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

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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.

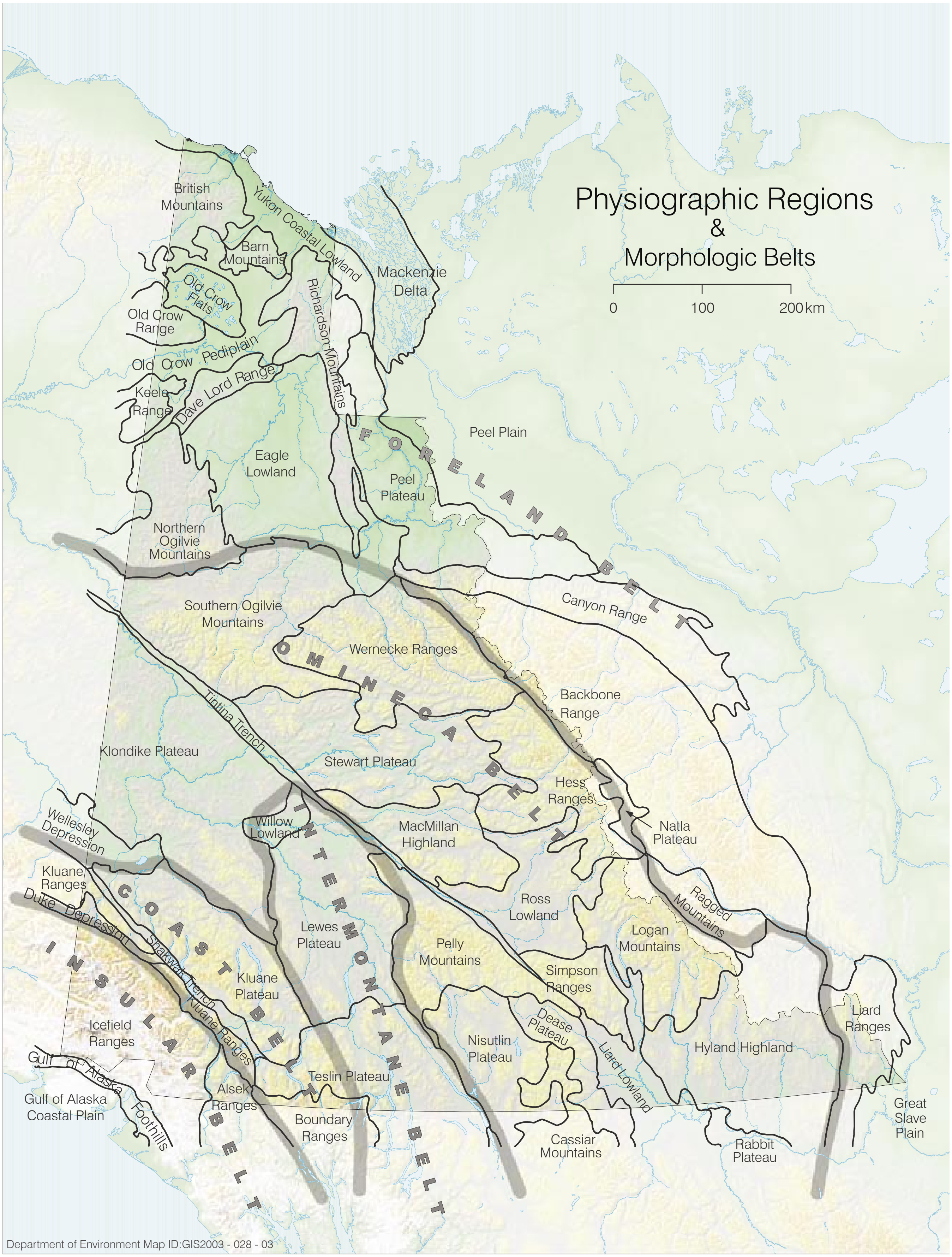

Figure 4. Physiographic regions and morphologic belts of the Yukon. Adapted from Mathews (1986) and Gabrielse *et al.* (1991).

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.

