashy. On smaller streams approximately 40% of the annual maximum flows are due to intense summer rainstorm events. Some small steep streams are susceptible to mudflows triggered by these summer rainstorms. Mean annual runoff is moderately high and variable with values ranging from 130 mm in some non-glaciated basins to 500 mm in glaciated basins with an ecosystem mean of 317 mm. Mean seasonal and summer flows are moderately high with values of 21 X 10^{-3} and 17 X 10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are moderately low and moderate with values of 63 X 10^{-3} and 42 X 10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March or earlier with the relative magnitude higher than many other ecoregions due to higher winter temperatures and subsequently greater groundwater contributions.

The mean annual minimum and mean summer minimum flows are relatively high with values of 1.7 X 10^{-3} and 6.9 X 10^{-3} $m^3/s/km^2$, respectively.

PERMAFROST

Permafrost is sporadic in the valleys of the Yukon Stikine Highlands Ecoregion, though it occurs regularly at high elevations. Valleys that act as conduits for the passage of maritime air often receive abundant snowfall in winter. Permafrost is rarely encountered under such conditions. Brown (1967) did not find frozen ground along the Haines Road and it is rare along the Klondike Highway south of Carcross (Public Works Commission, 1986). Valleys in the rain shadow of the Coast Mountains are dry and sufficiently warm in summer to prevent permafrost development at most sites (EBA, 1988b). Localized perennially frozen ground has been reported in moist locations (Horel, 1988b).

At higher elevations in the ecoregion, a full suite of alpine periglacial features occur, with well-developed solifluction lobes on hills, frost-shattered bedrock outcrops, patterned ground, and stone nets and stripes on flatter terrain. There are few reports on ground ice in the Yukon portions of this ecoregion, including those for road construction and maintenance, however, rock, debris-covered, and cirque glaciers are found on some north-facing aspects, and perennial snowbanks in places.

SOILS

Soil development reflects the relatively mild, humid climatic conditions of the ecoregion and its steep, rugged topography. Most of the soils are developed on mixed colluvium and moraine materials within steep mountain valley systems. Precipitation and topographic relief tend to increase southward toward the British Columbia border. Eutric and Dystric Brunisols are the predominant soils. In alpine environments, Sombric Brunisols with well-developed Ah horizons can be found.

In an ecological survey along the northern extent of the ecoregion, Oswald *et al.* (1981) reported Eutric Brunisols on a variety of parent materials under predominantly boreal forest vegetation. In adjacent British Columbia, Luttmerdig *et al.* (1995) described slightly more humid conditions and the development of Dystric Brunisols and sporadic Humo–Ferric Podzols. These later soils are not known to occur in the Yukon portion of the ecoregion, except for isolated localities on granitic bedrock in alpine environments near the headwaters of the Takhini River.

Permafrost is sporadic in the ecoregion and Cryosols are not common except in poorly drained portions of alpine environments where patterned ground is common. Generally, soil temperatures remain relatively warm through the winter under heavy snow pack conditions. Although there are a few small alpine glaciers in the ecoregion, these are not associated with extensive permafrost. Where permafrost does occur, active layers are often too thick for the soils to be classified as Cryosols.

Wetlands are not a dominant feature of the ecoregion, being confined to some of the alluvial landforms along the Takhini, Primrose, Tatshenshini and Alsek river valleys. Most of the soils are classified as Humic Gleysols or occasionally as Typic and Terric Mesisols in fen wetlands with over 2 m of peat accumulation (Fig. 179-3).

VEGETATION

The vegetation of the Yukon Stikine Highlands Ecoregion reflects the great variation between alpine summits and moist forested valley floors. Much of the area lies above treeline (around 1,200 m asl). Because of the coastal influence — greater winter snowfalls, more moderate winter temperatures, and lack of permafrost in the valleys — the vegetation does not suffer the moisture stress of the ecoregion to the east. Coniferous and some mixed forests dominate the valley bottoms (Fig. 179-1), grading to shrubs in the subalpine and dwarf shrub and lichen tundra above 1,350 m asl (Fig. 179-2).

White spruce is the dominant tree species in the lowlands, often with an understory of feathermoss and some upland surfaces (Oswald *et al.*, 1981). Labrador tea and willow are common shrubs. On warmer sites, white spruce is often mixed with trembling aspen. These sites are dominated by a shrub understory of lingonberry, kinnikinnick, and twinflower and lichens. Taller shrubs include soapberry, rose, willow, and high-bush cranberry. Balsam poplar is common on margins of lakes and streams, and along roadsides. It is often mixed with white spruce on floodplains. Lodgepole pine often occurs on burned areas in the eastern part of the ecoregion. Paper birch is occasionally found in mixed stands on moister sites.

In the subalpine, white spruce and sometimes subalpine fir are found with shrub birch and willow. Fir is found in the subalpine, but is restricted to eastern portions of the ecoregion. Subalpine valleys subject to cold air drainage often have spruce or fir along the valley walls while the valley floor and upper slopes are dominated by shrub birch and willow associated with ericaceous shrubs, graminoids, moss, herbs and lichen.

Alpine areas cored by granitic rocks are sparsely vegetated by lichen, ericaceous shrubs, and prostrate willows.

WILDLIFE

Mammals

The ecoregion exhibits a coastal climatic influence on flora and fauna. The highest densities of mountain goats in the Yukon are found here (Barichello *et al.*, 1989b). The Ibex woodland caribou herd inhabits the eastern section of the ecoregion (Fig. 30). It is small and fragmented, numbering about 450. The herd is exposed to predation by a large number of wolf packs (R. Farnell, pers. comm., 2002). Moose, Dall sheep, wolves, wolverine and black bear are all common (Fig. 179-4). Grizzly bear reach their highest density in the Yukon, estimated at one bear per 45 km^2. Isolated populations of marten occur in climax forests, being most common at higher elevations.

The tundra shrew, once believed to be restricted to the northern Yukon, has been found within the ecoregion in British Columbia (Nagorsen, 1996) and therefore, probably occurs in the Yukon portion of the ecoregion. Bats have received little attention in the Yukon, and species other than the little brown myotis may yet be found. Bat species found near the Yukon include the long-legged myotis, Keen's long-eared myotis, the silver-haired bat and the big brown bat. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

The known northern limit of the Columbian spotted frog occurs in this ecoregion (Fig. 179-5).

Birds

In early spring, open water at the outlet of Bennett Lake provides a staging area for swans, diving ducks, and some dabbling ducks (Theberge *et al.* [editors], 1979). Large lakes such as Bennett and Kusawa provide breeding and staging habitat for Pacific and Common Loons, Common Merganser, Bonaparte's, Mew, Herring Gulls, and Arctic Tern, (Godfrey, 1951; Soper, 1954; Department of Public Works and U.S. Department of Transportation, 1977). Belted Kingfisher and Bank Swallow nest in the mud banks of these lakes. Shallower lakes and wetlands support Mallard, Northern Pintail, and Green-winged Teal (Soper, 1954).

W.J. Schick

Figure 179-4. Some of Yukon's best habitat for Dall sheep *(Ovis dalli dalli)* occurs at the northern or lee edge of this ecoregion. In the steeper terrain to the south where snowfall is greater is the highest density of mountain goats *(Oreamnos americanus)* in Yukon.

L. Mennell

Figure 179-5. The Columbia spotted frog *(Rana luteiventris)* has been observed at two locations along the West Arm of Bennett Lake. It is isolated from other populations to the south and is at its northern limit in the Yukon portion of this ecoregion.

Salmon spawning streams, such as the Takhanne River, attract breeding pairs of Bald Eagle with especially high numbers in the autumn (Department of Public Works and U.S. Department of Transportation, 1977). Swift mountain streams provide habitat for Harlequin Duck and American Dipper (Department of Public Works and U.S. Department of Transportation, 1977). Wandering Tattler breed at the heads of these mountain streams while Semipalmated Plover breed on the sparsely vegetated alluvium of larger drainages (Department of Public Works and U.S. Department of Transportation, 1977). Orange-crowned Warbler, Yellow Warbler, Common Yellowthroat, Wilson's Warbler, Fox Sparrow, and Lincoln's Sparrow breed in thickets bordering streams, bogs, and moist meadows (Godfrey, 1951).

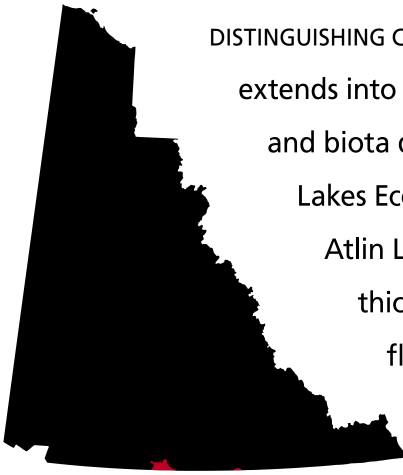
Low elevation coniferous forests support year-round residents such as Northern Goshawk, Spruce Grouse, Great Horned Owl, Northern Hawk Owl, Three-toed Woodpecker, Gray Jay, Common Raven, and Boreal Chickadee (Godfrey, 1951; Department of Public Works and U.S. Department of Transportation, 1977). These are joined in the breeding season by Sharp-shinned Hawk, Merlin, Olive-sided Flycatcher, Western Wood-Pewee, Golden-crowned and Ruby-crowned Kinglets, Swainson's Thrush, Varied Thrush, and Yellow-rumped and Blackpoll Warblers (Godfrey, 1951). Scattered pockets of deciduous forest provide breeding habitat for Ruffed Grouse and Northern Flicker (Godfrey, 1951). Say's Phoebe, American Robin, and Chipping Sparrow (Theberge, 1974) use forest openings. Rufous Hummingbirds, rare visitors to the southern Yukon (Eckert *et al.*, 1998), also use openings, especially those with suitable flowering plants (Godfrey, 1951).

High densities of breeding Golden Eagle inhabit alpine and subalpine areas, and some overwinter in years of high prey abundance (Hayes and Mossop, 1983). Peregrine Falcon nest in localized areas of rock outcrops and cliffs, usually near wetlands (Theberge, 1974). The Coast Mountains represent the southern limit of nesting Gyrfalcon in North America; Willow, Rock, and White-tailed Ptarmigan provide their main prey base (Hayes and Mossop, 1983). Species that breed in subalpine shrubs include American Kestrel; Willow Ptarmigan; Wilson's Warbler; Brewer's, American Tree and Golden-crowned Sparrow; Dark-eyed Junco (Canadian Wildlife Service, unpubl.); Dusky Flycatcher; Townsend's Solitaire; and Common Redpoll (Godfrey, 1951; CWS, Birds of the Yukon Database). American Pipit, Savannah Sparrow and Horned Lark breed in tussock tundra of the extensive alpine plateaus along exposed ridges.

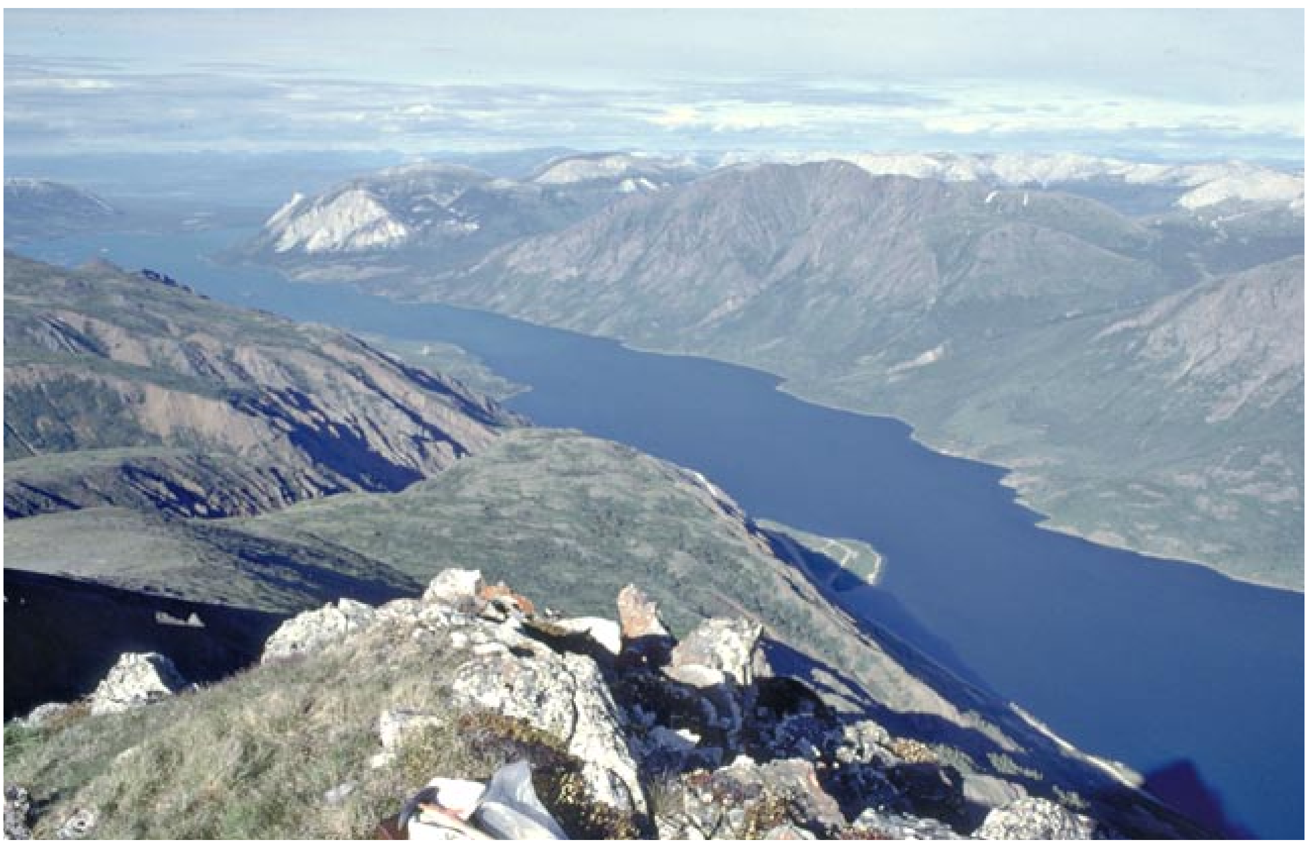
Boreal Mountains and Plateaus

Boreal Cordillera Ecozone

ECOREGION 180



DISTINGUISHING CHARACTERISTICS: This ecoregion, centred in northern British Columbia, extends into only two small areas in southern Yukon. In these, the landscape and biota differ little from the highlands of the neighbouring Yukon Southern Lakes Ecoregion. The relatively long and narrow arms of Tagish Lake and Atlin Lake reflect the northward flow of Pleistocene glaciers, as do the thick, well-drained deposits of sand and gravel remaining on the valley floors. Wetlands and subalpine forest support a diverse bird population, particularly during spring and fall.



C.F. Roots, Geological Survey of Canada

Figure 180-1. The Boreal Mountains and Plateau and adjacent Yukon Southern Lakes ecoregions have extensive areas of alpine tundra and remnants of an erosion surface at about 1700 m asl. This view is over Windy Arm of Tagish Lake looking northeast toward Lime Mountain.

APPROXIMATE LAND COVER
boreal/subalpine coniferous forest, 55%
alpine tundra, 35%
alpine rockland, 5%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
102,840 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
948 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
<1%

ELEVATIONAL RANGE
660–1,700 m asl
mean elevation 1,050 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Portion of **Coast Mountains Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Northwestern portion of **Northern Cordilleran Forests** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Boreal Mountains and Plateaus Ecoregion occupies a large block of north-central British Columbia; only two small projections enter southern Yukon. One of these surrounds and includes Tagish, Nares and Atlin lakes (in British Columbia portion of the ecoregion), and the other is a small part of the Swift River drainage, about 250 km to the east.

In the Yukon, the western part of ecoregion belongs to the Teslin Plateau and the eastern projection is part of the Nisutlin Plateau in the Cassiar Mountains (Mathews, 1986). Both are components of the Yukon Plateau, the large, diverse Northern Plateau and Mountain area described by Bostock (1948) and Hughes (1987b).

This is an area of tablelands of up to 1,700 m in elevation dissected by large valleys (Fig. 180-1). In the west part, the valleys are occupied by Tagish Lake (655 m) and Nares Lake (668 m), in the eastern part by the Swift River (less than 900 m), all of which are components of the Yukon River watershed.

BEDROCK GEOLOGY

The northern half of the ecoregion almost exactly coincides with the distribution of metamorphosed volcanic and carbonate rocks. The rocks in the two prongs of the ecoregion that lie within the Yukon are shown on 1:250,000 scale geological maps by Wheeler (1961) and Poole *et al.* (1960), with updated correlations by Gordey and Makepeace (compilers, 2001).

The northwestern prong of the ecoregion is part of Slide Mountain Terrane, which was thrust over adjacent Stikinia to the west (Gordey and Stevens, 1994a) in Middle Jurassic time (175 Ma), and subsequently faulted against Quesnellia to the east. In contrast, the eastern prong of the ecoregion is underlain by the Dorsey Assemblage (Stevens and Harms, 1995; Roots *et al.*, 2000) of Dorsey Terrane, which is separated from the granitic Cassiar batholith to the east by a major fault zone. Both terrane associations are summarized in the Overview section of this report, and in Gabrielse and Yorath (editors, 1991).

The northwestern prong includes tablelands surrounding Tagish Lake and islands within the lake. Abundant bedrock protrudes through thin soil cover. Cliffs and ridges on Lime Peak, White Mountain and Jubilee Mountain are light-grey dolostone and recrystallized bioclastic limestone of Horsefeed Formation, as well as black limestone and ribbon chert of Kedahda Formation (Monger, 1975). Both units contain Permian fusilinids, fossils that resemble concentric-cored kernels of wheat. These fossils are similar to those found in Japan and China, which indicates a West Pacific origin for these rocks. Dark-green amphibolite, or greenstone, of the Mississippian Nakina Formation, represents the underwater basaltic flows and breccia included in the Cache Creek Group. Where the Atlin Road crosses the British Columbia–Yukon border, there are outcrops of biotite–hornblende monzodiorite of the Middle Jurassic Fourth of July batholith (Mihalynuk *et al.*, 1992).

In the northeast prong of the ecoregion, subdued ground is underlain by argillite, phyllite, quartzite and chert. The edge of the ecoregion north of the Alaska Highway includes the rim of the 100-million-year-old Seagull batholith and interlayered chert and black slate, minor chert pebble conglomerate and a limestone band in which Pennsylvanian crinoids and conodonts have been found (Stevens and Harms, 1995). The valley of the Swift River also contains outcrops of relatively recent basaltic lava (Rancheria flows, about 6 Ma) which were extensively used in the Alaska Highway construction and stabilization projects.