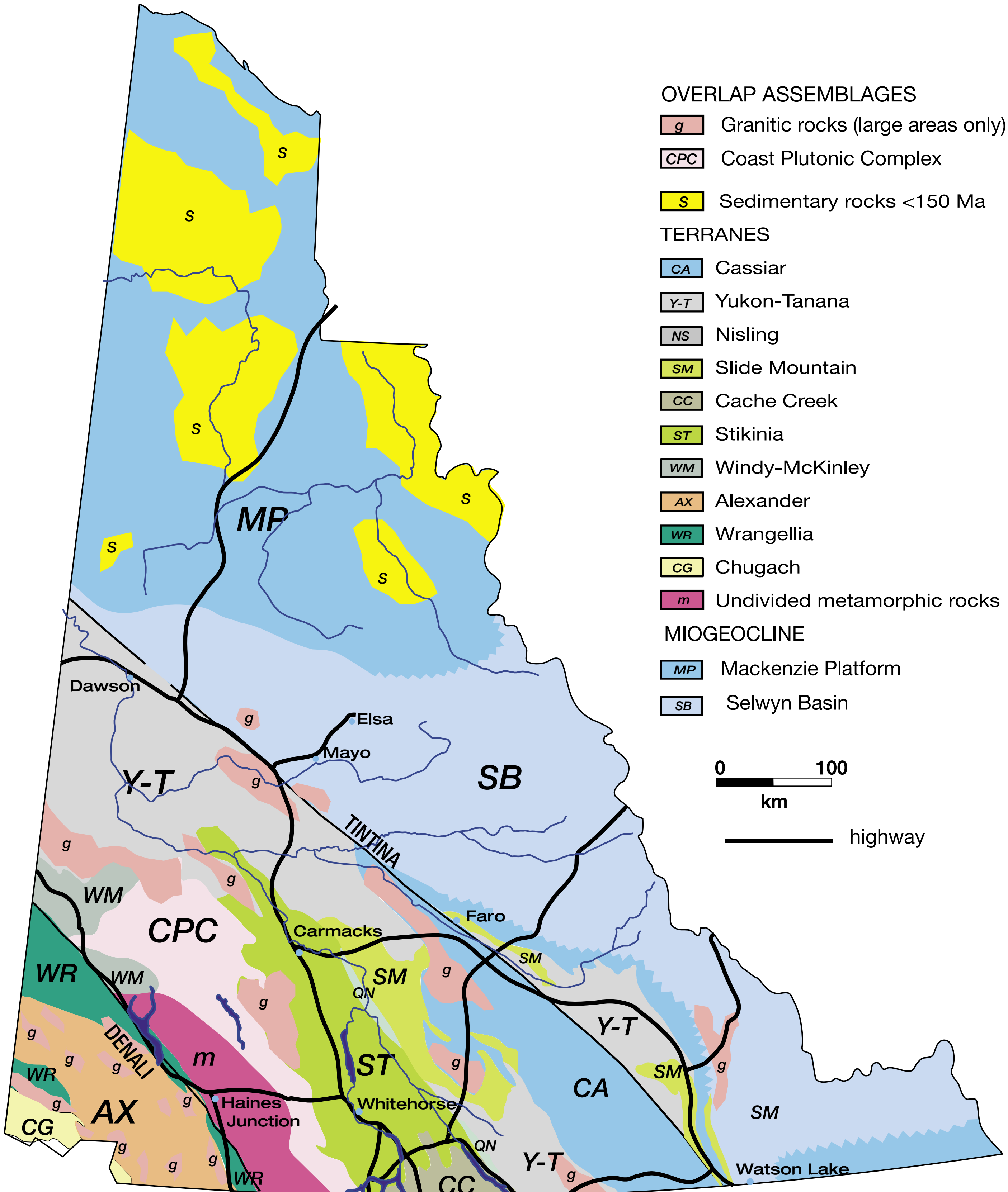

Figure 5. Major associations of bedrock in the Yukon, from Bedrock Geology of Yukon Territory (Gordey and Makepeace, compilers, 2001); Geological Survey of Canada, Open File map 3754; and Exploration and Geological Services Division, Indian and Northern Affairs Canada, Open File 2001-1; map scale 1:1,000,000.

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

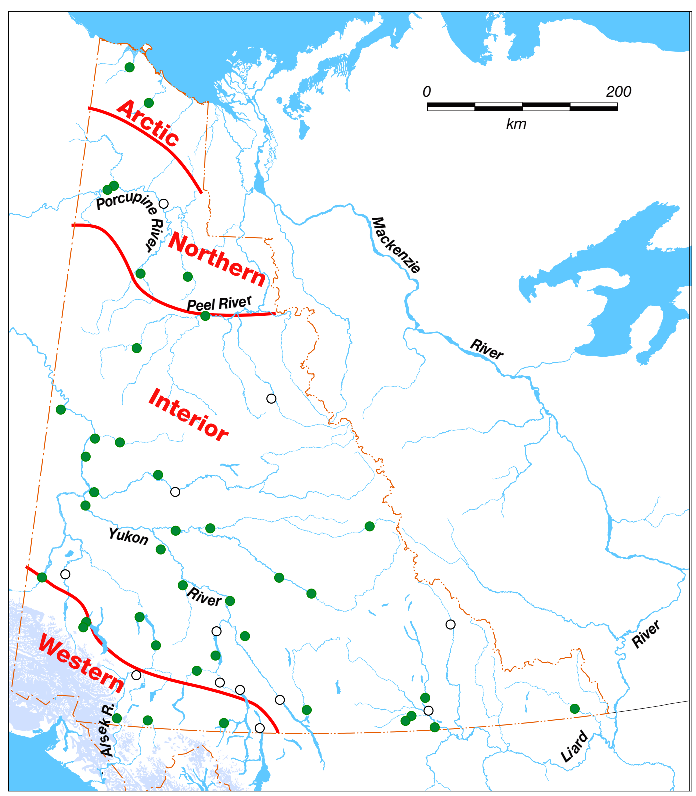

Figure 8. The four hydrologic regions of the Yukon. The dots indicate hydrometric stations used to compile streamflow statistics (Table 2). Open dots are inactive stations; solid dots represent active stations.

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.