Mineral potential is moderate in the Yukon portion of this ecoregion. Copper showings surround a small dunite lens on Jubilee Mountain; typically the surrounding altered carbonate hosts gold-bearing vein occurrences (e.g. Hart, 1996), and chromite, although there is no indication that this pod has any vertical extent. On Lime Mountain are showings of native copper in the altered volcanics, molybdenite in a small granitic plug and silver–gold vein occurrences. The Rancheria district contains numerous lead, zinc and silver vein occurrences. The eastern portion of this ecoregion lies immediately east of the Seagull Creek tin and tungsten district (Abbott, 1981a).

SURFICIAL GEOLOGY

The main sources of information for this section are Morison and Klassen (1991) and Klassen (1982b) who describe the surficial geology of the Yukon part of the ecoregion.

The surface deposits of this ecoregion are similar to those of the Southern Lakes Ecoregion. They are associated with the most recent Cordilleran ice sheet, the McConnell, believed to have covered the south and central Yukon between 26.5 ka and 10 ka. Most of the Yukon portion of the ecoregion was covered by the Cassiar lobe, which flowed towards the northwest from the Cassiar Mountains.

The distribution of Quaternary deposits in this area follows a general pattern. High elevation slopes are covered with colluvium or moraine veneer over bedrock. At high elevations, the exposed bedrock is weathered and frost-shattered.

A veneer of glacial till, as well as colluvial fans or aprons, covers most mid-elevation slopes. The general composition of the till matrix in adjoining map sheets (Jackson, 1994) indicates a wide range of sand and silt content (20 to 80%). Isolated lenses of ice-rich permafrost may be present on north-facing slopes. At high elevations the Quaternary sediments contain permafrost were overlain by thick organic deposits. Drumlins indicating a northerly ice flow are found on the west shore of Taku Arm.

Glaciofluvial sand and gravel terraces flank the valley sides and pitted or hummocky deposits of sand and gravel deposits line the bottom of some valleys (Fig. 180-2). Usually these deposits are free of permafrost and have stable surfaces, but may contain undesirable, weak lithologies for potential use as aggregate.

C.F. Roots, Geological Survey of Canada

Figure 180-2. A mosaic of lakes and ponds forms in the Jennings Lake valley in hummocky glaciofluvial materials deposited during deglaciation. These ice-contact deposits are composed of sands and gravels and are common in the larger valleys in the ecoregion.

Floods related to ice jams, snowmelt and summer rainstorms are possible hazards in lower reaches of most streams in the area. Because of this flood risk, the steep portions of alluvial fans have the potential to release mudflows and debris flows associated with rapid increases in water discharge.

GLACIAL HISTORY

This upland region was the source area for the part of the Cordilleran Ice Sheet that drained east toward the Mackenzie Valley and north into the Yukon River Basin (Ryder and Maynard, 1991). Uplands were subjected to intense glacial erosion, with the highest peaks sculpted into classical alpine landforms such as horns, arêtes and cirques. A single thin till mantles upland areas.

CLIMATE

The two portions of this ecoregion within the Yukon near Tagish Lake and Atlin Lake have a climate similar to the Yukon Southern Lakes Ecoregion. A climate station representative of the lower valleys of this area is Atlin Lake, British Columbia,

The eastern section near Swift River has a climate similar to the Pelly Mountains Ecoregion. A climate station representative of this section is Swift River, Yukon.

HYDROLOGY

Two small areas of the ecoregion protrude northward into the southern Yukon. The larger western portion is within the Western Hydrologic Region. It includes Tagish and Atlin lakes that are part of the upper Yukon River drainage. The smaller eastern portion is within the Interior Hydrologic Region and includes a portion of the upper Swift River, which drains into the Teslin River. The western portion of the ecoregion in the Yukon, which drains the western foot slopes of the Coast Mountains, has higher relief and subsequently higher runoff and peak flows, than the eastern portion that drains the Cassiar Mountains. Within British Columbia, the ecoregion contains many major streams including the Stikine and Dease rivers while the Yukon portion contains only smaller representative streams including the Swift and Tutshi rivers. The Atlin River is within this ecosystem; however, it is not representative of hydrologic response, because it includes glacier melt inputs from upstream of the ecosystem. A relatively large portion of this small area is water in several large lakes including Tagish and Atlin.

There are seven representative active, historical continuous, and seasonal hydrometric stations within the ecoregion: Wann, Fantail, Atlin, Swift and Tutshi rivers, and Pine and Partridge creeks. Annual streamflow is characterized by a rapid increase in snowmelt discharge to a peak in June, with secondary rainfall peaks later in the summer. Peak flow events on smaller streams may be generated by intense summer rain storm events. Mean annual runoff is the highest of all Yukon ecoregions with a range in values of 236 to 980 mm and an ecosystem mean value of 577 mm. Mean seasonal and summer flows are similarly the highest of all Yukon ecoregions with values of 39×10^{-3} and 36×10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are moderately high and relatively high with values of 92×10^{-3} and 78×10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during April, with the relative magnitude higher than other Yukon ecoregions due to the moderating influence of the Gulf of Alaska on winter temperatures and subsequent groundwater contributions. The minimum annual and summer flows are the highest of all Yukon ecoregions with values of 2.6×10^{-3} and 11×10^{-3} $m^3/s/km^2$, respectively. Only very small streams experience zero winter flows during cold winters.

PERMAFROST

Permafrost in the ecoregion is sporadic and the distribution is controlled mainly by elevation. Above an elevation of about 1,800 m, permafrost is likely continuous (Harris, 1986), but in valleys its occurrence depends on site wetness and the thickness of the organic layer. Isolated palsas have been reported (Tallman, 1973; Seppala, 1980), but overall, there is little permafrost in the valleys (Hoggan, 1992b). There is no permafrost at the Cassiar townsite at 1,060 m, but it is widespread at the abandoned asbestos mine at 1,820 m (Brown, 1967). Here, the thickness of the organic layer likely controls active layer development to a greater extent than elevation, as recorded by Harris (1987) in the Kluane Front Range.

There is extensive evidence of frost action on the plateaus of this ecoregion. Alley and Young (1978) describe well-developed blockfields, patterned ground, and frost boils from plateau surfaces, and solifluction lobes from mountainsides in southern Stikina Plateau. They also report ice-rich zones developed at depth in valley-bottom glaciolacustrine sediments.

SOILS

The soils in this ecoregion have formed under relatively mild and somewhat moist climatic conditions. Therefore, they tend to be well leached and show stronger chemical weathering than most other soils in the Yukon. The topography in the Yukon portion of this predominantly northern British Columbia ecoregion is mountainous. The predominant soil parent material is colluvium formed from the mixed lithologies present.

At higher elevations, above 1,500 m in the portion of the ecoregion around Tagish Lake, Regosols formed on talus from rock outcrops are common. Beneath extensive areas of alpine tundra vegetation, the soils are most commonly Orthic Turbic Cryosols and show evidence of patterned ground. This is the only environment where near-surface permafrost is common in the ecoregion. On mountain slopes, soils are formed under coniferous and mixed vegetation. Orthic, Eutric and Dystric Brunisols are the most common soil types of the area (Davies *et al.*, 1983a). The acidic Dystric Brunisols are most common at subalpine elevations, adjacent to the 60th parallel where precipitation is highest.

In the British Columbia portion of the ecoregion adjacent to Swift River, soils tend to be predominantly Dystric Brunisols formed on a landscape composed primarily of moraine and colluvium (Luttmerdig *et al.*, 1995) on the more subdued terrain of the Cassiar Mountains south of the Yukon border.

VEGETATION

The vegetation of the Boreal Mountains and Plateaus Ecoregion varies from boreal forest in the lowlands and valleys to subalpine shrublands and alpine tundra on the rolling plateaus and higher mountains (Davis *et al.*, 1983a).

Below treeline, white spruce dominates mature forests. Willow, soapberry, kinnikinnick, lowbush cranberry, crowberry and feathermoss are common understory species. Because of frequent fires, lodgepole pine and trembling aspen are also common in the forest canopy. Lodgepole pine is common on well-drained sites that have burned in the last 100 years. Aspen or mixed spruce and aspen forests cover southerly slopes. Balsam poplar may be found along creeks and lakeshores. On steep, south-facing slopes, stunted aspen grows with grass, sagewort, kinnikinnick and juniper; these species reflect the drought conditions of these slopes.

At higher elevations, subalpine fir is common in valleys around treeline, but shrub birch and willow, underlain by ericaceous shrubs and lichen, dominate most of the subalpine. Dwarf willow, *Dryas* spp. and ericaceous shrubs dominate the alpine areas.

WILDLIFE

Mammals

Mountain goats and Dall sheep, common in the Boreal Mountains and Plateaus Ecoregion in British Columbia, are absent in the Yukon portion. The Carcross and Atlin woodland caribou herds use the Tagish Lake and western Atlin Lake area (Fig. 30). The herds are small and fragmented, numbering about 300. They are exposed to predation by many wolf packs. Grizzly bears, wolves, wolverine, and lynx are common. Isolated populations of marten exist in climax forests, most commonly at higher elevations. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

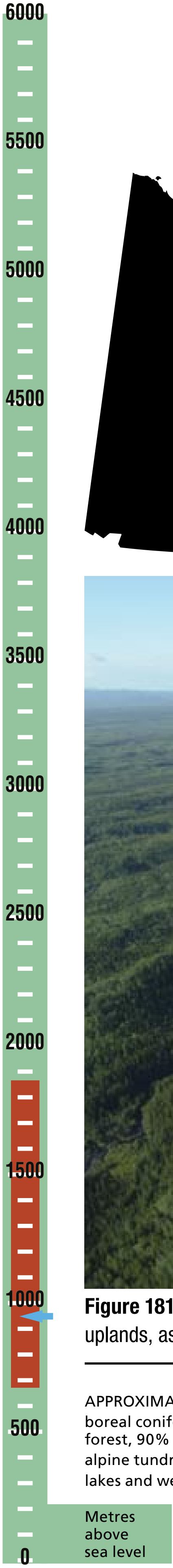
Birds

During migration, staging waterbirds and shorebirds occurring in wetland areas include Red-throated and Pacific Loons, Tundra and Trumpeter Swans, small numbers of geese, Northern Pintail, scaup, scoters, Bufflehead, and many shorebirds (Swarth, 1936; Dennington, 1985; Hawkings, 1994). Breeders include Common Loon; Mallard; Green-winged Teal; scaup; scoters; Barrow's Goldeneye; Red-breasted and Common Mergansers; Bald Eagle; Bonaparte's, Mew, and Herring Gulls; Arctic Tern; Semipalmated Plover; Killdeer; Lesser Yellowlegs; Solitary, Spotted and Least Sandpipers; and Belted Kingfisher (Swarth, 1936; Godfrey, 1951; Canadian Wildlife Service, 1979a; Nixon *et al.*, 1992). Common Snipe and Rusty Blackbird are common breeders in marshy areas (Swarth, 1936). Songbirds such as Yellow Warbler, Northern Waterthrush, Common Yellowthroat, and Savannah, Fox, and Lincoln's Sparrows nest in shrubby wetland areas (Godfrey, 1951). During the breeding season, Common Nighthawk and Tree and Cliff Swallows commonly forage over marshes, forest openings and lakes (Swarth, 1936). The rare Rufous Hummingbird is a regular summer visitor in open areas with suitable flowering plants, although breeding has not been confirmed (Godfrey, 1951).

Year-round residents of lowland forests include Northern Goshawk; Spruce Grouse; Great Horned Owl; Three-toed Woodpecker; Gray Jay; Common Raven, Black-capped, Mountain and Boreal Chickadees; and Pine Grosbeak (Swarth, 1936; Godfrey, 1951). In summer, resident species are joined by breeding Sharp-shinned and Red-tailed Hawks; Merlin; Olive-sided Flycatcher; Western Wood-Pewee; Ruby-crowned Kinglet; Yellow-rumped, Townsend's and Blackpoll Warblers; and Dark-eyed Junco (Swarth, 1936; Godfrey, 1951). Pockets of deciduous and mixed forests on warmer slopes provide breeding habitat for Ruffed Grouse, Northern Flicker, Hammond's Flycatcher, and Swainson's Thrush (Williams, 1925; Swarth, 1936; Soper, 1954). Red Crossbill and Pine Siskin also nest in these forests in some years (Swarth, 1936; Godfrey, 1951). Say's Phoebe, Mountain Bluebird, American Robin, and Chipping Sparrow share the shrubby forest openings that commonly occur in these valleys (Swarth, 1936).

Blue Grouse are year-round residents of the subalpine forest, joined by Willow Ptarmigan that move to lower elevations in winter (Swarth, 1936). Subalpine forests also provide breeding habitat for Townsend's Solitaire and Dark-eyed Junco, with Willow Ptarmigan, Alder Flycatcher, Dusky Flycatcher, Northern Shrike, Wilson's Warbler, American Tree, Brewer's, and Golden-crowned Sparrows occurring in shrubby areas (Clarke, 1945; Godfrey, 1951; Canadian Wildlife Service, unpubl.).

At higher elevations, resident species such as Rock and White-tailed Ptarmigan are joined in the breeding season by Golden Eagle, Horned Lark, American Pipit, and the coastal race of Gray-crowned Rosy Finch (Swarth, 1936; Sinclair, 1995).



Liard Basin

Boreal Cordillera Ecozone

ECOREGION 181

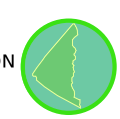
DISTINGUISHING CHARACTERISTICS: This ecoregion is an area of low hills separated by broad plains, surrounded by mountains and plateaus. The low elevation, moderate precipitation and relatively long, warm summers result in vigorous forest growth, most notably in the floodplains of the Liard, Meister, Frances, Hyland and Coal rivers. The extensive boreal forest of the Liard Basin includes prime habitat for moose, marten, snowshoe hare and lynx. Thousands of Sandhill Cranes migrate through the Liard Basin Ecoregion each spring and fall, following the Frances and Liard valleys.

J. Meikle, Yukon Government

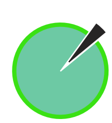
Figure 181-1. Lakes and eskers mark the location where stagnant McConnell glacial ice diverted the Coal River. Numerous uplands, as seen in the distance, occur within the ecoregion with elevations ranging from 1,200 to 1,800 m asl.

APPROXIMATE LAND COVER
boreal coniferous and mixed wood forest, 90%
alpine tundra, 5%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
34,100 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
21,113 km^2



ECOREGION AREA AS A PROPORTION OF THE YUKON
4%

ELEVATIONAL RANGE
580–1,890 m asl
mean elevation 950 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Equivalent to **Liard River Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Portion of **Northern Cordilleran Forests** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Liard Basin Ecoregion occupies the Liard Lowland (Mathews, 1986), Liard Basin (Hughes, 1987b) or Plain (Bostock, 1948) physiographic units, and the western portion of the Hyland Plateau. About two-fifths of the ecoregion extends south into British Columbia.

This ecoregion is an area of low hills separated by broad flats and surrounded on all sides by mountains and plateaus (Fig. 181-1). More than half of the ecoregion lies below 900 m but rounded hills of 1,200 m are common in the eastern part. Only a few high points in the central part of the ecoregion are over 1,500 m, the highest being 1,887 m.

BEDROCK GEOLOGY

This ecoregion is underlain by a thick mantle of unconsolidated glacial sands and gravel over Early Tertiary fluvial sediments. These sediments have been collectively called the Liard Plain (Klassen, 1987), through which protrudes bedrock on higher ground and in river canyons. Abundant rock is exposed east of the Frances River, west of Simpson Lake, and throughout the ecoregion east of Hyland River.

The geology is unusually complicated because major faults that splay northward juxtapose contrasting rock assemblages within the ecoregion. Areas of bedrock are shown on regional geology maps by Gabrielse (1967, 1968), Gabrielse and Blusson (1969) and Roots (1966). More detailed, though generally unpublished, mapping surrounds the major mineral occurrences, principally the Sa Dena Hes Mine (e.g. Abbott, 1981b), Macmillan, Quartz Lake, and MEL-JERI properties. Stream water characteristics and metal content of silt have been systematically analyzed throughout the western region (Friske *et al.*, 1994).

The Tintina Fault, with about 450 km of dextral offset in the last 100 million years, lies beneath the Liard Plain and trends parallel to the Liard River. Beneath the Frances River lies the Finlayson Lake Fault Zone. The Yukon–Tanana terrane lies between these faults. Across the faults to either side are slivers of Cassiar Platform, consisting of continental margin clastic and carbonate rocks. Further east are fault slices of ocean margin volcanic and ultramafic rocks; the eastern third of the ecoregion contains sedimentary rocks of the miogeocline. Current terrane interpretations are shown on the Yukon geological map compilation (Gordey and Makepeace [compilers], 2001).

General rock types across the ecoregion are described below, beginning in the east. East of Coal River, about 20 km north of the British Columbia–Yukon border and within the dominantly Proterozoic to Carboniferous strata, is an east–west boundary between dominantly shale rocks of the Meilleur embayment to the north and carbonate of the Macdonald Platform to the south. West of Coal River, most of the area is underlain by dark shale, slate, gritty quartzite and conglomerate of the Late Proterozoic to Cambrian Hyland Group. West of Hyland River, a narrow strip extending 40 km southwest from Stewart Lake contains dark-green serpentine, ultramafic and metabasaltic rocks. A distinctive rock (eclogite, composed of garnet–pyroxene–rutile–quartz) originating at great depth, is in two places here (Erdmer, 1987). Where ultramafic rock is incorporated into overlying soil, vegetation will be sickly or stunted by the high magnesium and lack of alkali minerals. Between this strip and Frances River lie reddish weathering chert, rusty black shale and dark-coloured sandstone, with a structural window to underlying argillite and phyllite on Mount Murray and Mount Hundere.

Gravel pits along the Robert Campbell Highway and polymictic conglomerates east of Simpson Lake contain metamorphic clasts and felsic volcanic rock derived from the west (Mortensen, 1997). Between the Frances and Liard rivers, rocks are dominantly schist and phyllite, with 200 m thick Mississippian limestone near Martin and Sambo lakes and in the Middle Canyon of Frances River. Sheared granite is exposed north of Tuchitua River and on Mount Murray. These rocks comprise the Yukon–Tanana Terrane in this area. Grey slate, phyllite, limestone and biotite schist southwest of Liard River comprise the western Cassiar Platform. In the valleys, these rocks are overlain by vesicular olivine basalt flows (about 6 Ma) exposed along and near the Rancheria River, and west of the Upper Canyon of Frances River.

Despite the few areas of exposed bedrock, the region has significant mineral potential. The Sa Dena Hes mine, 45 km north of Watson Lake, yielded zinc, lead and silver from rich deposits between a Cambrian limestone and phyllite. The lead, zinc and barite veins 115 and 75 km northeast of Watson

Lake, respectively, are the most extensively explored of several dozen vein occurrences in the eastern part of the ecoregion. Barite veins cut black shale and chert along the Liard River south of Watson Lake, and lignite to sub-bituminous coal south of Upper Liard, have the potential to be economic deposits.

The Coal River Springs issue along a north-trending fault and precipitate tufa on a ridge of Middle Devonian limestone (Fig. 181-2).

SURFICIAL GEOLOGY AND GEOMORPHOLOGY

Several geological reports and maps on surficial geology of this ecoregion are available: Dyke (1990a,b,c); Jackson (1986; 1993a,b; 1994); Klassen and Morison (1981); and Klassen (1982a). The following comments are derived from these maps and reports.

This part of the Yukon was also subjected to several glaciations since the late Tertiary, but the present surface deposits are from the last glaciation. Ice flow patterns in this region are indicated by the well-defined drumlins on the floor of the Frances, Liard and Hyland River valleys. They show that lobes of McConnell ice, which originated in the Logan Mountains (Dyke, 1990a), moved southwards through the Frances River valley, and from the Pelly and Cassiar mountains flowed east and north-eastwards in the southern part of the ecoregion.

In the alpine areas around Frances Lake, ridge crests and steep walls were modified by large-scale glacial erosion and periglacial and alpine processes. Other bedrock surfaces show little signs of erosion and are probably the remnant of preglacial surfaces.

Further south, high-elevation bedrock slopes and summits are usually covered by a veneer of colluvial moraines, thin moraines over bedrock, and weathered and mass-wasted bedrock. Till on lower slopes can be thicker than 30 m. This is a mixture of cobbly sand, silt and minor clay, which drains well to moderately well. In the Frances River Valley, a dark till results from the incorporation of black Devonian shale (Dyke, 1990a). Geochemically, most till units in the northern part of the ecoregion have a distinctive signature, due to the incorporation of short-travelled bedrock fragments. For example, the clay fraction from the shale-derived till shows a high background level of mercury (up to 100 ppb compared with 200 ppb in other till clay fractions). Tills associated with the Cretaceous monzonite and granodiorite, and with the Precambrian gneiss, have higher background concentrations of uranium than other till bodies (up to 20 ppb compared with 4 ppb in most other tills). Anomalies, usually expressed as high levels of cadmium, molybdenum, silver,

J. Meikle, Yukon Government

Figure 181-2. Coal River Springs are cool, tufa-producing springs. Tufa is a whitish precipitate of calcium carbonate forming the "terracettes" visible in this photo. The closed canopy boreal forest growing on the landscape surrounding the springs is typical of the ecoregion.

uranium, zinc, arsenic or lead, are identified in areas of known mineralization, and in the Frances River valley along the Robert Campbell Highway, as well as along the shores of Frances Lake (Dyke, 1991).

Glaciofluvial sand and gravel are found in several of the major valley floors (Fig. 181-1). The Frances and Yusezyu valleys in the north and the Liard, Rancheria, and Hyland river valleys in the south have significant gravelly deposits, in some cases as thick as 30 m (Fig. 181-3). In addition to ice contact and proglacial outwash, several less common features associated with ice margins are present in this area. Ice crevasse fillings are associated with esker ridges in several areas between Nipple Mountain and the east arm of Frances Lake.

As in most mountainous settings, glacial meltwater was dammed at some point during deglaciation and fine-grained glaciolacustrine sediments and beach deposits can be found in a few areas. Slumping of these sediments can be expected as the streams undercut their banks.

The floodplains of most large rivers, particularly the Hyland, Liard and Rancheria, encompass wetlands, many of which have thick peat deposits. Floods related to ice jams, snowmelt and summer rainstorms are possible hazards in lower reaches of most streams in the area (Dougherty *et al.*, 1994)

GLACIAL HISTORY

The surficial geology of the Liard Basin Ecoregion is dominated by till, glaciofluvial gravels and glaciolacustrine clay and silt deposited during the McConnell Glaciation in the Yukon (Bostock, 1966). Deposits from older glaciations are preserved in the subsurface below the Liard Lowland (Klassen, 1987).

During McConnell time, ice flowed into the ecoregion from the Pelly and Selwyn mountains to

J. Meikle, Yukon Government

Figure 181-3. Glaciofluvial deposits as deep as 30 m are common in the ecoregion. Stream erosion at the base of these deposits creates steep, unstable bluffs along the Coal River (shown here) and lower Hyland rivers.

the north and the Cassiar Mountains to the west (Dyke, 1990a; Jackson and Mackay, 1991; Jackson *et al.*, 1991). A trunk glacier hundreds of metres thick and the width of Liard Plain flowed down the Liard Valley, where it merged with ice from the northwestern Rocky Mountains. This trunk glacier most likely contacted the retreating Laurentide Ice Sheet in the Mackenzie Valley about 23 ka, and also spilled west into the Coal River basin. The streamlined topography of this region was shaped by this flow. The glacier was probably gone well before 9 ka (Jackson *et al.*, 1991). During the postglacial period, streams incised the glaciated terrain, left flights of stream terraces, and built alluvial fans. Intense mechanical weathering and mass-wasting processes created mantles of colluvium on mountain slopes.

CLIMATE

The ecoregion has a southeast to northwest orientation, which comes under the influence of weather systems from the Pacific Ocean that frequently regenerate over northeastern British Columbia and Alberta. Precipitation is moderate; combined with a relatively extended summer, it results in good vegetative growth.

Mean annual temperatures are near –4°C, ranging from a mean of near –25°C in January to between 10 and 14°C in July. Extremes have been –59 to 34°C. These temperature regimes are modified at higher elevations. Mid-winter thawing temperatures can occur, but are not as common as in the southwestern Yukon. Although midsummer frosts can occur, they are uncommon from early June to late August.

Mean annual amounts of precipitation range from 400 to 600 mm with the heavier amounts over the higher terrain to the north and west. Monthly amounts range from 40 to 70 mm, although February through May receive only 20 to 50 mm. Rain showers and thunderstorms are predominant during the summer.

Winds are generally light, but prolonged periods of moderate easterly winds can occur during the winter. Local strong winds can occur during the summer in association with thunderstorms.

Representative climate stations are Watson Lake and Tungsten.

HYDROLOGY

The Liard Basin ecoregion is situated within the Interior Hydrologic Region (Fig. 8). This hydrologic region encompasses the lower and middle elevations of the Liard River watershed, including the Liard, Frances, Hyland, Coal and Smith River basins within the Yukon, and the Dease and Kechika basins within northern British Columbia. The Liard River is a fifth-order stream, and as such has several large streams within its drainage area. Because the headwaters of many of these streams are located in mountainous regions outside the ecoregion, the hydrologic responses of these streams are not representative of the ecoregion. There are two large lakes, Frances and Simpson, and smaller lakes include Watson, Blind, Stewart, Tillei and McPherson. The coverage by wetlands is also moderately high. Numerous large wetlands are in the many wide river valleys within the lower elevations of the ecoregion.

There are four representative (active, historical continuous, and seasonal) hydrometric stations within the ecoregion: Frances River and Big and Tom creeks within the Yukon portion, and Geddes Creek within the British Columbia portion of the ecoregion. Because of the modest relief of the ecoregion, runoff and peak flow events are relatively low. Annual streamflow is characterized by an increase in discharge in April, due to snowmelt at lower elevations, rising to a peak in May within most of the lower elevation streams. Higher elevation streams such as the Frances River experience their peak flows in June. Summer rain events will produce secondary peaks throughout the summer. Mean annual runoff is moderate but variable, with values ranging from 78 mm at lower elevations to 390 mm at higher elevations with an ecoregion average of 260 mm. Mean seasonal and summer flows are moderately low with values of 15×10^{-3} and 11×10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are 41×10^{-3} and 33×10^{-3} $m^3/s/km^2$, respectively. The minimum annual and minimum summer flows are relatively high and moderate with values of 1.7×10^{-3} and 4.5×10^{-3} $m^3/s/km^2$, respectively. Minimum streamflow generally occurs during March. Some small streams may experience zero winter flows during cold winters.

PERMAFROST

Permafrost is sporadic throughout this ecoregion, and is rarely encountered during excavations for municipal or highway construction. Permafrost was recorded in less than 5% of holes drilled in the ecoregion in association with the proposed Alaska Highway gas pipeline (Rampton *et al.*, 1983). When permafrost has been identified near Watson Lake, it is "warm," and the base of frozen ground is between 2 and 4 m below the ground surface (EBA, 1982b, 1995). Beneath moist organic soils, the active layer may be less than 1 m, but at dry sites the active layer may be up to 2 m thick (Hoggan, 1991a). Where the upper surface of permafrost has been recorded at depths between 3 and 5 m, the permafrost may be degrading. Winter frost penetration of 2 m is often recorded during drilling in early summer (EBA, 1982b; Hoggan, 1991b).

Thin permafrost is found in peat plateaus at moist sites and beneath organic soils (Dyke, 1990c; Harris *et al.*, 1992; UMA, 1992). Sand and gravel sites, even beneath a dense spruce cover, usually do not support permafrost (Hoggan, 1991b).

SOILS

The soils of the Liard Basin have formed on level to undulating landscapes of primarily morainal, glaciofluvial, and lacustrine parent materials. Much of the landscape adjacent to the Liard River is mantled by up to 50 cm of silty loess. Growing season precipitation is moderate in the ecoregion, leading to the formation of a variety of well-developed soils (Lavkulich, 1973; Rostad *et al.*, 1977). Soils underlain by near-surface permafrost are confined to north-facing slopes and some wetlands.

Brunisolic Gray Luvisols are common on moraine with high clay content. When this moraine is covered by loess, a unique soil morphology results. Weathering in the loess produces often reddish horizons that overlie deeply developed greyish-brown clay-rich B horizons in moraine. Total profile development is often greater than 1 m deep. Where clay contents are less, Eutric Brunisols are common on sandy loam moraine under mixed and coniferous vegetation.

Hummocky and terraced glaciofluvial parent materials underlie much of the landscape where Eutric Brunisols are the dominant soils. Recently deposited alluvial materials along the Meister and Liard rivers have produced some of the most productive forest soils in the Yukon (Fig. 181-4). These deposits are silty to fine sandy, moderately well to imperfectly drained, supporting vigorous stands of white spruce and important wildlife habitat (Zoladeski and Cowell, 1996). The soils show evidence of periodic deposition that has buried organic matter throughout the profile. The soils are classified as Cumulic Regosols (Rostad *et al.*, 1977). These nutrient-rich, neutral-reaction soils have limited distribution, but are an important resource of the ecoregion.

Wetlands are a common, though not extensive, component of the ecoregion. Fen vegetation characterizes the ecoregion's wetlands. Basin fens are a common wetland form; these tend not to be underlain by permafrost. The soils are classified as Typic Mesisols being developed on semi-decomposed sedges and mosses. In areas where permafrost has established within the fens, peat plateau and palsa

R. Florkiewicz, Yukon Government

Figure 181-4. The Liard River floodplain upstream from Watson Lake is formed of nutrient-rich, silty alluvium. The resultant soils are termed Cumulic Regosols. Stable surfaces can support very productive forests of balsam poplar and white spruce. More active alluvial surfaces are vegetated by alder–willow shrubs.

bogs are found. Bog soils are Mesic Organic Cryosols of semi-decomposed sphagnum and other mosses.

VEGETATION

Most of the Liard Basin lies below treeline and the vegetation is dominantly boreal forest. The low elevation, moderate precipitation and relatively long, warm summers result in good vegetative growth. Coniferous forests dominate the landscape. The best growth, with tree heights of 30 m or more, occurs along the nutrient rich loamy floodplains of the Liard, Meister, Frances, Hyland and Coal rivers (Applied Ecosystem Management, 1999b).

White spruce is the dominant tree species found on river terraces, where it is underlain by feathermoss and a rich shrub layer including willow, alder, rose, high-bush cranberry and ground shrubs (Zoladeski and Cowell, 1996). Younger stands are often mixed with balsam poplar. On very dry and gravelly fluvial sites, a lichen–kinnikinnick groundcover is found under lodgepole pine or white spruce. Subalpine fir forms extensive open stands in the subalpine between 900 and 1,500 m asl.

On low wooded hills and broad treed uplands, white and black spruce are found with a moss or moss-shrub understory. Where soils are drier and nutrient poor, as on many moraine and glaciofluvial soils, lodgepole pine–black spruce forests are common. Younger stands are often mixed forests of spruce, pine, and trembling aspen, which are found on many sites; paper birch and black spruce are on north aspects, and white spruce and balsam poplar on fluvial sites.

Shrubby–herbaceous fens surrounded by permafrost-induced moss–sphagnum (peat) plateau bogs are typical wetlands in the ecoregion.

WILDLIFE

Mammals

The Liard Basin is one of the most biologically productive ecoregions in Yukon. The northern section is winter range of the Finlayson woodland caribou herd. Intensive management, including harvest restrictions and wolf population reductions in the 1980s, has greatly increased the herd size, which is now about 4,000. High calf recruitment contributed to this population growth. Moose (Fig. 181-5) also increased to high abundance, and wolves have recovered to pre-management levels (Hayes, 1995). The long-term persistence of these population levels is unknown (Hayes, 1995).

R. Florkiewicz, Yukon Government

Figure 181-5. During the winter, moose congregate in the Liard River lowland. Most of these moose disperse into upland habitats during the summer.

The Nahanni Caribou herd to the east estimated at 2,000, the smaller Smith River caribou herd estimated at 200, and the Little Rancheria herd estimated at 700 to the south also inhabit the ecoregion. Moose, black bear, wolverine, marten, and lynx are all common. Grizzly bears are at one of their lowest densities in the Yukon. Alluvial spruce forests are prime marten habitat. Fishers are found in low numbers in the eastern section of the Liard Basin and Hyland Highland ecoregions. Recent burns have enhanced populations of beaver, marten, snowshoe hare and lynx. Alluvial willows and balsam poplar support healthy beaver numbers in the Liard River drainage.

Mule deer and small numbers of white-tailed deer are at their northern limit in the southeast Yukon. Mule deer typically occur in small herds of 12 to 15. About 20 to 30 white-tailed deer reside in the Yukon (M. Hoefs, pers. comm., 2002), mostly in this ecoregion. There are occasional records of cougar from the Liard Basin.

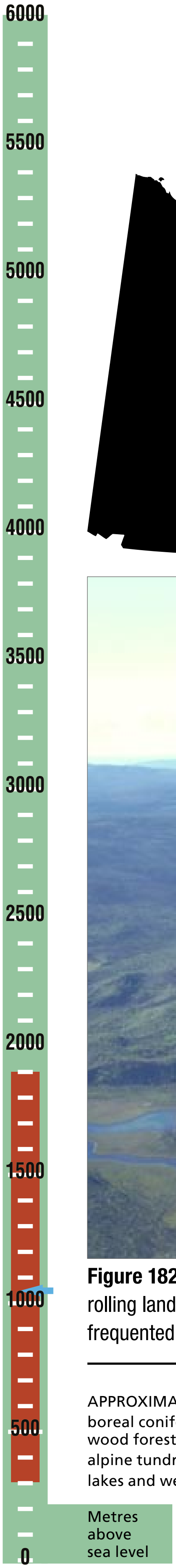
Several bat species, including the western long-eared myotis, northern long-eared myotis, long-legged myotis, big brown bat, and silver-haired bat, have recently been found in this ecoregion in British Columbia (Wilkinson *et al.*, 1995). Bats have received little attention in the Yukon and additional species are expected to occur here. A complete list of mammal species known or expected to occur in this ecoregion is given in Table 4.

Birds

The Liard Valley is part of the southern Tintina Trench and is used by Trumpeter and Tundra Swans, geese, ducks, and Sandhill Crane during migration (Dennington, 1986a). Thousands of Sandhill Cranes migrate through the Liard Valley each spring and fall with some branching off to follow the Frances River Valley and the rest continuing to follow the Liard system into the Pelly Mountains (Dennington, 1986b). The Liard Valley also functions as a migration corridor for many raptors and passerines (McKelvey, 1982), including Northern Harrier, Northern Goshawk, Rough-legged Hawk, American Kestrel, Northern Shrike, American Robin, and Lapland Longspur (McKelvey, 1982).

River and creek banks, as well as lake margins, provide breeding habitat for Osprey, Bald Eagle, Canada Goose, Common Merganser, Spotted Sandpiper, Mew and Herring Gulls, and Northern Rough-winged and Bank Swallows (McKelvey, 1982). Wetlands including oxbows, sloughs, and back-channels of major rivers, support relatively high numbers of breeding and moulting diving ducks in summer (Dennington, 1985; 1988), and provide breeding and fall staging habitat for Trumpeter Swan and dabbling ducks (Theberge *et al.* [editors], 1979; McKelvey and Hawkings, 1990). These wetlands are also important for shorebirds such as Greater and Lesser Yellowlegs, Solitary Sandpiper, and Common Snipe. Songbirds, such as Alder Flycatcher, Yellow Warbler, Northern Waterthrush, Common Yellowthroat, Wilson's Warbler, Savannah, Lincoln's and Swamp Sparrows, and Red-winged and Rusty Blackbirds, inhabit these wetlands (Eckert *et al.*, 1997; Canadian Wildlife Service, unpubl.). Marshes at Blind Lake support the only known breeding population of Black Tern in the Yukon (Eckert, 1996). In spring, migrant American Pipit and Lapland Longspur occur in open wetland areas (McKelvey, 1982).

Riparian forests along larger rivers and creeks are very productive, and support diverse and abundant songbird communities, including several species that are at the northwest edge of their range and others that reach peak densities here (Eckert *et al.*, 1997). Riparian white spruce forests are critical for habitat specialists such as Three-toed Woodpecker, Boreal Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet, Varied Thrush, and Pine Siskin (Eckert *et al.*, 1997). Other species that occur in these forests include Western Tanager and White-winged Crossbill (Eckert *et al.*, 1997). Species found predominantly in balsam poplar forests are Yellow-bellied Sapsucker, Least and Hammond's Flycatchers, Warbling Vireo, Magnolia Warbler, American Redstart, and Northern Waterthrush, while trembling aspen forests support Yellow-bellied Sapsucker, Warbling Vireo, Bohemian Waxwing, and Chipping Sparrow (Eckert *et al.*, 1997). Species that reach their peak densities in upland lodgepole pine forests are Gray Jay, American Robin, Yellow-rumped Warbler, Dark-eyed Junco and Pine Grosbeak (Eckert *et al.*, 1997). White-throated Sparrow reaches the western limit of its range in this area. This is one of the few Yukon ecoregions in which Pileated Woodpeckers live (Canadian Wildlife Service, unpubl.).



Hyland Highland

Boreal Cordillera Ecozone

ECOREGION 182

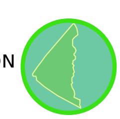
DISTINGUISHING CHARACTERISTICS: Cordilleran ice sheets during the Late Pleistocene blanketed much of the ecoregion with fine-textured morainal and well-defined, sandy, gravelly glaciofluvial deposits (Fig. 182-1). Most of the ecoregion drains into the Liard River through south flowing tributary rivers. Permafrost is relatively rare. Dominated by coniferous forests, the Hyland Highland Ecoregion is home to moose, black bear, grizzly bear, and woodland caribou. Thermal springs and associated vegetation are features of this ecoregion.