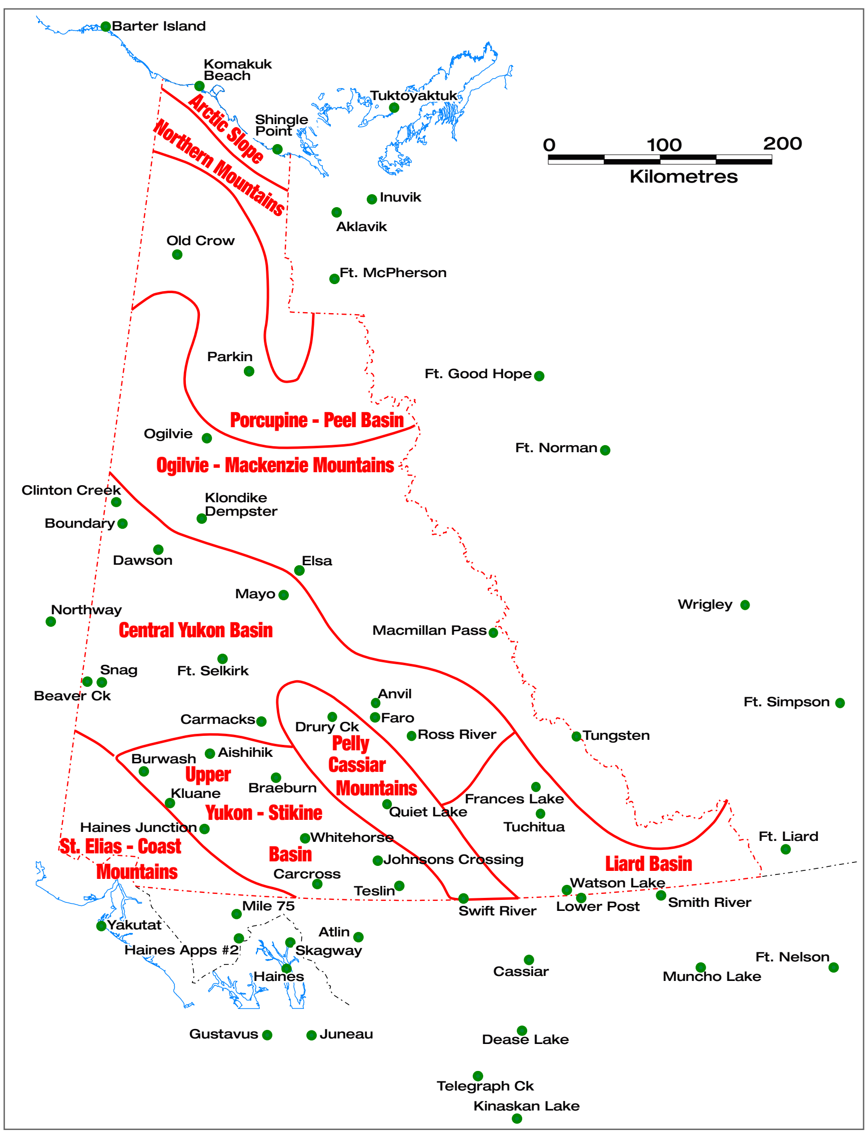


Figure 10. The climatic zones of the Yukon and the weather stations, both active and inactive, that were used to generate regional climate values. These also appear in Figures 11 and 12. (Adapted from Wahl *et al.* 1987)

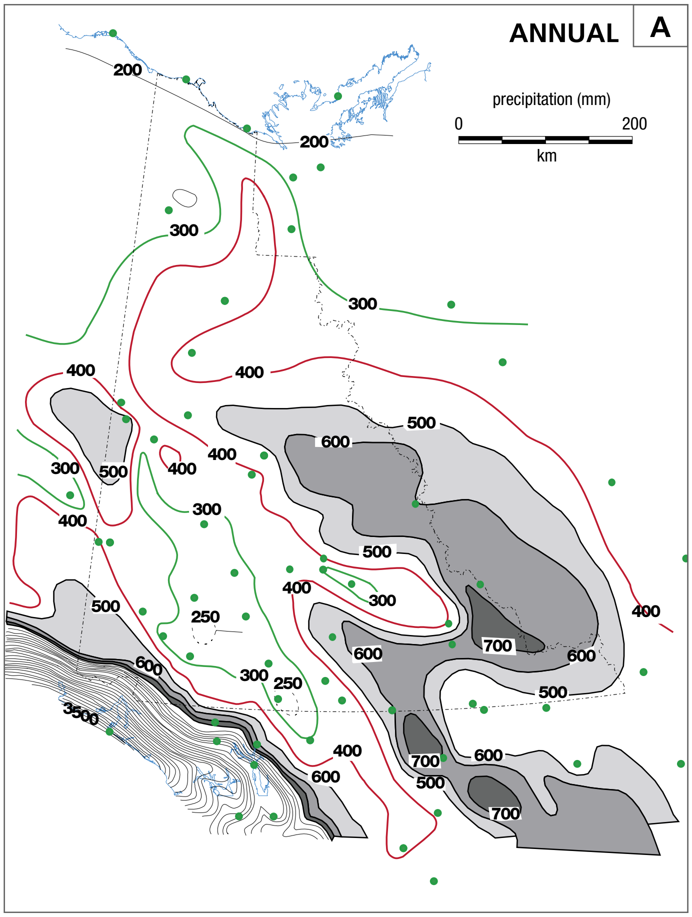
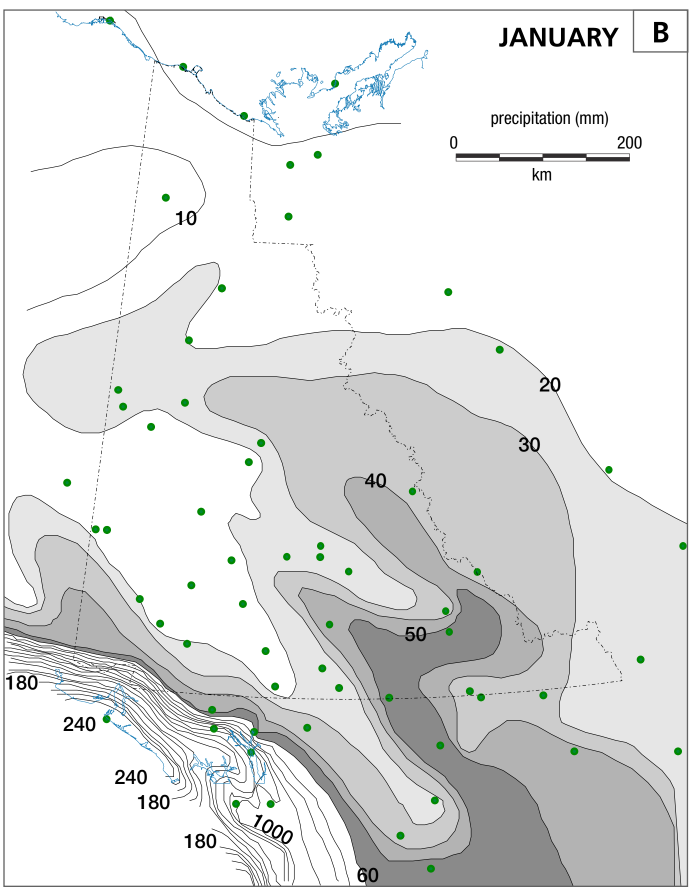


Figure 11. Mean total precipitation: (a) annual, (b) January, (c) July.