J. Meikle, Yukon Government

Figure 182-1. The Crow Plateau within the Hyland Highland Ecoregion was glaciated from the west (left to right) creating a gently rolling landscape. Elongated sandy and gravelly landforms include eskers several kilometres long. Numerous small lakes are frequented by Trumpeter Swans in summer. The extensive upland forests provide good habitat for species such as Pine Marten.

APPROXIMATE LAND COVER
boreal coniferous and mixed wood forest, 90%
alpine tundra, 5%
lakes and wetlands, 5%

TOTAL AREA OF ECOREGION IN CANADA
25,860 km^2



TOTAL AREA OF ECOREGION IN THE YUKON
14,661 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
3%

ELEVATIONAL RANGE
300–1,900 m asl
mean elevation 1,050 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Western portion of **Liard River Ecoregion** and eastern portion of the **Beaver River Ecoregion** (Oswald and Senyk, 1977) • Portion of **Cordillera Boreal Region** (CEC, 1997) • Portion of **Northern Cordilleran Forests** (Ricketts et al., 1999)

PHYSIOGRAPHY

The Hyland Highland Ecoregion consists of the Hyland Highland and the Liard Ranges (Mathews, 1986) or the Hyland Plateau and Liard Plateau physiographic units of Hughes (1987b) and Bostock (1948). Bostock and Hughes have separated the Hyland and Liard plateaus along the Toobally Lakes, differentiated by the presence of intrusive rocks in the Hyland Plateau.

The highland is an elevated area higher than neighbouring plains and plateaus, but lacking the rugged summits of mountains or ranges. The Liard Ranges in the Yukon, though no higher than parts of the Hyland Plateau, are southern extensions of the La Biche, Tlogotsho and Kotaneelee ranges, part of the Mackenzie Mountains.

The highest points in the ecoregion are on the Yukon–Northwest Territories border, in the Tlogotsho Range at 1,902 m asl and between the Coal and Rock rivers at 1,900 m asl. Most of the ecoregion lies above 900 m asl. The lowest elevation is on the floodplain of the Liard and the lower La Biche rivers, which are less than 300 m asl. Local relief is usually between 300 and 750 m.

Large rivers flow southward toward the Liard River, thus dissecting the plateau area. From west to east, the upper reaches of the Coal and Rock rivers flow south, the Beaver, Whitefish and La Biche southeast. Except for Toobally Lakes, the lakes are small and uncommon, and typically occur at creek headwaters.

BEDROCK GEOLOGY

All but the northeastern fifth of this ecoregion lies within the Yukon and is underlain primarily by sedimentary rock. Abundant rock exposure lies in the Kotaneelee and La Biche ranges in the east, along secondary drainages in the central part, and in the west on north-trending ridges and flanking gullies. Where outcrops are sparse, overlying colluvium reflects the bedrock, which is predominantly limey in the southern and eastern areas, but consists of black shale, sandstone, clay and coal under the low areas to the north. A coarse-grained syenite body, about 8 km long, lies 25 km east of Toobally Lakes, and several granitic intrusions lie between Coal River and the Northwest Territories border (Abbott, 1981c).

This entire ecoregion is within the miogeocline (continenetal shelf of ancient North America). The eastern three-quarters of the ecoregion is the southern extent of both the Franklin Mountains and the adjacent Mackenzie Mountains; both are fold-and-thrust belts. The western quarter is part of the Omineca Belt where the metamorphic grade and degree of deformation is higher. Bedrock geology and isolated outcrop locations are shown on regional maps by Gabrielse and Blusson (1969), Gabrielse *et al.* (1973) and Douglas (1976). The bedrock of selected areas has been mapped in more detail by Abbott (1981c), Currie *et al.* (1998) and hydrocarbon exploration (unpublished). These later studies have contributed to the regional synthesis by Gordey and Makepeace ([compilers], 2001).

Along the eastern edge, the Lower Cretaceous Fort Saint John Group shale, siltstone and sandstone fills broad synclines, between which protrude topographic heights exposing grey-banded chert and sandstone of the Permian Fantasque Formation and shale, sandstone and limestone of the Carboniferous Mattson Formation. These anticlines range from symmetrical box-folds to steep west-dipping and gentle east-dipping limbs, and have sinuous traces (Currie *et al.*, 1998). Underlying Devonian limestone is a potential reservoir for natural gas (Morrow *et al.*, 1990), although the only producing gas wells to date are located immediately to the southeast in the Muskwa Plateau Ecoregion (National Energy Board, 1994).

Paleozoic sediments, which generally get older to the westward, lie under the Whitefish and upper Beaver River drainages. The Carboniferous Mattson Formation lies within the core of major synclines; the resistant, unvegetated character of the thick sandstone mid-section is particularly apparent on Last Mountain (Fig. 1 *in* Gabrielse and Blusson, 1969). Anticlines expose Devonian, Mississippian and older sandstone and carbonate in the south. These units “shale-out” northward into the Besa River Formation which consists of black, brown and green shale, regionally showing elevated barium and base metal content in soil and stream silt. Farther west are Silurian–Devonian black and grey dolomite underlain by the Middle Ordovician Sunblood Formation dolomite in the south, which trends south to the eastern part of the Liard Plain Ecoregion, and black shale of the time-equivalent Road River Formation in the north. Barite nodules in the Besa River shale, and numerous lead–zinc vein and skarn occurrences in the Paleozoic carbonate units are the known mineral potential of this area.

The Rock River valley is underlain by eastward-directed thrusts that were active during late Mesozoic contraction. The overriding western side in the Toobally Lakes area consists of uplifted Late Proterozoic to Lower Cambrian volcanic rocks and the Rabbitkettle Limestone of dark grey silty limestone and phyllite. The upper Coal River and West Coal River drainages in this ecoregion are underlain by dark shale, gritty quartzite, limestone, quartz pebble conglomerate, and maroon shale of the Late Proterozoic to Cambrian Hyland Group. (Fig. 182-2) Copper, tin and tungsten showings, as well as lead–zinc vein and skarn occurrences, are scattered over the western region. Coal exploration licences currently cover the area between Coal River and the Northwest Territories border, which contains several very thick layers of lignite and sub-bituminous coal.

SURFICIAL GEOLOGY

Although this part of the Yukon was subjected to several glaciations since the late Tertiary, the present surface deposits are associated with the last glaciation. The Liard Lobe of McConnell ice, which originated in the Selwyn Mountains (Jackson, 1994), moved through the western half of the Coal River map area in an east to northeastward direction, as indicated by drumlins found in the southwest corner of the map and in the Coal and Rock river valleys. Alpine areas, at elevations higher than 1,050 m, consist of bedrock slopes and summits covered by a veneer of colluvium, thin moraines over bedrock, and weathered and mass-wasted bedrock. Moraine on lower slopes can be more than 30 m thick. The moraine is a mixture of cobbles, sand, silt and minor clay. Sporadic permafrost can be found in low-relief, poorly drained moraine covered by thick organic deposits. Large glaciofluvial deposits lie around Scoby Creek and Quartz Creek, and on the floor and lower slopes of the Rock River and Coal River valleys north of Quartz Creek.

J. Meikle, Yukon Government

Figure 182-2. The Beaver River, like the LaBiche to the east and the Coal to the west, have been deflected eastward from their pre-McConnell Glaciation channels. In this view, the Beaver River cuts through the Beavercrow Ridge, creating a relatively rare look at the Lower Paleozoic shelf strata underlying this ecoregion.

Glaciolacustrine deposits are present in the Rock River valley on the present floodplain, and in the Coal River valley north of the West Coal River fork. Slumping of these sediments is expected as the streams undercut their banks.

Unstable colluvial and alluvial fans are the most common landform associated with mass movement hazards in this area. The movement of sediments on slopes (e.g. solifluction) is limited to north-facing slopes and higher elevations where alpine permafrost may be present. Extensive shale deposits are prone to large slumps. Local till and widespread glaciolacustrine deposits rich in clay and ice have produced extensive debris flows and slumps (Smith, 2000). In the eastern part of the ecoregion, mass movements are mostly triggered by failure of the Mattson Formation sandstone along steeply dipping bedding planes with attendant flow of overlying unconsolidated deposits. Failure can be triggered by undercutting of slopes by rivers, slumping of underlying bedrock, and permafrost degradation. Slumping can be expected along the Coal and Rock rivers where streams undercut glaciolacustrine deposits.

GLACIAL HISTORY

The Hyland Highland Ecoregion follows a band along the Yukon–Northwest Territories boundary and includes the headwaters of the northern tributaries to the Liard River. This ecoregion was completely covered by the last Cordilleran Ice Sheet. It contains a drainage network of rivers and meltwater channels reflecting the varying dominance of separate ice masses. The Cordilleran Ice Sheet moved northward during the McConnell Glaciation from the Cassiar Mountains and the northwestern Rocky Mountains. However, the northwestern part of this ecoregion was affected by eastward-flowing glaciers emanating from Mount Laporte in the Logan Mountains, and extended about 20 km east of the Yukon–Northwest Territories boundary (Fig. 182-1). The ice sheet from the south moved across the Northwest Territories boundary draining into the South Nahanni River Basin. The maximum extent of the Cordilleran Ice Sheet occurred about 23 ka (Klassen, 1987; Duk-Rodkin and Hughes, 1991; Lemmen *et al.*, 1994; Duk-Rodkin, 1996).

Glacial Lake Nahanni was formed at the Laurentide maximum (ca. 30 ka) with an outlet to the southwest. At this time, glaciers were likely forming in the highest ranges of the Cordillera and had not yet reached their maximum extent. At its maximum, the Cordilleran Ice Sheet blocked the drainage of Lake Nahanni to the southwest causing the formation of an outlet to the east along the Mackenzie Mountain front. At this time, the Laurentide Ice Sheet was retreating from its maximum position, but still blocked the South Nahanni valley, forming a canyon between the Laurentide Ice Sheet and the mountain slope. The Cordilleran Ice Sheet barely crossed the continental divide and built a series of deltas into Glacial Lake Nahanni.

CLIMATE

No climate stations exist within this ecoregion, but some inferences can be made using Fort Liard (Northwest Territories) and Smith River (British Columbia). This ecoregion is subject to intrusions of arctic air that have moved southward up the Mackenzie Valley, and to clouds and moisture from storms originating over the Pacific and redeveloping in northeastern British Columbia and northwestern Alberta. These redeveloping storms are particularly significant in spring and early summer when warm heavy rains fall on remaining snowpacks and cause flooding.

Mean annual temperatures are near –4°C, ranging from averages near –20°C in January to near 13°C in July. Extremes in the lower valley floors probably range from near –55 to near 30°C. Summers are probably fairly warm from June through August, although some frost can occasionally be expected even during these months. Prolonged cold spells could be expected from November through mid-April.

Precipitation is moderate with annual amounts of 500 to 600 mm. The heaviest precipitation occurs from June through August, with monthly amounts averaging 60 to 80 mm. Much of this rain would be showers and thunderstorms, but periods of prolonged rain could occur with the redeveloping storm centers.

No wind data are available, but periods of prolonged easterly winds could be expected, particularly during the winter months. Local strong winds could also occur with the summer thunderstorms.

Climate information could be inferred using data from Smith River and Fort Liard.

HYDROLOGY

The Hyland Highland Ecoregion is situated within the Interior Hydrologic Region (Fig. 8). The ecoregion drains the Hyland and Liard plateaus, which are areas of moderate relief. The Yukon portion of the ecoregions drains primarily southward into the Liard River, which forms the southern boundary within British Columbia. Major streams include the Beaver, Whitefish, La Biche, upper Coal and Rock rivers. With no major lakes, the area of waterbodies is small. The only intermediate-sized lakes are the Toobally Lakes, though there are numerous small lakes within the Beaver, Whitefish and Coal River headwaters. Located largely within the Coal and Beaver headwaters, wetland coverage is relatively small.

There are three representative active and historical continuous hydrometric stations within the ecoregion: Beaver River within the Yukon, and Grayling River and Teeter Creek within British Columbia. Annual streamflow is characterized by an increase in discharge in May due to snowmelt at lower elevations, rising to a snowmelt peak in June. Approximately 50% of the time, annual peak flow is due to intense summer rain events. Mean annual runoff is moderate, with values ranging from 185 to 271 mm, with an ecosystem average of 249 mm. Mean seasonal and summer flows are moderately low, with values of 12×10^{-3} and 10×10^{-3} $m^3/s/km^2$, respectively. The mean annual flood and mean maximum summer flow are moderately low, with values of 62×10^{-3} and 33×10^{-3} $m^3/s/km^2$, respectively. The timing of the minimum annual streamflow is variable, ranging from January to March, but generally occurring during March. The mean annual minimum and mean summer minimum flows are relatively high and moderately low, with values of $1.8 X 10^{-3}$ and $3.3 X 10^{-3} m^3/s/km^2$, respectively.

PERMAFROST

There is little permafrost in Hyland Highland Ecoregion, principally because terrain elevation is less than the Selwyn Mountains to the north or Rocky Mountains to the south. Harris (1986) estimated that permafrost would be continuous above an elevation of 1,500 m, but most of the area is below this level. Permafrost distribution is sporadic and most likely in organic soils and at wet sites.

SOILS

The soils in this ecoregion have formed on rolling or inclined uplands with extensive hills and incised river valleys. Moraine and colluvial deposits cover much of the upland, while the valley floors are often filled with terraced or hummocky glaciofluvial sands and gravels. Where moraines are fine-grained, Brunisolic Gray Luvisols are common. On coarser materials and all glaciofluvial deposits, soils are generally classified as Eutric and Dystric Brunisols (Zoladeski and Cowell, 1996). Permafrost is discontinuous and scattered. Cryosols are limited to alpine environments and some north-facing lower slopes that are imperfectly drained and support thick veneers of moss and peat, which insulate the ground against summer thaw, and some bog wetland forms. Mineral soils are classified most often as Orthic Turbic Cryosols.

There are a few isolated peaks and massifs with alpine environments where patterned ground is common. Patterned ground is primarily non-sorted circles associated with Orthic Turbic Cryosols. Wetlands are common in major valley systems. These are primarily northern ribbed fens and peat plateau bogs. Under peaty ridges and bog islands within the fens and under the peat plateau bogs, permafrost may be found.

VEGETATION

The Hyland Highland Ecoregion is dominated by open boreal forest. Only a small portion of the ecoregion reaches above treeline between 1,200 and 1,350 m. The moderate precipitation received in this area, most of which falls in spring and summer, and fairly warm summers are reflected by good forest growth on favourable sites (Fig. 182-3). The most productive forest areas occur along the La Biche, Beaver, and Coal rivers, where trees reach 20 m or more on the best sites in their first 100 years of growth.

White spruce dominates the well-drained fluvial terraces of the major rivers. The understory is usually rich in shrubs such as highbush-cranberry, rose, alder, dogwood, lingonberry, feathermosses and horsetail (Fig. 182-4). Balsam poplar is often a component of the canopy, especially in younger stands. As an early colonizer with willow of recent floodplain deposits, young balsam poplar often forms dense shrub or low tree thickets.

Black spruce grows in cool, poorly drained bogs on lowland fluvial or lacustrine sites. It is often associated with organic soils. Willow, shrub birch,

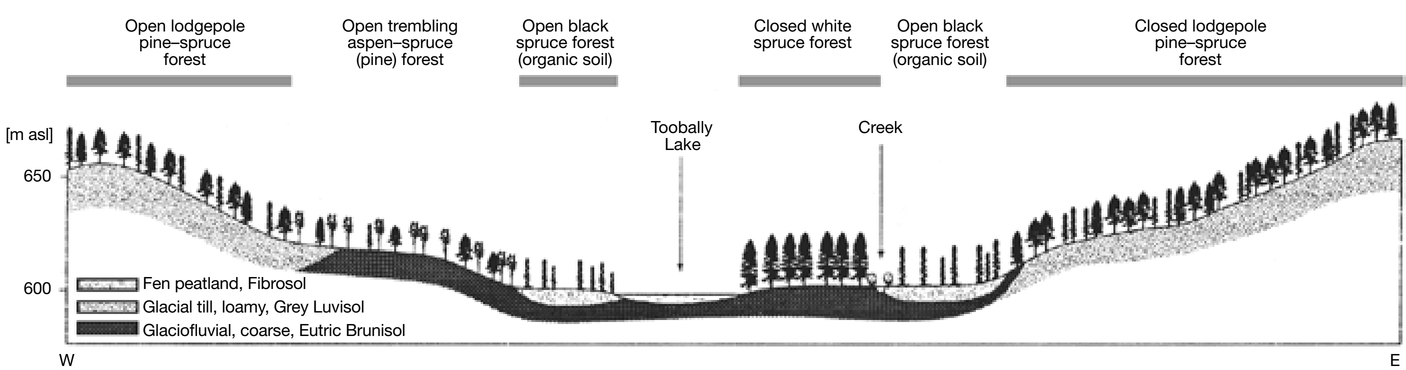


Figure 182-3. Cross-section showing the relationship of soil and vegetation distribution across a typical landscape in the Hyland Highland Ecoregion (adapted from Zolakeski and Cowell, 1996).

Labrador tea and alpine blueberry are common with a range of mosses, which reflect the moisture and nutrient status of the site. Black spruce bogs are usually associated with permafrost and Cryosol soils. Larch may be present on nutrient-rich sites. Black spruce is also the climax tree species on upland moraine or glaciofluvial deposits. Feathermoss and ground shrubs such as lingonberry, shrub birch, Labrador tea and crowberry usually dominate the understory. On drier sites, lichens can have prominent cover. On these nutrient-poor sites, lodgepole pine is often present, as it is usually the first conifer to colonize the drier sites after fire. It provides the cover for black spruce to establish in the understory and later take over the canopy (Kuch [editor], 1996). Pure stands of pine predominate in many old burns (Davis *et al.*, 1983b).

C.D. Eckert, Yukon Government

Figure 182-4. Well-developed riparian forests are found along the floodplain of the Beaver and other large rivers in the ecoregion. This site is composed of white spruce with a feathermoss–horsetail understory. Highbush-cranberry *(Viburnum edule)* is the most common shrub in the community.

Subalpine fir with shrub birch and lichen is prevalent at higher elevations (Fig. 182-5), replacing spruce as the dominant tree species.

Fen wetlands dominated by sedges and willows are common along the major river valleys. Natural springs on the Beaver River and Larsen Creek also host numerous species that are rare in the Yukon (Fig. 182-6). These species could be part of a refugia with pockets of vegetation, such as poison ivy (*Toxicodendron rydbergii*) and poverty oatgrass (*Danthonia spicata*), not known anywhere else north of 55°N. There are other rare species found in the Whitefish and Tropical creek areas.

The above populations are disjunct and may represent a remnant of a distribution that was at one time larger. The plants of the glacial refugia are found on the Kotaneelee Ridge. Those species are Beringian in distribution such as Porsild's poa (*Poa porsildii*) and Yukon groundsel (*Senecio yukonensis*). They are arctic alpine species.

WILDLIFE

Mammals

A number of woodland caribou herds range across the Yukon and Northwest Territories border. Of these, the best studied is the Nahanni herd estimated at about 900 in 2001. Other caribou

J. Meikle, Yukon Government

Figure 182-5. On the north-facing aspect of the Beavercrow Ridge, white spruce forests give way to subalpine fir, above which is a minor willow and shrub birch zone, with extensive alpine communities along the crest. The sedimentary strata are dipping to the southeast.

J. Meikle, Yukon Government

Figure 182-6. Hot springs in this ecoregion occur along deep-seated faults. Yukon occurrences of vascular plants, such as beggarticks (*Bidens cernua*; inset), Indian paintbrush (*Castilleja miniata*) and poison ivy (*Toxicodendron rydbergii*) are known in the Yukon almost exclusively from these springs.

are known to live in the alpine blocks of the upper Hyland, Coal, and La Biche watersheds in the Yukon. These caribou and the Nahanni herd all appear to use a large wintering area within Nahanni National Park and south of the park. The southernmost portion of this wintering area is near Jackpine Lake in the upper Beaver watershed. Their range use is known only from movements of a few satellite radio-collared caribou. A caribou herd with limited seasonal movements just south of the Yukon–British Columbia border has a northern fringe of its range in Yukon in the Larsen Lake area of the Beaver Watershed. Moose have not been surveyed in much of the region but surveys taking in the eastern portion of the Liard Basin and the lower La Biche indicate moose densities similar to Yukon averages of 150 to 250/1000 km^2. Marten are the most economically important fur-bearer in this region, which still has a few trappers living much of the year in the bush. Trappers in the Beaver Watershed have caught 200 to 250 marten in some years, indicating some rich marten habitat in this region. A few fisher are also caught each year. Hares and lynx are generally caught in relatively low numbers, possibly because of the high proportion of mature and old forests and the scarcity of early- to mid-successional forests. In general there has been relatively little wildlife work in this remote region. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Amphibians

The boreal toad (*Bufo boreas*), common throughout northern British Columbia, enters the Yukon only in the southeast (Fig. 182-7). The boreal toad is restricted to areas of high snowfall and geothermal activity, where ground freezing is limited and it can burrow below the frost line. It is known to occur in this ecoregion which hosts numerous geothermal sites. The wood frog (*Rana sylvatica*) is common in this ecoregion.

L. Mennell

Figure 182-7. The range of the boreal toad reaches its northern limit in southeast Yukon. It has been observed as far west as the Meister River in the Liard Basin Ecoregion and has been observed at Toobally Lakes and the lower Beaver River in the Hyland Highland Ecoregion. It is considered rare in Yukon.

Birds

Significant numbers of Trumpeter Swans breed in the Toobally Lakes area, along with numerous dabbling and diving ducks (CWS, Birds of the Yukon Database). The north end of North Toobally Lake serves as a spring staging area for Trumpeter Swan and ducks (Dennington, 1985), while the outlet of South Toobally Lake is important in both spring and fall as a staging area (Dennington, 1986a). Other important wetlands include Larsen Lake and the upper Whitefish River (Fig. 182-8) (Dennington, 1985; McKelvey and Hawkings, 1990). Lee Lake, just west of the confluence of the Beaver River, and Larsen Creek, and the Beaver River Wetland, northwest of the confluence of the Beaver and Whitefish rivers, provide important breeding habitat for a variety of waterfowl as well as Pied-billed Grebe, American Coot, and Sora (Eckert *et al.*, in prep.). Songbirds associated with these wetlands include Western Wood-Pewee, Common Yellowthroat, Le Conte's and Swamp Sparrows, and Red-winged and Rusty Blackbirds (Eckert *et al.*, in prep). Lee Lake is one of only two Yukon locations where Marsh Wren has been documented (Eckert *et al.*, in prep.).

C.D. Eckert, Yukon Government

Figure 182-8. A clutch of trumpeter swan eggs in the upper Whitefish River wetland. As the species returned from the brink of extinction, these were the first observed nesting locations in the Yukon.

Productive and diverse forests, especially along the Beaver, Smith and Whitefish rivers, and Larsen and Siwash creeks provide important breeding habitat for many species. These include some that occur at the northwest edge of their range such as Blue-headed Vireo, Cape May Warbler, Bay-breasted Warbler, Ovenbird, Mourning Warbler, and Rose-breasted Grosbeak (Sinclair, 1998; Eckert *et al.*, in prep.). Riparian balsam poplar stands, especially the extensive forests at the Whitefish River delta, provide important breeding habitat. High densities of Least Flycatchers occur here, as well as Yellow-bellied Sapsucker; Hammond's Flycatcher; Swainson's Thrush; Warbling Vireo; Tennessee, Yellow; Magnolia, Yellow-rumped and Bay-breasted Warblers; Northern Waterthrush; Rose-breasted Grosbeak; and White-throated Sparrow (Eckert *et al.*, in prep.).

Riparian white spruce forests support especially high densities of Tennessee and Bay-breasted Warblers. Other inhabitants include Three-toed and Black-backed Woodpeckers; Golden-crowned Kinglets; Swainson's and Varied Thrushes; Blue-headed Vireos; Western Tanagers; Cape May and Yellow-rumped Warblers; Chipping and White-throated Sparrows; and Evening Grosbeaks. Yellow-bellied Sapsucker, Magnolia Warbler and American Redstart exist in areas of mixed white spruce, deciduous trees and tall shrubs (Sinclair, 1998; Eckert *et al.*, in prep.).

Black spruce forests provide breeding habitat for Gray Jay, Boreal Chickadee, Ruby-crowned Kinglet, Hermit Thrush, Tennessee Warbler, Yellow-rumped Warbler, Dark-eyed Junco, and Pine Siskin. Lodgepole pine forests support Common Nighthawk, Gray Jay, Red-breasted Nuthatch, Yellow-rumped Warbler and Dark-eyed Junco. Higher elevation treeline in the Kotaneelee Range provides breeding habitat for Blue Grouse; Dusky Flycatcher; Townsend's Solitaire; and White-throated, White-crowned and Golden-crowned Sparrows (Eckert, 1999a). Cedar Waxwing is most common in the Hyland Highland and Muskwa Plateau ecoregions, although it occasionally occurs further west in the Yukon (Eckert, 1995a). Year-round residents include Ruffed and Spruce Grouse, Three-toed and Black-backed Woodpeckers, Gray Jay, Common Raven, Boreal Chickadee, and White-winged Crossbill (Canadian Wildlife Service, unpubl.).

PACIFIC MARITIME ECOZONE

This ecozone covers the Pacific coast of British Columbia and a small portion of the Yukon Territory. It includes the Coast Mountains that trend the length of the Cordilleran from Puget Sound to Gulf of Alaska. The wettest climate in Canada occurs in this ecozone. The mountainous topography is cut through by numerous fjords and glacial valleys and bordered by coastal plains along the ocean margin. Igneous and sedimentary rocks underlie most of the ecozone. Colluvium and glacial deposits are the main surface materials. The southern portion of the ecozone incorporates the mainland coast, Coast Mountains and offshore islands of British Columbia. North of 55°N, the ecozone includes the Boundary Ranges along the British Columbia–Alaska border.

In the Yukon, the ecozone occurs only along the westernmost portion of the St. Elias Icefields and is represented only by the Mount Logan Ecoregion. This ecoregion is considered part of the Pacific Maritime Ecozone because its climate is under the dominance of maritime weather systems from the Gulf of Alaska. However, the extremely high elevations and high precipitation result in the ecoregion acting as the source area for a system of glaciers moving both out to the Pacific — most notable is the Malaspina Glacier, and toward the interior into the southwestern Yukon through the St. Elias Mountains Ecoregion.

Although no climate stations exist in the Yukon portion of the ecozone, it is estimated that up to 1,500 mm of precipitation, virtually all of it as snow, falls annually. Each year, mountain climbers ascend Mount Logan and the other major peaks during May and June.

C.F. Roots, Geological Survey of Canada

The St. Elias Mountains consist of steep rock and ice (with summits 4,000 to 5,000 m elevation) with little vegetation, separated by broad valley glaciers (with surfaces at 2,000 to 3,000 m elevation). View is northward from the north flank of Mount Logan.

W.J. Schick

Mountain goats, tolerant of deep snow, have colonized steep rocky slopes at the margin of this ecozone in the Yukon.

C.F. Roots, Geological Survey of Canada

King Peak (5,172 m) is a 50 Ma granite pluton that rises above the Quintino Sella Glacier and the King Trench.

Mount Logan

Pacific Maritime Ecozone

ECOREGION 184

DISTINGUISHING CHARACTERISTICS: This most northerly of Pacific Maritime ecoregions is composed of high elevation ice fields, alpine glaciers and summit outcrops. It incorporates part of the largest nonpolar icefields in the world and includes the highest mountains in Canada; most notable is Mount Logan, at 5,959 m asl, the highest in Canada. Lying on the windward side of the St. Elias Mountains, the ecoregion is subject to heavy precipitation, most of which is snow. While extremely limited, some plant and animal life is found on nunatuks.

C.F. Roots, Geological Survey of Canada

Figure 184-1. Steep mountain walls confine glaciers marked by deep crevasses and debris from avalanches of collapsing seracs. Few plants or animals inhabit this ecoregion. Small birds are blown onto the icefields by maritime storms. Mountain climbers ascend this slope (King Trench) every May and June.

APPROXIMATE LAND COVER
perrenial snow or ice, 85%
alpine tundra, 5%
rockland summits, 10%

TOTAL AREA OF ECOREGION IN CANADA
4,193 km^2

TOTAL AREA OF ECOREGION IN THE YUKON
4,193 km^2

ECOREGION AREA AS A PROPORTION OF THE YUKON
1%

Metres above sea level

ELEVATIONAL RANGE
1,500–6,000 m asl
mean elevation 3,150 m asl

CORRELATION TO OTHER ECOLOGICAL REGIONS: Western portion of **St. Elias Mountains Ecoregion** (Oswald and Senyk, 1977) • Portion of **Pacific Coastal Mountain Tundra** and **Icefields Ecoregion** (Ricketts et al., 1999) • Contiguous with the **Chugach–St. Elias Mountains Ecoregion in Alaska**

PHYSIOGRAPHY

The Mount Logan Ecoregion in the extreme southwest of the Yukon comprises the highest part of the St. Elias Mountains dominated by icefields. It is centred on Mount Logan, which reaches an elevation of 5,959 m asl, the highest mountain in the Yukon, and in Canada. Mount St. Elias at 5,488 m asl, Mount Augusta at 4,288 m asl, and Mount Vancouver at 4,785 m asl straddle the Alaska–Yukon border. Other peaks over 4,000 metres asl include King Peak (5,172 m) and Mount Cook (4,194 m).

This ecoregion is primarily made up of precipitous cliffs rising above intermontane glaciers (Fig. 184-1) to broad summit areas. The large extent of the Seward and Hubbard glaciers shows the influence of a maritime climate. In the north, the large Logan and Walsh valley glaciers flow west toward Alaska, where the Walsh reaches the lowest elevation in the ecoregion, less than 1,500 m asl.

BEDROCK GEOLOGY

Nunataks and cliff faces poking through glaciers and beneath seracs provide geologists the few rock surfaces available for study, although many are inaccessible because of ice-related hazards. This ecoregion is part of the Insular Geomorphologic Belt (Gabrielse and Yorath [editors], 1991) and includes three terranes. The Border Ranges Fault (a west-trending belt across the middle) separates the Yakutat Terrane to the south. The Contact–Columbus Fault separates Chugach Terrane from Wrangell Terrane to the north. The Hubbard Fault lies under the Walsh Glacier, the northern boundary of this ecoregion. The entire region was geologically mapped by helicopter reconnaissance (Campbell and Dodds, 1982b).

The region is one of active tectonic contraction arising from the North America Plate overriding the Pacific Oceanic Plate at a subduction zone beneath the Gulf of Alaska. The spectacular topography of the Mount Logan area reflects Cenozoic uplift, making these among the youngest high ranges in the world (O'Sullivan and Currie, 1996).

Marine and non-marine sediments near the subduction zone were uplifted along steep, north-dipping thrust faults. The Chugach and Yakutat terranes represent fault slices of Paleocene and Triassic to Cretaceous strata, respectively. An oblique cross-section of the Chugach Terrane, exposed in nunataks across the Seward Glacier, reveals an increase in metamorphic grade southward from fossil-bearing mudstone in the footwall of the Border Ranges Fault through andalusite schist to biotite gneiss north of the Contact–Columbus Fault (Campbell and Dodds, 1978). Bivalve fossils of Jurassic and Cretaceous age are found on ridge spurs extending southeast from Mount Logan (Sharpe and Rigsby, 1956; Campbell and Dodds, 1982b). North of the Border Ranges Fault, hornblende–biotite quartz diorite comprises the Mount Logan pluton (153 Ma; Dodds and Campbell, 1988), which intrudes Wrangellia, leaving only gneissic pendants on spurs west and north of Mount Logan (Roots and Currie, 1993). North of the massif, schist, marble, amphibolite and conglomerate on the ridge between the Logan and Walsh glaciers are believed to be part of the Skolai Group.

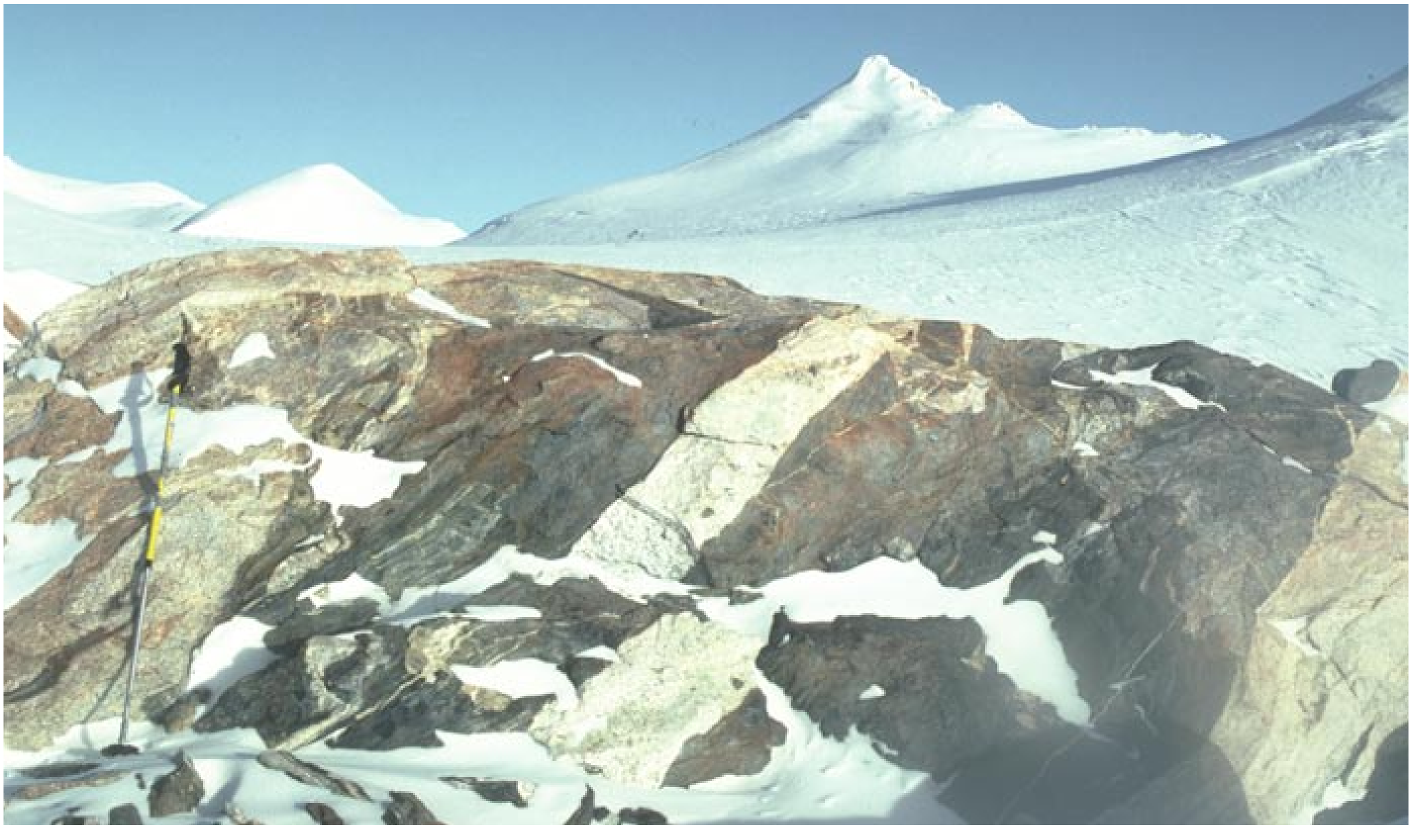
The Border Ranges Fault is well studied as an exhumed subduction zone in south-central Alaska (e.g. Pavlis, 1982). Within the ecoregion, it is exposed across the sheer south face of Mount Logan, which results in part from preferential erosion of the soft Chugach mudstone on the south, compared with the more resistant quartz diorite (Fig. 184-2) to the north. The fault appears to be inactive; it is intruded by a 53-million-year-old tonalite pluton across King Peak and the ice-filled valley to the northwest.

Three very large earthquakes within one week in 1899 appear to have had an epicentre in the St. Elias–Mount Logan area, but the area is not noted as having frequent seismic activity (Horner, 1983).

The rocks of the ecoregion contain no known mineral occurrences, although the Skolai Group typically hosts copper, silver, lead and zinc in quartz veins.

SURFICIAL GEOLOGY

Surfaces of this ecoregion are dominated by icefields and nunataks, which are exposed rock islands and mountain summits sticking out above the icefield.



C.F. Roots, Geological Survey of Canada

Figure 184-2. Among the highest rocks in Canada, the Mount Logan plateau (ca. 5,000 m elevation) is an undulating icecap with snowy peaks at the rim. Nunataks (exposed rock) reveal mafic gneiss intruded by bands of lighter coloured granitic rocks that are 170 and 53 million years old.

GLACIAL HISTORY

This ecoregion occupies the southwestern part of the Yukon Territory and includes Mount Logan, which rises in the central part of an almost continuous carapace of ice (Fig. 184-2). Most of this ecoregion is located on the south-facing slope of the St. Elias Mountains, oriented towards the Pacific Ocean. The presence of an ice sheet to the southwest contrasts with a network of valley glaciers to the northeast, reflecting the difference in precipitation between south and north sides of the divide. The humid air masses from the Pacific Ocean leave most of the moisture in the south side of the divide, such that ice cover to the north (see St. Elias Mountains Ecoregion) is restricted to valley glaciers.