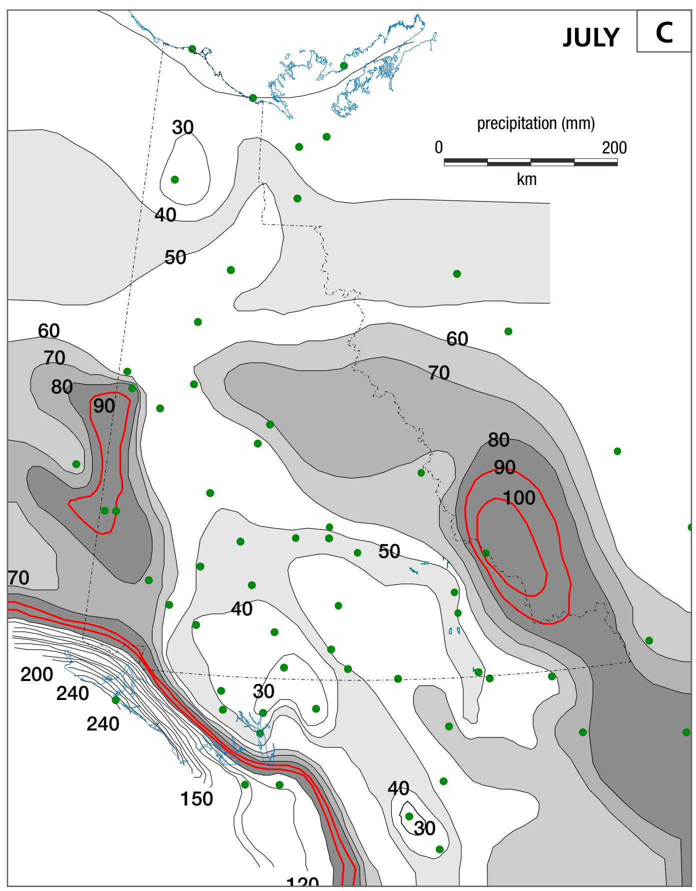
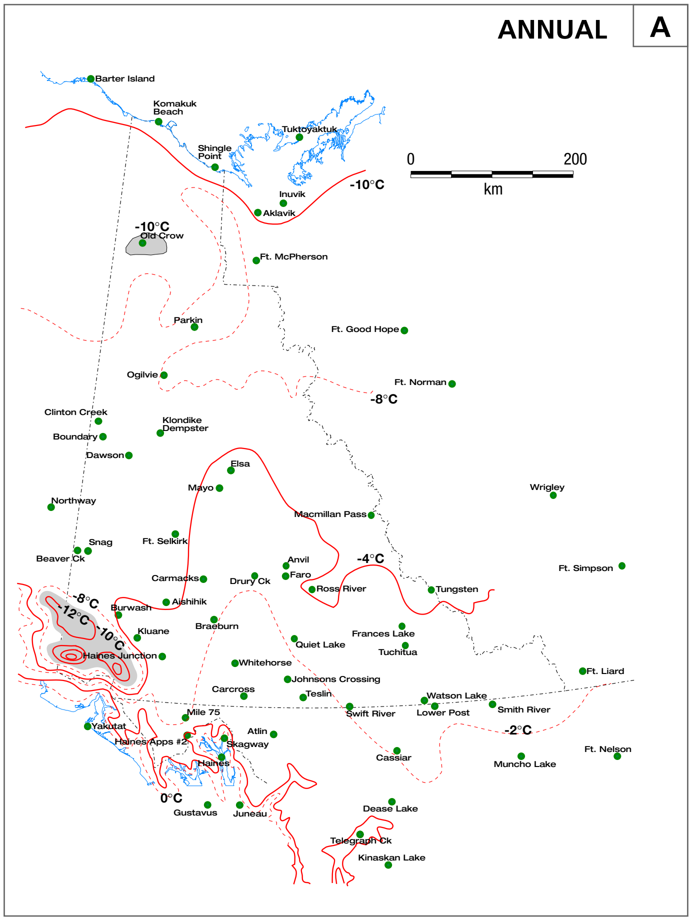