Several glaciations occurred in this region during the late Miocene–Pliocene and Pleistocene age (Denton and Armstrong, 1969). They relate to the history of uplift of the coastal mountains, beginning about 14 Ma (O'Sullivan and Currie, 1996), and climatic cooling, beginning about 10 Ma (Denton and Armstrong, 1969). Subsequent regional erosion and then renewed uplift about 4 million years ago were associated with further cooling and increased glaciation (Raymon, 1992; Duk-Rodkin *et al.*, 1996; Duk-Rodkin and Barendregt, 1997).

CLIMATE

This is the first orographic barrier between the Pacific Ocean and the interior of the Yukon. It is a very high barrier with elevations ranging from 1,500 to almost 6,000 m asl. The average elevation is near 2,500 m. The only known weather stations in this region were at Seward for two weeks at 1,700 m in June 1965 and at Logan for three weeks at 5,360 m in July 1970. However, climatic guides can be extrapolated using meteorological principles, nearby weather stations, and upper air data. The stations include Yakutat at sea level, Haines APPS#2 near Canada Customs on the Haines Road and Mule Creek, Mile 75 on the Haines Road. The stations show a great difference in climate due to elevation and orographic aspects but do not describe the higher elevations.

The Mount Logan Ecoregion lying on the windward side of the St. Elias Mountains is subject to heavy precipitation. This precipitation would be primarily snow because of the high elevations, with rain occasionally at elevations below 2,500 m from June through August. Due to the frequency of storm activity in the Gulf of Alaska, the heaviest precipitation is during the fall and winter. Although there is a seasonal variation in temperature, the greatest control is that of elevation. Again due to the storm activity, winds are moderate to strong and generally increase with elevation. The lightest winds are during the summer months.

Table 173-1 (see St. Elias Mountains Ecoregion) lists probable mean values of precipitation and temperature at various elevations and seasons. The result is that most of the ecoregion is snow-covered and glaciated throughout the year, except relatively steep rock faces and ridge crests abraded by wind.

HYDROLOGY

The ecoregion has glacier coverage of approximately 85%. Mount Logan is in the centre of the ecoregion with the predominant ice flow into Alaska, to the west down the Logan Glacier and to the south down the Seward Glacier. Approximately 20% of the ecoregion lies in the Yukon River drainage, with ice flow into the Kluane River system down the Kaskawulsh and Donjek glaciers. Because of the ice-covered nature of the ecoregion, there is very little open, surface streamflow present within the Yukon portion. The largest land surfaces exist in the extreme northwest corner of the ecoregion, which also contains several meltwater lakes which are open during the summer. There are no wetlands within the ecoregion.

Perennial steep channels less than 2 km long are present in this area, predominantly on south-facing slopes. Larger meltwater channels also exist beneath

F. Mueller

Figure 184-3. A hanging garden on a nunatak overlooking Seward Glacier (elevation 1,800 m) contains the sedge *Kobresia myosuroides* and moss campion. Both are important forage for the collared pika, the most important resident mammal in this ecoregion. View is eastward to Mount Vancouver (elevation 4,785 m).

the ice of the valley glaciers. Because of the limited channelling associated with the perennial streams, streamflow is limited to summer only and is diurnal. Peak surface flows occur during June or July from snow covered areas during times of maximum snowmelt. Peak subsurface flows occur during July or August, during times of maximum glacier melt. There are no hydrometric stations within the Canadian portion of the ecoregion.

PERMAFROST

There are no records of permafrost conditions in this ecoregion, but the maintenance and thickness of glacial icefields suggests that conditions are conducive to permafrost. Thus, permafrost is likely present wherever ice is absent or thin enough that its basal temperature is below the pressure melting point.

SOILS

There is no soil development in this ecoregion other than some physical weathering of exposed bedrock surfaces that form nunataks above the icefields. Due to the high elevation and severe climatic conditions, there are no vegetative communities on these surfaces other than some lichen formation. Where unconsolidated materials are present, Regosols (soils without development) exist.

VEGETATION

Only a few high peaks protrude above the ice in the Mount Logan Ecoregion, so there are few seedbeds available for the establishment of plant species (Fig. 184-3). Small pockets at elevations greater than 2,200 m in the St. Elias Mountains are known to shelter flowering plants typically found at lower elevations (Environment Canada, 1987). Vegetation cover is extremely sparse, of course. Three plant species have been identified from elevation above 2,800 m asl (Murray and Douglas, 1980).

WILDLIFE

Mammals

The Mount Logan Ecoregion has the lowest mammalian diversity of any in the Yukon, because few suitable habitats exist. Nunataks have been colonized by mountain goats near the Alaska border. Arctic ground squirrels, collared pikas and singing voles may also be found here (Fig. 184-4). Wolverine and grizzly bear make occasional forays to the nunataks. Mammal species known or expected to occur in this ecoregion are listed in Table 4.

Birds

Apart from one record of a Wilson's Warbler, there is no documented evidence of birds using this ecoregion. Despite this, species that encounter strong coastal winds or inclement weather while migrating over the St. Elias Range may meet their demise on the icefields (D. Hik, unpubl. data). Many species, including ducks and songbirds, have been found dead or dying on the icefields of the adjacent St. Elias Mountains Ecoregion (D. Hik, unpubl. data). Species may find temporary food on a few scattered pocket meadows on wind-exposed nunataks (D. Hik, unpubl. data).

P. Merchant, Yukon Government

Figure 184-4. Collared pikas are one of the few year-round mammalian residents in the ecoregion.

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APPENDICES

Glossary

Geologic time scale

GLOSSARY

A

abiotic: Having no life; applied to non-living components of the environment such as bedrock, soil, water, solar radiation, etc.

ablation till: Glacial deposits left by the slow, in situ melting of debris-rich glaciers. These melt-out deposits, consisting of coarse-textured debris within and on top of glaciers, may overlie tills that formed first beneath glaciers (sub-glacial till).

accretion: The accumulation of sediments from any cause, representing an excess of deposition over erosion. In tectonics, the addition of rock masses (such as island arcs or faulted-off fragments of continents) to a continent. Much of the Yukon bedrock southwest of Tintina Fault is the product of accretion in the last 110 million years.

active layer: The layer of ground above the permafrost that thaws and freezes annually.

aeolian: Wind-transported sediment. See “loess.”

aggradation: Sorted or stratified deposition in a stream or river. Reducing steepness by deposition.

allochthonous: Not indigenous: acquired. Applied to rock that did not originate in its present position.

alluvial fan: Cone-shaped deposit of alluvium laid down by a stream where it emerges from an upland onto to a plain.

alluvial soil: Soil that has developed from transported and relatively recently deposited material (alluvium), characterized by little or no modification of the original material by soil-forming processes.

alluvium: A general term for all detritus deposited or in transit by rivers or streams, including gravel, sand, silt, clay and all variations and mixtures of these.

alpine: (1) Refers to those portions of mountain landscapes above tree growth, or to those organisms living there. (2) That vegetation occurring between the upper limit of trees (treeline) and the lower limit of snow (snowline) on mountains high enough to possess both of these features. (3) Implies high elevation, particularly above treeline and a cold climate.

alpine meadow: (1) A dense, low, meadow-like type of herbaceous plant cover found above treeline. (2) Low herbaceous vegetation dominated by grasses, sedges and other herbs in the alpine zone.

alpine tundra: That portion of the landscape above the upper limit of tree growth that supports a plant cover of dwarf shrubs and herbs.

ammonite: Any of a subclass *(Ammonoidea)* of extinct cephalopods with flat spiral shells that were especially abundant in the Mesozoic age.

Amphiberingian: Distribution of a plant species on both sides of the Bering Strait. Differs from “circumpolar” by lacking “amphi-Atlantean” distribution.

amphibolite: A mafic metamorphic rock containing mostly amphibole (e.g. hornblende) and plagioclase feldspar. Amphibolite weathers relatively slowly, supplying iron, magnesium and sodium to the soil. Synonym: greenstone.

amygdaloidal: Containing small cavities in igneous rock that are filled with deposits of different minerals (as chalcedony or calcite).

anadromous: Living in salt water but breeding in fresh water. Applies to the migratory behaviour of fish.

anaerobic: An environment where oxygen is lacking or absent.

andalusite: Mineral consisting of a silicate of aluminum; typically indicates medium-grade regional and thermal metamorphism.

andesite: Volcanic or shallow intrusive, usually dark grayish rock consisting of plagioclase feldspar and clinopyroxene.

anticline: Arch of stratified rock in which the layers bend downward in opposite directions from the crest.

anticlinorium: An area of folds whose overall structure is arch-like.

arctic: High latitude region from which tree growth is usually absent due to unfavourable environmental conditions including low temperatures and short growing season; more or less following the 10°C mean daily isotherm for the warmest month of the year. In general, north of 67°N.

arête: A narrow, jagged mountain ridge, often above snowline, sculptured by alpine glaciers and formed by backward erosion of adjoining cirque walls.

argillite: (made of clay) Compact argillaceous rock cemented by silica and having no slaty cleavage.

arsenopyrite: Mineral consisting of a combined sulfide and arsenide of iron; typically contains sub-economic gold.

aspect: The azimuth direction toward which a slope faces; principal influence in amount of sunlight at high latitudes.

aufeis: Sheets of ice formed by the freezing of overflow water, typically in braided streambeds north of about 63°N.

augen gneiss: Clots of coarse crystals that develop in quartz and feldspar bands in a metamorphic rock.

augite: Aluminous usually black or dark green pyroxene that is found in igneous rocks.

B

basalt: Dark gray to black, dense to fine-grained igneous rock that consists of basic plagioclase, augite and usually magnetite.

batholith: Great mass of intruded igneous rock that, for the most part, stopped in its rise a considerable distance below the surface.

bedding plane: A distinct rock layer surface; surface separating layers of sedimentary rocks and deposits. Each bedding plane marks the termination of one deposit and the beginning of another of different character, such as a surface separating a sandstone bed from an overlying mudstone bed. Rock tends to break or separate readily along bedding planes.

bedload: Rocks, sediment and other debris rolled along the bottom of a stream or river by moving water.

bedrock: Attached rock that underlies the soil and other unconsolidated material. Bedrock at earth's surface is an outcrop.

bentonite: Absorptive and colloidal clay used especially as a sealing agent or carrier (as of drugs).

Beringia: Unglaciated, essentially treeless part of the Yukon, Alaska and eastern Siberia cut off from more southerly land of North America by ice sheets during many glaciations between 3 million and 10,000 years ago. Used to describe distribution of a species that does not extend east of Coppermine and south of northern British Columbia.

biogenic: Of biological origin, such as the calcareous and silicous oozes on the ocean floor.

biotic: Having to do with living things; applies to the living components of the environment.

biotite: A generally black or dark green form of mica that is a constituent of crystalline rocks and consists of a silicate of iron, magnesium, potassium and aluminum.

bituminous coal: The second hardest coal, compressed, carbonized vegetation. Coal that when heated yields considerable volatile bituminous matter. Also called soft coal.

bog: A peat-covered or peat-filled area, generally with a high water table dominated by mosses, especially Sphagnum. In the Yukon, most bogs are underlain by permafrost, therefore there is little standing water except in ponds.

boreal: Northern, or having to do with northern forested regions.

borehole: Hole drilled in the earth as an exploratory well.

boulder: Rock fragment larger than 60 cm (2 feet) in diameter.

boulder fields: Areas covered with angular boulders resulting from frost fracture of bedrock or rock fall.

braided stream: A stream that consists of a number of small channels separated by sand and gravel bars.

breccia: A rock composed of angular, coarse fragments, fused or cemented into a secondary rock.

Brunisol, Brunisolic: Mildly weathered mineral soil, commonly forming under forest cover and glasslands in southern Yukon.

C

Cache Creek terrane: A tectonic element consisting of Lower Carboniferous to Middle Jurassic-aged rocks between Tagish and Teslin lakes and extending into north-central British Columbia. It is characterized by very thick grey limestone reefs, thinly bedded chert, and submarine volcanic and ultramafic rocks.

calcareous soil: A soil containing enough calcium carbonate or magnesium carbonate to effervesce (fizz) visibly when treated with dilute hydrochloric acid at room temperature.

caldera: A collapsed volcanic cone; a volcanic crater that has a diameter many times that of the vent and is formed by collapse of the central part of a volcano or by explosions of extraordinary violence.

canopy: (1) More or less continuous cover of branches and foliage collectively formed by crowns of adjacent trees, shrubs or herbs depending upon the type of vegetation. (2) The cover of leaves and branches formed by the tops or crowns of plants as viewed from above.

castellations: Pillars of rock on ridges and mountain tops that look like battlements. See "tor."

chalcopyrite: Brassy yellow mineral consisting of copper–iron sulfide and constituting an important ore of copper.

chert: A very hard, smooth-faced rock type consisting essentially of cryptocrystalline quartz and amorphous silica. Like flint, but does not make sparks when struck.

chlorite: A group of usually green minerals associated with and resembling the micas. Characteristic of low grade metamorphism of mafic volcanic rocks.

chromite: Mineral consisting of an oxide of iron and chromium.

chronosequence: A sequence of related vegetation and/or soils that differ in their degree of development because of differences in their age.

chrysotile: Mineral consisting of a fibrous silky serpentine and constituting a kind of asbestos.

circle (stone- or frost-): A form of patterned ground in tundra areas formed by frost action consisting of patches of exposed soil with a border of vegetation and/or rocks.

circumpolar: Distribution throughout the polar regions of North America, Asia and Europe.

cirque: Steep-sided amphitheatre-like hollow in an alpine landscape resulting from mountain glaciation. Progressive headward expansion of neighbouring cirques results in the reduction of the unglaciated slopes between them to sharp, knife-edged ridges or aretes; likely also called horns.

clast: Rock fragment; includes colluvium, gravel, alluvium, tephra, sand, silt and clay.

clay: As a soil separate: mineral soil particles less than 0.002 mm in diameter. As a soil textural class: soil material that is 40% or more clay, less than 45% sand and less than 40% silt.

climate: The sum total of all atmospheric or meteorological influences, mainly temperature, moisture, wind, pressure and evaporation, that influence the landforms, soil, vegetation and land use of a region.

colluvial (colluvium): (1) In soils, material that has been transported downhill and accumulated on lower slopes and/or at the bottom of a hill. (2) In geology, angular fragments of rock; also talus and cliff debris; material of avalanches. (3) Debris transported and deposited by mass-wasting and local unconcentrated runoff on and at the base of steep slopes (including scree, landslide material and talus).

community, plant: (1) A general term for an assembly of plants living together and interacting among themselves in a specific location, no particular ecological status is implied. (2) A unit of vegetation that is relatively uniform in structure and floristic composition and consisting of competing plants of one or more species in a common location. The basic unit of vegetation.

concretions: Hard, compact spherical, oblate or irregular masses in porous sedimentary rocks formed by precipitation from aqueous solution around a nucleus (possibly organic matter). Concretions are composed of silica, carbonate, iron hydroxide, pyrite or gypsum, typically different from the enclosing rock.

conifer, coniferous: A plant belonging to the order Coniferales, bearing cones and needle-like or scale-like leaves.

conodont: Paleozoic tooth-like fossil that is probably the remains of an extinct marine invertebrate.

convection: (1) A cycling between layers due to heat/density changes at lower levels; the circulatory motion that occurs in a fluid at a non-uniform temperature owing to the variation of its density and the action of gravity. (2) The transfer of heat.

copper, native: Relatively pure samples of the metal found in ore bodies.

Cordilleran glaciation: Ice sheets that originated in the mountain ranges of western and northwestern Canada. During the Pleistocene, these sheets coalesced and formed expansive cover in Yukon, British Columbia. and parts of the Northwest Territories.

cover, vegetative: (1) Any vegetation producing a protective mat on or just above the soil surface. (2) The plant parts, living or dead, on the surface of the ground. Vegetative cover is composed of living plants and litter cover of dead parts of plants. (3) The area of ground covered by the vertical projection of the aerial parts of plants of one or more species. (4) The entire canopy of all plants of all sizes and species found in an area. (5) Plants or vegetation used by animals for nesting, resting, escape or protection from adverse environmental conditions.

craton: Stable relatively immobile area of the earth's crust that forms the nuclear mass of a continent or the central basin of an ocean.

crustose lichen: Having a thin thallus adhering closely to a substrate (such as rock, bark or soil).

cryoplanation: Reduction of a land surface by intensive frost action, supplemented by erosion and transport by wind or running water.

cryoplanation terrace: Flat surfaces separated by short, steep rock walls, which have formed after long-term frost weathering of host material.

Cryosol: A class of soils that are all underlain by near-surface permafrost.

cryoturbation: Frost heaving producing mass displacement and mixing within a soil. Soils affected by cryoturbation are classified as Turbic Cryosols.

cryptocrystalline: Having a crystalline structure so fine that no distinct particles are recognizable under the microscope.

D

dacite: Extrusive igneous rock composed of plagioclase, quartz, pyroxene and/or hornblende.

deciduous: Woody plants, or pertaining to woody plants, that seasonally lose all of their leaves and become temporarily bare-stemmed.

deformation: A general term for the process of folding, faulting, shearing compression or extension of rocks as a result of various earth forces.

degradation: To wear down slowly, as by erosion (land) and melting (ice or permafrost).

delta: An alluvial deposit, commonly triangular, deposited above and below water at the mouth of a river or stream. See "outwash fan."

dextral displacement: Moved towards the right (when viewed from above and oriented northward).

diamicton: Any unconsolidated material composed of clay, sand, silt, gravel and boulders.

diorite: Dark-coloured igneous intrusive rock containing plagioclase and hornblende (an amphibole), augite (a pyroxene) or biotite (mica) minerals.

disjunct: Applied to a species that was once found over a wide area but has become separated into isolated populations.

distal: Applied to a depositional environment sited at the farthest position from the source area and generally characterized by fine-grained sediments.

disturbance: Any mechanism that limits plant biomass by causing its partial or total destruction.

diversity: An expression of the variety of species that exists in a community, or of the variety of communities in a landscape. It bears to qualitative observations the relation that variance bears to quantitative measurements.

diversity, species: A product of richness and evenness; species richness weighted by species evenness and expressed as an index number. Species richness: Expression of the number of species of plants or animals present in an area. The more species present, the higher the degree of species richness.

divide: A dividing ridge between drainage areas; watershed.

dolostone: A carbonate rock made up predominately of the mineral dolomite, $CaMg(C0_3)_2$.

downcutting: Vertical erosion of a riverbed by running water.

downfaulting: Process in which a part of the land surface is lowered from the surrounding surface due to movement of the crustal plates of the earth. Synonym: graben.

drainage basin, hydrology: An area sloping into a single stream. Synonym: watershed.

drainage, pedology: Frequency and duration of the periods when the soil is free of saturation or partial saturation. Commonly expressed from very poorly drained to excessively drained.

drift: Glacial sediment deposits, both unstratified (till) and stratified (glaciofluvial).

drumlin: A smooth, oval-shaped landform resulting from glacial override that deposits unconsolicated materials on the lee side of surface protrusions and streamlines them. The long axis of the drumlin is parallel to the direction of glacial advance.

dwarf shrub: A shrub or woody plant usually less than 0.2 m tall.

E

ecoregion: A regional ecological unit with a fairly wide range of environmental conditions existing under a broadly similar physiography and climate.

ecotone: A transition zone that exists between two ecological communities. Members of both communities may compete within this zone, thus yielding an apparent enrichment known as the edge effect.

ecozone: Large tracts of land where general ecological conditions are similar.

edge effect: In ecology, the apparent increase in number of species inhabiting an ecotone compared with a smaller number occupying.

embayment: Formation of a bay. A bay or a conformation resembling a bay.

endemic (ecology): A taxon confined to a particular region and with a comparatively restricted distribution (usually a relatively small geographic area or an unusual or rare type of habitat).

eolian: Borne, deposited, produced or eroded by the wind.

ericaceous: Low- to moderate-growing shrub in, or closely related to, the heath family Ericaceae, e.g. blueberry.

erosion: (1) The wearing, or denudation, or the land surface. A term for the way in which geologic agents of movement secure earth materials. Used loosely to include processes both of acquisition and transportation by running water, wind, ice or other geologic agents. (2) Erosion caused by geologic processes acting over long geologic periods and resulting in the weathering of mountains and the creation of such landscape features as floodplains and coastal plains.

erratic: A rock transported by glacier action from a distant source.

esker: A narrow, winding ridge of stratified gravelly and sandy drift resulting from deposition between ice walls by meltwater channels flowing on, in, or under the glacial ice.

Eutric Brunisol: A brownish soil without permafrost that is mildly chemically weathered and has an alkaline to slightly acidic reaction. See "Brunisol."

evaporite: A chemical sedimentary rock consisting of minerals precipitated by evaporating water, mainly halite (salt) and gypsum.

evapotranspiration: Combined loss of water from soil by evaporation and water lost from the surfaces of plants, mainly via leaf pores (transpiration).

evolution: Change with continuity in successive generations of organisms; descent with modification.

exfoliation: Stripping of concentric rock slabs from the outer surface of a rock ass: like peeling the layers of an onion.

exposure: (1) Susceptibility of a site to weather conditions, particularly sun and wind. (2) Direction in which a slope faces. See "aspect." (3) Cross-section of bedrock visible at the earth's surface.

extralimital: Outside of a usual range; an accidental or uncommon (species) occurrence.

F

facies: General appearance; a part of a rock or group of rocks that differs from the whole formation (as in composition, age, or fossil content).

fault: A fracture in the crust of the earth accompanied by a displacement of one side of the fracture relative to the other, usually in a direction parallel to the fracture. The surface of rock rupture along which there has been differential movement of the rock on either side.

feldspar: The most abundant group of rock-forming silicate minerals. The plagioclase series extends from calcic to sodic end-members; the alkali feldspar group extends from potassic to sodic end-members.

felsenmeer: (1) From the Danish "fjoeld-mark," or rock desert. A type of tundra ecosystem characterized by rather flat relief, very stony soil; and low, widely spaced vascular plants. (2) Rocky habitats with a cover of low plants on exposed alpine summits and ridges, characterized by low mat and cushion plants and an abundance of surface rocks. (3) Stony, sparsely vegetated alpine habitats that are intermediate between a boulder field and an alpine meadow.

felsic: Silica-rich igneous rocks with a relatively high content of potassium- and sodium-rich minerals. Generally light-coloured and synonymous with silicic, opposite of mafic.

fen: (1) A type of wetland characterized by grass, sedge, or reed-covered peatlands. The water table is at the surface most of the time. The water and peat are less acidic than in a bog and richer in nutrients. (2) A tract of low, wet ground containing sedge peat, relatively rich in mineral salts, alkaline in reaction and characterized by slowly flowing water. Vegetation is generally sedges and grasses, often with low shrubs and sometimes a sparse cover of trees. Sphagnum mosses are absent or of low cover.

firn: A German term for snow above a glacier that is partly consolidated by alternate thawing and freezing, but has not yet become glacier ice. It is compacted, granular, but still pervious snow that has a density usually greater than 0.4, but less than 0.82 g/cm^3. Considered by some to be any snow that has survived one or more ablation seasons. Firn may later become glacial ice.

floodplain: Low area that borders a stream over which water spreads when the stream tops its channel banks.

fluvial: Pertaining to a river. The set of mechanisms that operate as a result of water flow within a stream channel, bringing about the erosion, transfer and deposition of sediment.

flysch: Thick and extensive deposit, largely of sandstone, that is formed in a geosyncline adjacent to a rising mountain belt and is especially common in the Alpine region of Europe.

flyway: Established bird migration route.

foliated: Leaf-shaped.

footwall: The lower wall of an inclined fault.

forb: A non-cultivated herbaceous plant other than grasses.

formation: (botany) A regionally extensive assemblage of natural vegetation with a recurring physiognomy determined by its dominant life forms.

frost action: The physical weathering process of repeated cycles of freezing and thawing usually in the presence of water.

frost blister, frost boil: Areas of bare soil that are sufficiently disturbed by frost action to prevent plant colonization. On slopes, fine material in unsorted circles moves slowly downhill producing banked or "stepped" frost boils. Synonym: circle.

frost churning: Effect of frost heaving on soil material above the permafrost table. Also referred to as cryoturbation, hence the soil name Turbic Cryosol.

fruticose lichen: Having a shrubby often branched thallus that grows perpendicular to the substrate.

fusilinid: (fossil type) Any of a family (Fusulinidae) of extinct marine foraminifers.

G

galena: A bluish-gray metallic mineral consisting of lead sulfide; the principal ore of lead.

geomorphology (geomorphic processses): The scientific study of the landforms of the earth's surface and the processes that have shaped them.

glacial outwash: Coarse deposits that are left by glacial meltwater streams that have high sediment loads and turbid water.

glacier: A mass of ice, formed by the recrystallization of snow, that flows or has flowed under the influence of gravity at some time in the past.

glaciofluvial material: Gravel and sand deposited by glacial meltwater.

glaciolacustrine: Silt and clay originally deposited within glacial lakes.

glaciomarine: Pertaining to glacial-marine conditions; sediment deposited in seawater along glacial margins.

glauconitic: Mineral consisting of a dull green earthy iron potassium silicate occurring in greensand.

Gleysol, Gleysolic, Gleyed soil: A class of soil having one or more horizons form as a result of waterlogging and lack of oxygen. The term "gleyed" also designates gray horizons and horizons having yellow and gray mottles as a result of intermittent waterlogging.

gneiss: A coarse-grained regional metamorphic rock that shows compositional banding and parallel alignment of mica, hornblende and other metamorphic minerals.

graminoid: (1) Grass-like in appearance, with leaves mostly very narrow or linear in outline. (2) An herbaceous grass or plant of similar growth form. (3) Plants which are grass-like in appearance, even though they are not grasses in a taxonomic sense, such as sedges, reeds, cattails and others, (e.g. cottongrass).

granite: Family of light-coloured intrusive igneous rocks in which quartz, feldspar and mica are the chief minerals.

granodiorite: Granular intrusive quartzose igneous rock intermediate between granite and quartz containing diorite with plagioclase predominant over orthoclase.

greywacke: An old rock name applied to a dark and very hard coarse sandstone or fine-grained conglomerate in an abundant and compact (sometimes partly metamorphosed) clayey matrix having the composition of slate.

ground ice: Term used to denote bodies of more or less clear ice within permanently frozen ground (permafrost); also includes pore ice, ice lenses, ice wedge ice, pingo ice and buried ice.

H

habitat: (1) The particular kind of environment in which a plant or plant community is living or the environment in which the life needs of a plant, population or community are supplied. (2) The natural abode of a plant or animal; refers to the kind of environment in which a plant or animal normally lives as opposed to the range or geographical distribution.

hanging glacier: A body of ice that exits into a valley above the level of either the valley floor or its contained glacier; a terminal "icefall."

hanging valley: A former glacial tributary valley that enters a larger valley above its base, high up on the valley wall.

heath: Open land overgrown with shrubs, typically heather *(Calluna)* or ericaceous plants.

herb: Flowering plant with no significant woody tissue above the ground; includes both forbs and graminoids.

heteropteran: Group of insects known as true bugs that includes plant bugs, water bugs and bed bugs.

Holarctic: Circumpolar; biogeographic region including the northern parts of the old and the new worlds and comprising the Nearctic and Palearctic regions or subregions.

horizon, soil: Approximately horizontal layer of soil with distinctive properties reflecting the formation processes.

horn: A sharp mountain peak; created by the rearward erosion of a number of cirques towards a single peak. Synonym: matterhorn. The sharp spire of rock formed as glaciers in several cirques erode into a central mountain peak.

hornblende: Mineral that is the common dark variety of aluminous amphibole.

hornfels: Fine-grained silicate rock produced by metamorphism, especially of slate.

hummocks, earth: (1) A type of patterned ground characterized by a three dimensional knob-like shape and a cover of woodland vegetation. (2) Low, rounded knobs of fine soil material covered by a tight mass of moss, scrubby plants and small trees commonly found in the subarctic region.

hummocky: Refers to a landscape of hillocks, separated by low sags, having sharply rounded tops and steep sides. Hummocky relief resembles rolling or undulating relief, but the tops of ridges are narrower and the sides are shorter and less even. Typical of landslide deposition and stagnant glacier meltout deposits.

hydrophilic: Water-loving.

Hypsithermal climatic optimum: A warm interglacial phase after the last glacial period, occurring about 6,000 years ago. Maximum ice shrinkage occurred during this period.

I

ice lens: Segregated ground ice oriented sub-parallel to the ground surface.

ice wedge: Wedge-shaped vertical or inclined sheets of foliated ground ice that forms in thermal contraction cracks in permafrost. Formation and active growth of wedges requires temperatures of 40°C to 45°C for creation of contraction cracks. Inactive wedges occur in the discontinuous permafrost zone.

imbricate: Lying lapped over each other in regular order.

inlier: Mass of rock whose outcrop is surrounded by rock of younger age.

interstices: Spaces that intervene between closely spaced things or in something generally continuous.

inversion: An air mass where warmer air overlies cooler air; an increase of temperature with height through a layer of air.

isostatic depression: A general lowering of a portion of the earth's crust maintained by a yielding flow of rock material beneath the surface under gravitative stress.

isostatic rebound: An adjustment of the land's position relative to current sea level as a result of deglaciation and the removal of the immense weight of the ice.

isothermal: Of connected points. Areas having the same temperature in a given time frame.

isotopic: Of any of two or more species of atoms of a chemical element with the same atomic number and nearly identical chemical behaviour but with differing atomic mass or mass number and different physical properties.

J

Jökulhlaup (pronounced "YOLK-a lup"): An Icelandic term for glacial outburst flood; a sudden, often annual, release of meltwater from a glacier-dammed lake.

K

kame: Stratified drift deposited in depressions and cavities in stagnant ice and left as irregular, steep-sided hills when the ice melts.

katabatic wind: Flow of cold dense air down a slope (as of a mountain or glacier) in an area subject to radiational cooling.

kilolangley: A unit of solar radiation equivalent to 1,000 g calories per square centimetre of irradiated surface.

krummholz: Gnarled, stunted and bushy trees hampered by sub-marginal growing conditions, snow loading and desiccating winds at high elevations (near alpine) in temperate mountains and arctic regions.

L

lacustrine: Pertaining to lakes.

lacustrine littoral wetlands: Freshwater wetland habitat extending from the shoreward boundary of a lake to a depth of 2 m below low water or to the maximum of non-persistent emergent vegetation.

landslide: The rapid downhill movement of a mass of soil and loose rock.

lapse rate: Decrease of atmospheric temperature with increasing altitude without a change in energy.

Laurentide glaciation: The large continental ice sheets that originated in the Canadian Shield and extended across all of North America from the Atlantic to the foothills of the western Cordilleran. Last active between 25,000 and approximately 10,000 years before present.

lazulite: Often crystalline azure-blue mineral that is a hydrous phosphate of aluminum, iron and magnesium.

leaching: Removal of soil nutrients or other elements by water percolation.

life history: Changes through which an organism passes in its development from the primary stage to its natural death.

listwaenite: A schist surrounding gold-bearing quartz veins.

lithology: Character of a rock formation; also, a rock formation having a particular set of characteristics.

lithostratigraphy: A part of rock strata science concerned with the component rock types, minerals and texture.

little brown myotis: The bat Myotis lucifugus (Le Conte).

Little Ice Age: A period of worldwide glacier expansion and contraction spanning from approximately 1450 to 1850. This is considered one of several neo-glacial pulses of ice.

littoral zone: In lakes, the shallow water zone occupied by rooted plants; in the sea, the intertidal zone.

loess: Unconsolidated, wind-deposited sediment composed of silt and fine sand with little or no stratification. Usually buff to yellowish brown loamy deposit found in North America, Europe and Asia. Soils derived from these wind-blown materials are fertile.

Loam: (1) A term used by soil scientists to describe a soil composed of approximately equal proportions of sand, silt and clay. (2) A soil textural class. See “texture soil.”

M

mafic: Silica-poor igneous rock with a high content of magnesium-, iron- and calcium-rich minerals. Typically dark-coloured igneous rocks.

magma: Molten rock that forms igneous rocks upon cooling. Magma on the earth’s surface is known as lava.

magnetite: Black isometric mineral of the spinel group that is an oxide of iron and an important iron ore.

marsh: Periodically inundated mineral ground characterized by a vegetation cover of submerged and floating aquatic plants, emergent sedges and grasses, and typically occupying the shoreline of a lake or river.

massif: A principal mountain mass; a block of the earth’s crust bounded by faults or flexures and displaced as a unit without internal change.

McConnell glaciation (Wisconsinian): Last glaciation between approximately 35,000 and 10,000 years ago in the mountains ranges of southern and central Yukon.

mesic: Of moderate moisture content.

metabasalt: Metamorphosed basalt.

metamorphism: Adjective to describe the process and changes to mineralogy and texture imposed on rocks by elevated pressure and temperature.

metasandstone: Metamorphosed sandstone.

micaceous: Containing mica; of any of various coloured or transparent mineral silicates crystallizing in monoclinic forms that readily separate into very thin leaves.

microtine: Of the shrew family.

mineral soil: Soil that is primarily composed of sand, silt and clay particles and is low in organic material (less than 20% by weight).

minerotrophic: Applied to wet peatlands, such as fens, that are supplied with mineral-rich groundwater.

miogeocline: Sedimentary rocks marking the coastal margin of ancient North America.

mixedwood: Forests composed of a mixture of deciduous and coniferous tree species.

moder humus form: Refers to the nature of the organic matter found in the surface of soil. Moder humus is well decomposed and found both lying on the surface and mixed into the upper mineral soil horizon. Typically found under open deciduous woodlands.

moiety: Clan; one of two basic group subdivisions within a tribal culture, often with particular duties, privileges and internal sexual taboos.

molybdenite: Blue, usually foliated mineral consisting of molybdenum disulfide that is a source of molybdenum.

montane glacier: Constant body of ice in the biogeographic zone of relatively moist cool upland slopes below timberline dominated by large coniferous trees.

monzonite: Granular igneous rock composed of plagioclase and orthoclase in about equal quantities together with augite and biotite.

moraine: (1) An accumulation of glacial drift formed by the direct action of glacial ice. Examples are lateral, terminal and recessional moraines. (2) Debris deposited directly by a glacier without appreciable water sorting. May contain boulders, gravel and clay mixed together.

moraine, terminal: A belt of thick glacial debris that generally marks the termination of major glacial advances.

morphogeological: Physiographic.

moss: A plant in the class Musci of the phylum Bryophyta, and which usually occurs in a damp habitat.

muck: Organic matter-rich silty colluvium and loess (often referred to as “muck” by placer miners).

mudboil: See “circle.”

muscovite: Light-coloured mica. Mineral that is a colourless to pale brown potassium mica.

mylonite: A chert-like rock without cleavage but with a banded or streaky structure produced by extreme shearing of rocks that have been pulverized and rolled during intense dynamic metamorphism.

N

Nearctic: Greenland and the northern area of North America.

neoglacial: Period of expanded alpine glaciation subsequent to the maximum ice retraction of the Hypsithermal Climatic Optimum. Pulses of neoglacial ice have occurred during the last 5,000 years.

net, non-sorted: Patterned ground with a mesh of non-sorted circles and/or stripes, and with a non-sorted appearance due to the absence of a border of stones that characterizes a sorted net.

net, sorted: Patterned ground with a mesh of sorted circles and/or stripes, and with a sorted appearance commonly due to a border of stones surrounding finer material. See “patterned ground.”

nonanadromous: living only in fresh or salt water.

nunatak: Inuit word (meaning "lonely peak") referring to an isolated mountain peak, usually of bare rock, projecting above the surrounding ice sheet, icefield or glacier.

O

oolite: Rock consisting of small round grains usually of calcium carbonate cemented together.

oribatid mite: Any of a superfamily (Oribatoidea) of small oval eyeless non-parasitic mites having a heavily sclerotized integument with a leathery appearance.

organic material: The material in or living immediately above the soil derived from organic sources, usually from plant remains. The term covers matter in all stages of decay and includes living soil biota.

organic soil: A class of wetland soils that are composed entirely of decomposed plant remains. Organic Cryosols are as above but are underlain by near-surface permafrost.

orogen: Deformed crustal belt associated with mountain building, typically linear or arcuate in plan.

orogeny: Process of mountain formation especially by folding of the earth's crust.

orographic: In meteorology, applied to precipitation or cloud caused by elevated topography on air streams. Orographic clouds and rain are produced by condensation of moist air during its ascent over mountains.

Orthic (soil): A taxonomic modifier used in soil classification to describe the "typical" or most commonly occurring member of a soil class.

outwash, glacial: Stratified sand and gravel produced by glaciers and carried, sorted and deposited by water that originated mainly from the melting of glacial ice. Glacial outwash is commonly in valleys on landforms such as valley trains, outwash terraces, eskers, kame terraces, kames, outwash fans or deltas.

outwash plain: A landform of mainly sandy or coarse textured material and of glaciofluvial origin deposited gradually. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

overlap assemblages: Younger igneous rocks and sedimentary rocks deposited on top of accreted terranes.

oxbow lake: Crescent-shaped lake located in an abandoned river bend that has become separated from the main stream by a change in the course of the river.

oxidation: The decomposition process by which iron or other metallic elements in a rock or soil combine with oxygen to form residual oxide minerals.

P

Palearctic: Biogeographic region or subregion that includes Europe, Asia north of the Himalayas, northern Arabia and Africa north of the Sahara.

paleoendemic: A remnant of a relict fauna that was more widely distributed before the last glaciation.

paleokarst: An area that was karstified and subsequently buried under sediments.