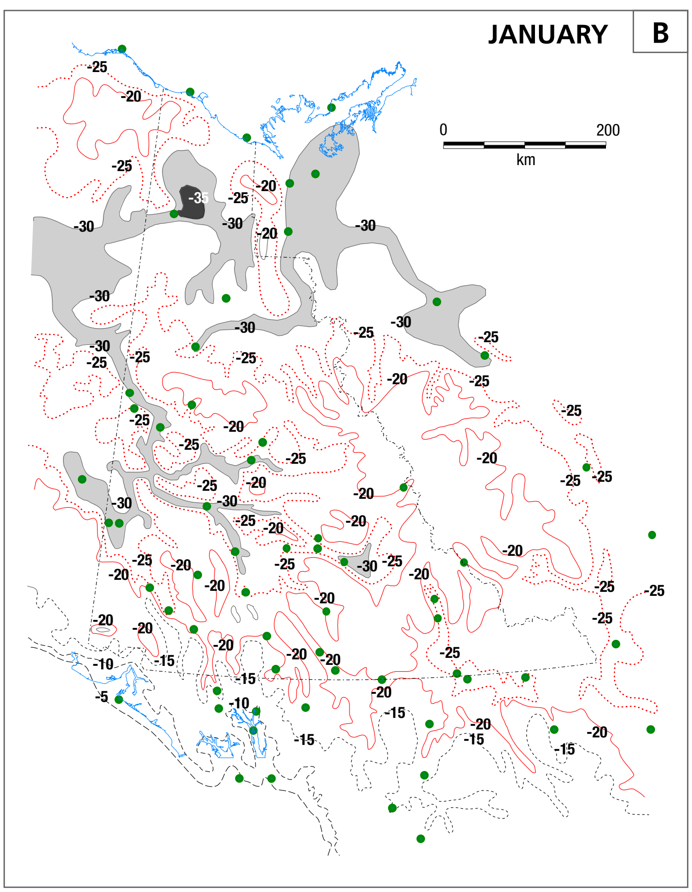
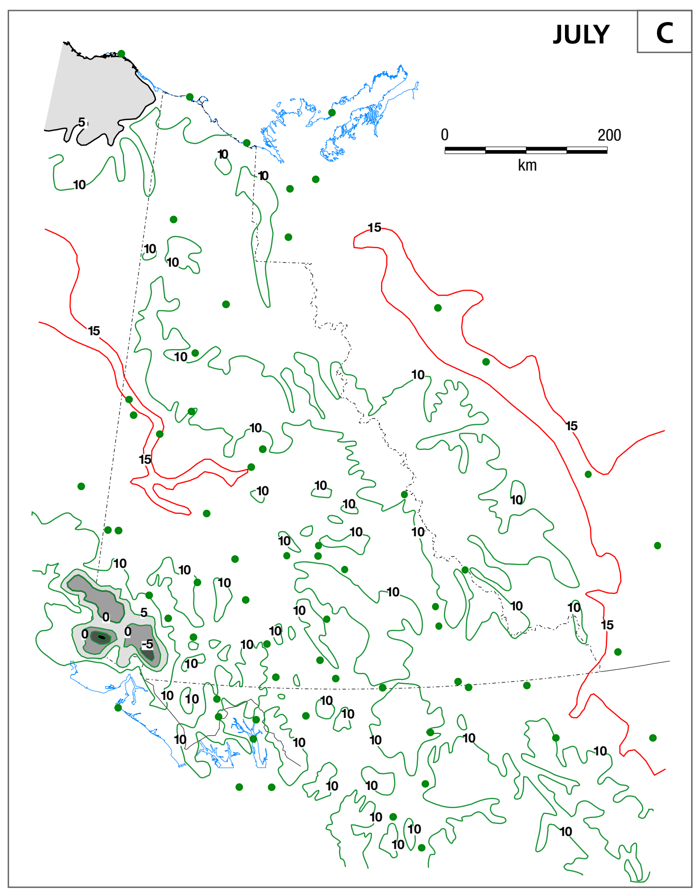