Palustrine: Pertaining to swamps or marches and to materials deposited.

palsa: Peat-covered mound with a perennially frozen core. Usually ombrotrophic and generally much less than 100 m across and from one to several metres high. In Fennoscandia, palsas are generally treeless, but in North America, they commonly support sparse stunted larch or black spruce.

parent material: (1) The great variety of unconsolidated and more or less weathered organic and mineral material from which soil forms. (2) The C horizon of the soil.

patterned ground: A ground term for the more or less symmetrical forms such as circles, polygons, nets, steps and stripes that are characteristic of, but not necessarily confined to, ground subject to intensive frost action or permafrost. Circles, polygons and nets are most typically formed on level ground and stripes and steps are found on slopes. Patterns may be sorted when the individual units of the pattern are bordered by coarse materials ejected from the finer matrix by freezing and thawing.

peat: (1) Partially decomposed plant remains accumulated under waterlogged conditions. (2) Layer consisting largely of organic residues originating under more or less water-saturated conditions through the incomplete decomposition of plant and animal constituents and resulting from anaerobic conditions, low temperatures and other causes in combination.

peat mound: Mound of peat elevated above the surrounding terrain and usually ombrotrophic. It differs from a palsa by lacking a permafrost core.

pediment: Broad gently sloping bedrock surface with low relief that is situated at the base of a steeper slope and is usually thinly covered with alluvial or colluvial unconsolidated deposits.

pericratonic terrane: Fragments of the earth's crust with consistent internal stratigraphy that in part resembles the stratigraphy of the miogeocline (the western margin of ancestral North America, also referred to as the craton). Pericratonic terranes are components of the Omineca Belt, which straddles the Tintina Fault in the Yukon. Although their origin is uncertain some may be faulted off sections of the miogeocline which have been displaced laterally.

peridotite: Any of a group of granitoid igneous rocks composed of ferromagnesian minerals and especially olivine.

periglacial: Originally used to indicate the climate and climatically controlled features adjacent to Quaternary ice sheets. A family of phenomena that is a result of frost weathering and that has developed in terrain marginal to Quaternary ice sheets and now loosely used to refer to supposedly similar climates and features whether or not they are related to glaciers including patterned ground in general. The predominant influence upon the substrate is freeze–thaw oscillations.

permafrost: Perennially frozen ground, or ground in which a temperature below 0°C has existed continuously for two or more years. Permafrost is defined exclusively on the basis of temperature and no moisture or ice need be present. The layer of ground above the permafrost that freezes and thaws each year is called the "active layer." Refers to both the phenomenon of permanently frozen ground and to the frozen material. See "permafrost, continuous" and "permafrost, discontinuous."

permafrost, continuous: A continental zone of perenially frozen ground in which permafrost is present everywhere except under lakes and rivers that do not freeze to the bottom.

permafrost, discontinuous: A broad belt across northern Canada and Alaska, south of the continuous permafrost zone, that includes numerous permafrost-free areas that progressively increase in size and area from north to south until the permafrost-free zone is reached.

permafrost table: The upper surface of permafrost typically found from 50 cm to 3 m below the soil surface.

phenocryst: One of the prominent embedded crystals of a porphyry.

phyllite: A metamorphosed mudstone with a silky sheen, more coarse-grained than a slate and less coarse-grained than a schist.

physiography: (1) The branch of physical science dealing with the physical features of the earth's surface and the description of landscape. (2) Study of the genesis and evolution of landforms.

picrolite: A fibrous or columnar variety of serpentine, a green or greenish yellow mineral with a greasy or silky luster.

piedmont ice: Frozen water lying or formed at the base of mountains. A piedmont glacier is formed by the coalescence of two or more valley glaciers and spreads out at the foot of the mountains.

pingo: An Inuktitut term for a perennial, conical-shaped, ice-cored mound as much as 65 m high and 1,000 m in diameter. Generally found in the Mackenzie River Delta, Yukon coastal plain, and with occasional occurrences in northern and central Yukon.

pioneer species, colonization: Plant capable of invading bare sites and persisting there, i.e. colonizing until replaced by other species as succession proceeds, for example, *Stereocaulon* spp. and *Epilobium* spp. Plants established on a relatively or absolutely bare area where there is as yet little or no competition.

placer: A detritus sedimentary deposit where valuable minerals or metal (gold, silver, copper) have been concentrated by water, owing to higher density than other gravels.

plateau: Usually extensive land area having a relatively level surface raised sharply above adjacent land on at least one side: tableland.

platform: Broad continental shelf.

Pleistocene: The first of two epochs of the Quaternary period, lasting from about 1.64 million years ago to the beginning of the Holocene, about 10,000 years ago. Also called the Glacial epoch, this time is marked by several glacial and interglacial episodes in the northern hemisphere.

plucking: The loosening and removal of rock fragments or larger blocks by glaciers.

pluton: A general term for a large mass of igneous intrusive rock such as granite, generally considered to have been intruded at low temperature in a near-solid state. According to increasing size, these bodies may also be referred to as plugs, stocks and batholiths.

pod: A tapered and roughly cylindrical body of ore or mineral.

polygon: A patterned ground closed-form, straight-sided feature, usually occurring due to ice-wedge creation.

polymictic: Referring to lakes in which water circulation occurs more or less continually with only short periods of stagnation.

porphyry: An igneous rock containing large, dispersed crystals of one mineral (quartz, feldspar) in a groundmass of much finer-grained minerals.

post-accretionary: Describes an igneous event (granitic intrusive or volcanic activity) that occurred after (and perhaps as a result of) the overriding of terranes along the western margin of ancestral North America.

predation: Hunting; a mode of life in which food is primarily obtained by the killing and consuming of animals.

proglacial lake: Impounded water in front of, and touching, an existing glacier.

pyroclastic: Lump of rock ejected by volcanic eruption; formed by or involving fragmentation as a result of volcanic or igneous action.

Q

Quesnellia: A tectonic element of Upper Paleozoic and Lower Mesozoic volcanic and sedimentary strata with associated granitic bodies, best developed in south-central British Columbia. In the Yukon, Quesnellia forms a thin strip east of Teslin Lake (augite porphyry volcanics) and early Mesozoic intrusions along trend (e.g. Tatchun pluton).

R

rain shadow: Lee of highlands.

range: (1) The geographic and altitude limits of occurrence of a species of plant or animal. (2) That portion of the earth's surface enclosed by a line drawn about the outermost limits of the distribution of a taxon. A species does not occupy all the area within its range owing to differences in soil, topography, etc. See "habitat."

refugia: Small areas in which organisms have survived when most of their former range became uninhabitable owing to climatic change or glaciation. (2) An area that has not been exposed to great changes undergone by the region as a whole, and, as a result, provided conditions suitable for the survival of relict species.

regolith: The unconsolidated residual or transported material above the bedrock layer. Synonym: parent material.

Reid Glaciation (Illinoian): Older glaciation estimated to have occurred in the Yukon prior to 120,000 years ago.

relict: (1) A species properly belonging to an earlier vegetation than that which is now found. (2) A plant community or species which, through the operation of some compensatory or protective environmental feature, has survived some important change, e.g. climate or land use, that has altered the general vegetation in the surrounding area. (3) A remnant or fragment of a flora that remains from some former period when it was more completely developed. (4) A remnant of the population of a species that was formerly more widespread.

Rendzina: Any of a group of dark grayish brown to black soils developed in regions of high to moderate humidity from soft calcareous marl, or limestone. In the Yukon, this type of soil is found in unglaciated regions of limestone ranges.

residuum: Materials remaining from the in situ weathering of bedrock.

retrogressive thaw slump: Landslide triggered by the melting of ice-rich permafrost. The headwall of the slump tends to melt back into the slope. Common on the Yukon north coast.

rhyolite: Very acid volcanic rock that is the lava form of granite.

riparian: Relating to, or living or located on, the bank of a natural watercourse (as a river) or sometimes of a lake or a tidewater. Synonym: riverine.

rock glacier: A creeping tongue-like body of angular boulders, fine material and interstitial ice with the general appearance and slow movement of a small valley glacier. It occurs at high altitudes in rugged terrain and initiate in actively wasting cirques or steep-walled amphitheatres.

rotational slide: Landslide of a largely intact mass of rock or soil material downslope but with a rotational motion.

S

scarp: Line of cliffs produced by faulting or erosion.

scheelite: Mineral consisting of the tungstate of calcium that is a source of tungsten and its compounds.

schist: A metamorphic rock defined by parallel alignment of platy or elongated minerals.

scree: Accumulation of loose stones or rocky debris lying on a slope or at the base of a hill or cliff; talus; angular pebbles.

sedge: A plant in the family Cyperaceae, grass-like in appearance, but with solid stems that are triangular in cross-section. Common peat-forming plant in wetlands.

sedimentary rock: Rock made up of particles deposited from suspension in water. The main kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

serac: A jagged pinnacle, sharp ridge or block of ice formed where a glacier is periodically broken (crevasses or icefall).

seral, sere: Non-climax, i.e. species or a community demonstrably susceptible to replacement by another species or community, usually within a few decades or a few centuries at most.

serpentine: Ultramafic rocks which have been subjected to hydrothermal alteration such that magnesium-rich minerals are converted to green and yellow minerals, which have a greasy or silky lustre.

sheetwash: A form of uniform surface erosion by rainfall runoff.

shrub: A woody perennial plant differing from a tree by its low stature and by generally producing several basal stems instead of a single bole, and from a perennial herb by its persistent and woody stem(s).

silica: The chemically resistant dioxide of silicon, generally known as quartz or (in cryptocrystalline form) chalcedony, or (hydrated) opal. Impure cryptocrystalline silica is chert or flint.

silicic: See “felsic.”

Slide Mountain Terrane: A tectonic element of mid- to late Paleozoic and rare Triassic rocks that in the Yukon underlies the Campbell Range and the Semenof Hills. It contains mainly mafic volcanic rocks with related ultramafic and granitic bodies, siltstone and chert.

snowpack, snowbed: Accumulated snow cover through the winter. Of particular interest to hydrologists in estimated spring runoff.

soil: The unconsolidated mineral and/or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. In this sense, soil has a thickness that is determined by the rooting depth of plants.

soil creep: Slow downhill movement of surface material due to gravity.

solifluction: Downhill movement (“flowing soil”) of earth materials resulting from frost action characteristic of areas with cold arctic or alpine climate. A potent agent of mass-wasting and more effective than those generally operating in temperate regions, solifluction prevents the development of typical soil profiles and influences the development of plant cover. Produces a smooth slope.

solifluction lobe: Tongue-like mass of mobile solifluction debris commonly with a steep front and relatively gentle upper surface.

solum, sola: Weathered layers of soil above the parent material including the A and B horizons.

sphalerite: Widely distributed ore of zinc composed essentially of zinc sulfide.

Stikinia: A terrane containing well-stratified Lower Devonian to Middle Jurassic volcanic and sedimentary strata and related plutonic bodies which underlies north-central British Columbia. from Smithers to Telegraph Creek and extends in the Yukon from Bennett Lake to Minto. It includes the Whitehorse Trough.

stratiform: Arranged in layers.

stratigraphy: The science of rock strata, especially their indications of past depositional environment, sequence in time, and correlation of beds in different localities. The succession and age relation of layered rocks.

stripes, non-sorted: Patterned ground with a striped pattern and a non-sorted appearance due to parallel lines of vegetation-covered ground and intervening strips of relatively bare ground, oriented up and down the slope. Such stripes change their dimensions with changes in slope steepness and position on a slope.

stripes, sorted: Patterned ground with a striped pattern and a sorted appearance due to parallel lines of stones and intervening stripes of dominantly finer material oriented down the steepest available slope. Also called stone-bordered stripes, earth stripes and rock stripes.

subaerial: Situated, formed, or occurring on, or immediately adjacent to, the surface of the earth.

subalpine: The distinctive type of vegetation, usually open forest of reduced height and vigour, below the alpine tundra in mountainous areas.

subarctic: Zone between the arctic (latitudinal) tree limit, more or less following the 10°C mean daily isotherm for the warmest month of the year, and the closed canopy boreal forests to the south. This zone is climatically related to the summer position of the arctic frontal weather system. It constitutes a biotic transition belt (the forest-tundra ecotone) between the treeless arctic zone and the forested boreal zone.

subduction: Action or process of the edge of one crustal plate descending below the edge of another.

succession: (1) The gradual replacement of one community of plants by another, the sequence of communities being termed a sere and each community a seral (successional) stage. A sere whose first stage is open water is termed a hydrosere; one whose first stage is dry ground is a xerosere. (2) Any series of vegetational communities following one another in an area, repeating themselves under similar conditions (habitat or environment) and clearly due in each case to the same or a similar set of causes. (3) The process of replacement of one plant species by another.

superterrane: Subcontinent-sized tectonic element resulting from the amalgamation of two or more terranes, before their collective impingement on ancestral North America.

supratidal: The portion of a tidal flat that lies above the level of mean high water for spring tides. It is inundated only occasionally by exceptionally high tides or storm surges.

surficial geology (surficial deposits): The study and description of unconsolidated surface deposits of fluvial, colluvial, aeolian or glacial origin.

swamp: A type of wetland in which certain trees and shrubs grow. Not a common form of wetland in the Yukon; more commonly found in temperate regions.

syenite: A coarse-grained granitic rock characterized by alkali (potassic) feldspar and up to 60% quartz.

syncline: Trough of stratified rock in which the beds dip toward each other from either side.

syngenetically: Formed together at the same time.

T

taiga: A Eurasian term for the subarctic forest dominated by conifers (as spruce and fir) that begins at the arctic (latitudinal) treeline and ends on the northern limit of the boreal forest.

talik: Area of unfrozen ground beneath large waterbodies in the zone of continuous permafrost.

talus: The debris from rock falls that is accumulated by gravity at the foot of cliffs and steep slopes. The sloping heap of rock fragments is termed talus (from the French term for slope). Synonymous with scree although this is usually composed of smaller fragment sizes.

tectonics: The study of movement and deformation of the crust on a regional to global scale.

tephra: A collective term for all volcanic materials, which during an eruption, are ejected from a crater or vent and transported through the air; includes volcanic dust, ash, cinders, lapilli, scoria, pumice, bombs and blocks.

terrace: (geology) An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a floodplain, and is seldom subject to overflow.

terrain(s): The physical features of a tract of land.

terrane: A fault-bounded body of rock of regional extent characterized by a geologic history different from that of adjacent terranes. They are tectonic elements considered to have been displaced from their place of origin.

texture, soil: A property defined on the basis of particle size distribution and thus dependent on relative proportions of sand, silt and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles are sand, loamy sand, sandy loam, loam, silt, silty loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay.

thallus: Simple vegetative body undifferentiated into true leaves, stem and root, e.g. lichen.

thalweg: Deepest part of a streambed.

thermokarst: Karst-like topography produced in a permafrost region by local melting of ground ice and subsequent differential settling.

thrust: When crust blocks are pushed towards one another and one slips higher in relation to the other along a fracture line; a nearly horizontal geological fault.

till: (1) An unstratified, non-sorted deposit of gravel, boulders, sand and finer materials which has been transported and laid down by glacial ice. (2) Non-sorted, non-stratified glacial drift deposited directly by the ice. (3) Sometimes used interchangeably with moraine.

tor: Isolated rock outcrops; heavily weathered pillar-like remnants atop flat ridges; castellation above the surrounding terrain. Tors typically contain jointed blocks piled one upon the other. Classic skyline in the Klondike Plateau Ecoregion.

tree: A woody perennial plant, typically large (a mature height of at least 5 m) and with a single well defined stem and a definite crown shape. Some plants, such as willows, may grow as either trees or shrubs.

treeline: A loose term for the limit beyond which trees cannot thrive. May refer to altitudinal or latitudinal tree limit. Timberline, by contrast, is sometimes used to describe the rough limit of timber (forest) rather than isolated trees.

tributary: The smaller of two streams where they meet.

truncate: Cut off flat; having the end square or even.

tufa: A porous rock formed as a deposit from springs or streams; travertine (tufa) variety of limestone that forms stalactites and stalagmites and other deposits in limestone caves (dripstone) and the mouths of hot and cold calcareous springs.

tuff: A consolidated rock composed of fragments and fine ash erupted by a volcano. It may have fused by compaction while still hot from the eruption, or later as a result of burial and percolating water.

tundra: (1) From the Finnish ("tunturi") meaning a treeless ecosystem and describing the landscape beyond the cold limits of tree growth. (2) A cold climate landscape having a vegetation without trees. The absence of trees is caused by a complex of conditions that is ultimately related to regional climate. This regional aspect distinguishes tundra from treeless bogs and similar local areas without trees due to edaphic extremes in areas that otherwise support a forest cover. (3) The landscape beyond the temperature limits of tree growth. (4) The so-called "barren ground" north of the circumpolar coniferous forests. (5) Treeless areas where dwarf shrubs and low herbaceous plants predominate, often with many lichens and mosses, on a permanently frozen subsoil.

Turbic Cryosol: A soil underlain by permafrost that shows evidence of extensive frost churning.

turbidite: The sedimentary deposit of a submarine landslide, in which sediment is transported long distances as density currents, and typically leaves graded bedding.

turbidity flows: Water-saturated landslide, may be submarine.

tussock: A grass plant form that is tufted, bearing many stems arising as a large dense cluster from the crown.

tussock tundra: A tundra landscape (beyond the limits of tree growth) with a herbaceous vegetation of tussock-forming plants, particularly *Eriophorum* spp.

U

ultramafic rock: An igneous rock consisting dominantly of mafic minerals and less than 10% feldspar and minimal quartz.

unconformity: A surface that separates two beds and represents an interval of time when deposition stopped and erosion removed some layers before deposition resumed.

underfit: Said of a stream that appears too small to have eroded the valley in which it flows. A typical result of drainage changes affected by capture, by glaciers, or by climatic variations; common in southern Yukon.

understory: Any plants growing under the canopy formed by others, e.g. herbs under shrubs and shrubs under trees.

upland: Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

V

vesicular: A texture of volcanic rocks in which cavities left by gas bubbles are abundant.

volcanogenic massive sulphide deposit: A mineral deposit of metallic sulfides formed directly through processes associated with volcanism, commonly in a submarine setting.

vuggy: Having small, unfilled cavities in a lode or in rock.

W

watershed: See "drainage basin."

water table: The upper surface of ground water or that level below which the soil is saturated with water.

weathering: (1) The combined erosive effects of the forces of weather on the surfaces of the earth; one of the soil-forming factors. (2) The set of all processes that decay and break up bedrock, by a combination of physically fracturing and chemical decomposition.

weir: (1) (hydrologic) Barrier across a stream. (2) Artifact used for gathering fish.

wetland: (1) Lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface.
(2) A general term for sites that are permanently, seasonally, rarely, or never flooded, but which support plants characteristic of saturated soils. Dominant plants, or at least one co-dominant plant, are terrestrial or emergent, with subaerial stems and leaves. Includes bog, fen, marsh and swamp.

GEOLOGIC TIME SCALE