Figure 12. Mean daily temperature in °C: (a) annual, (b) January, (c) July.







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.

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.

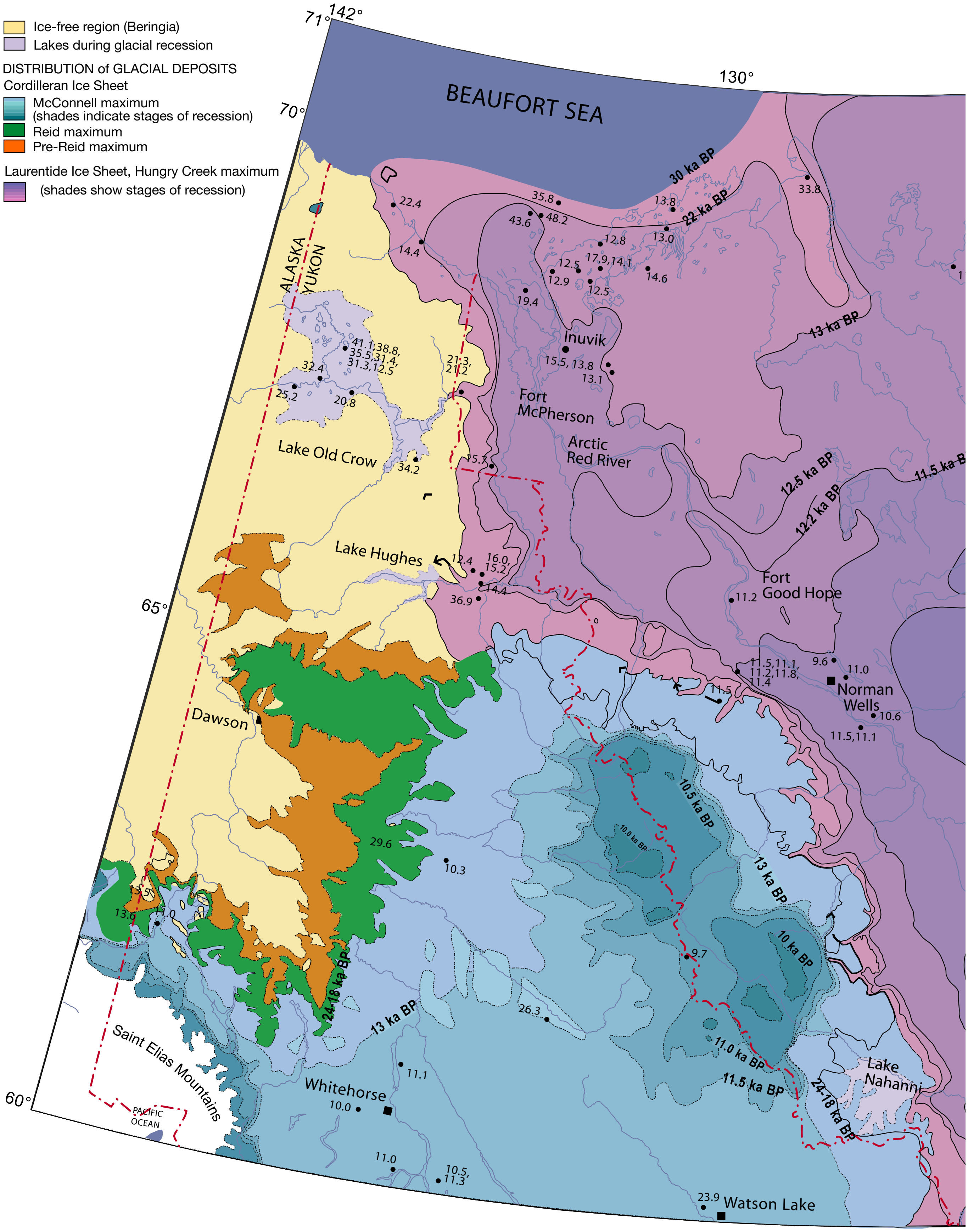

Figure 15. Areas of the Yukon and western Northwest Territories covered by glaciations in the past 3 million years. The timing and extent of glaciation are shown by shading and solid linework. Dotted lines represent stages of recession during the last glaciation. Points represent carbon dates used to 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.

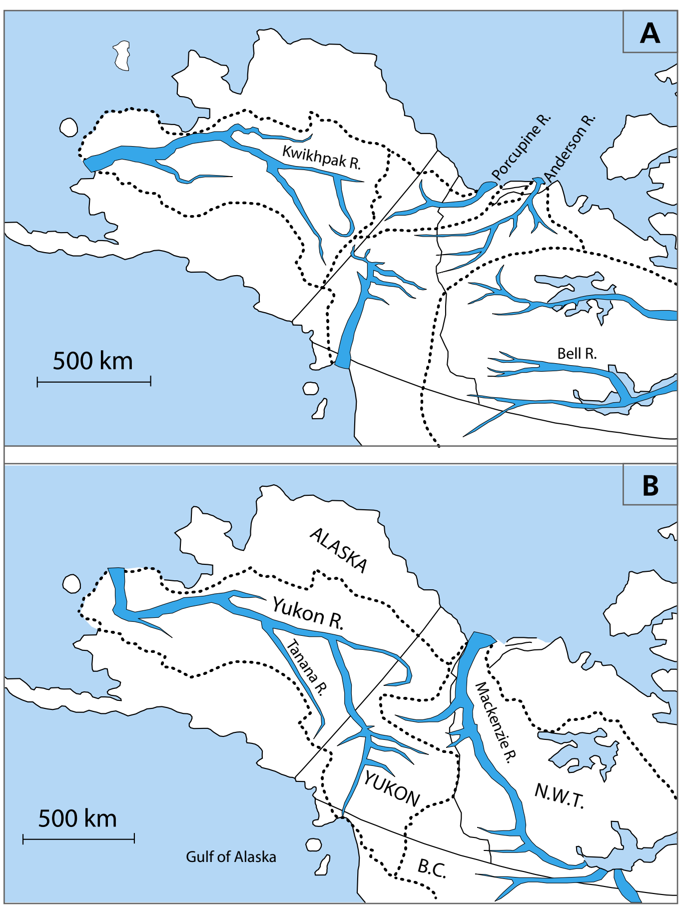

Figure 16. Dramatic changes in the drainage of northwestern North America occurred between pre-glacial (5 Ma) (Fig. 16A), and postglacial (since about 15 ka((Fig. 16B). Dotted lines outline watershed boundaries. Thickness of the drainage outline indicates relative volume of flow.

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).

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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

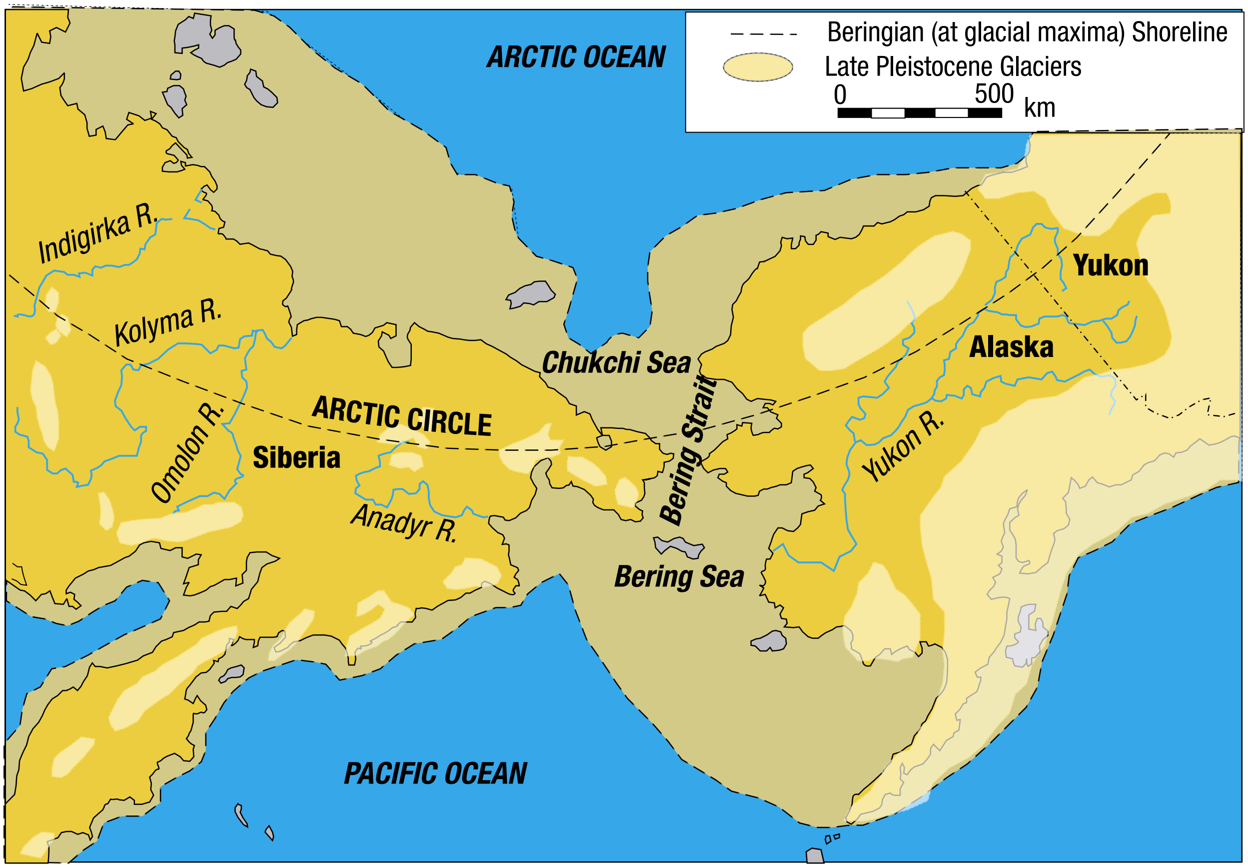

Figure 17. Beringia (dark yellow and dotted shading) at the height of the last glaciation. Adapted from Hopkins *et al.*, 1982.

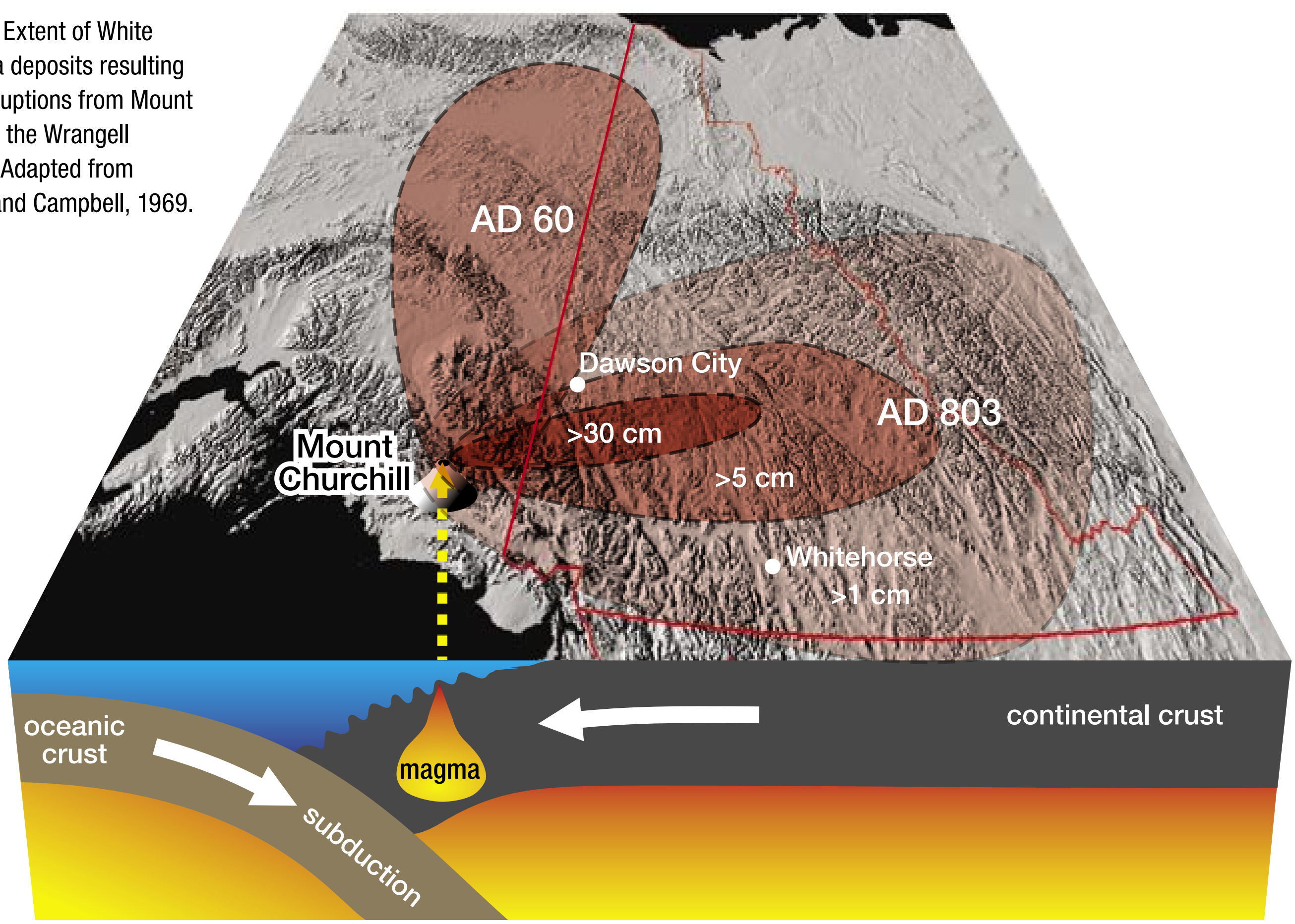

Figure 18. Extent of White River tephra deposits resulting from two eruptions from Mount Churchill, in the Wrangell Mountains. Adapted from Lerbekmo and Campbell, 1969.

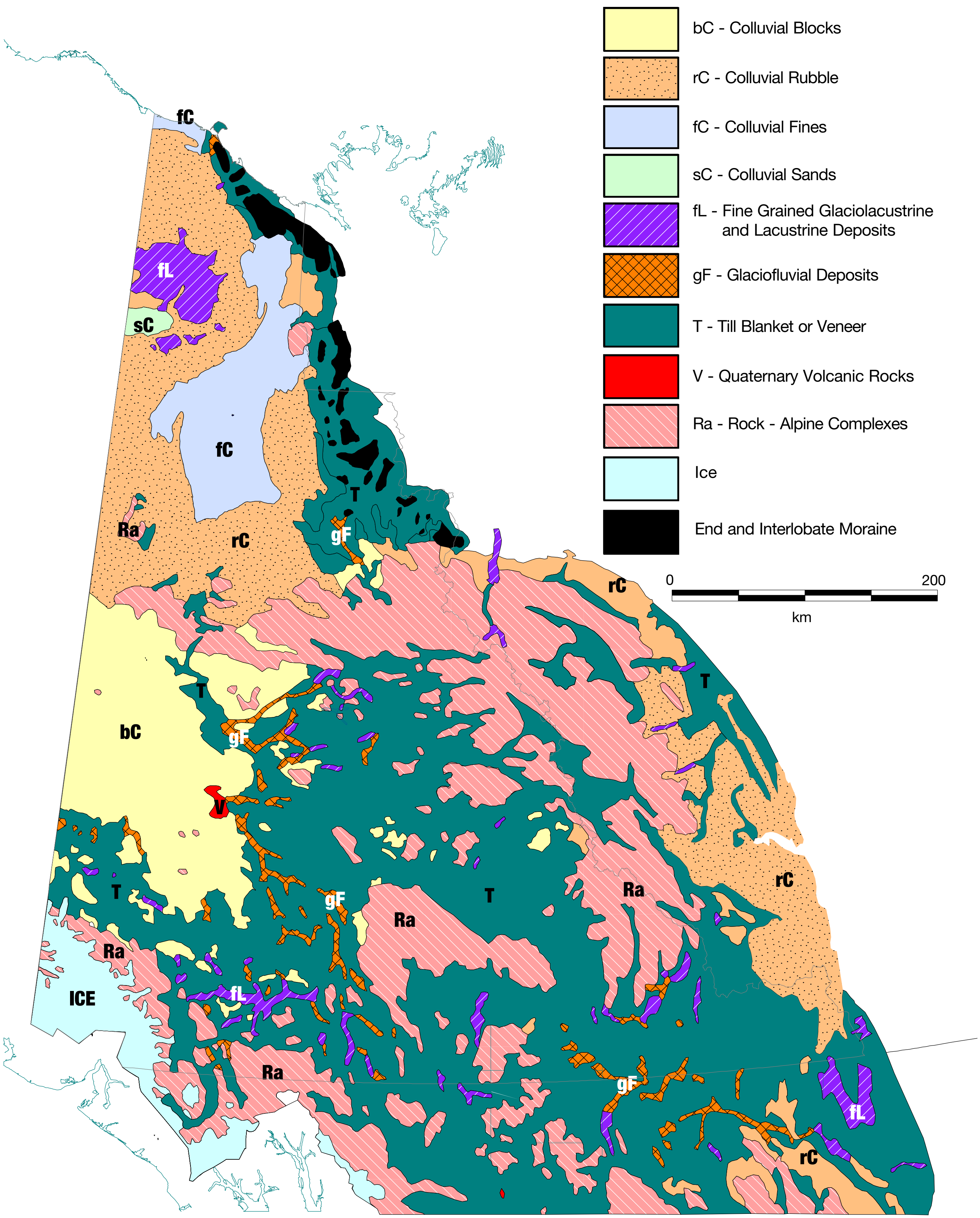

Figure 19. Distribution of surficial geologic material. Source: Fulton (1995).

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.

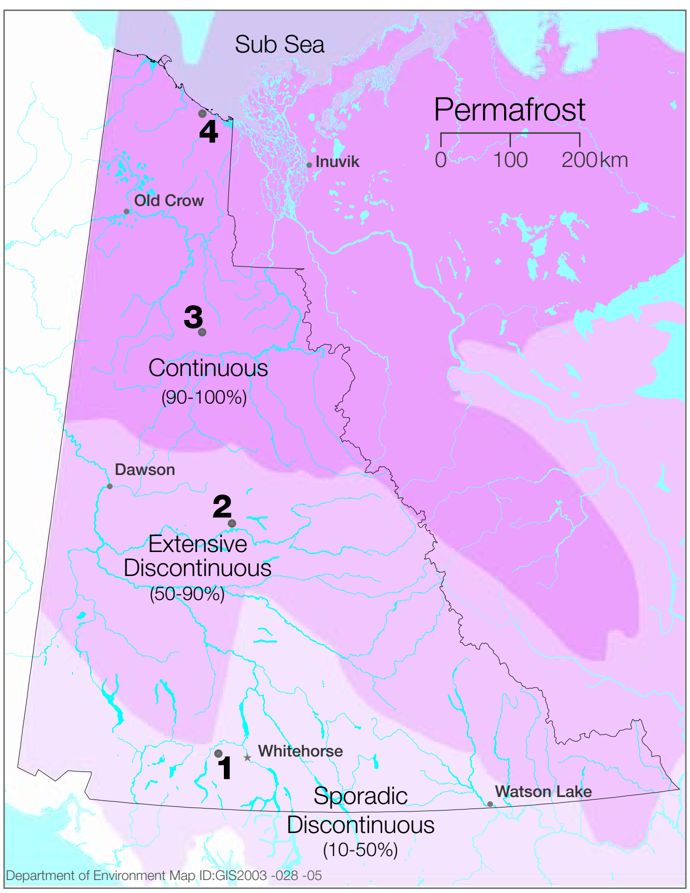


Figure 21. Permafrost zones, indicating locations of ground temperature profiles, as shown in Figure 22.

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.

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.

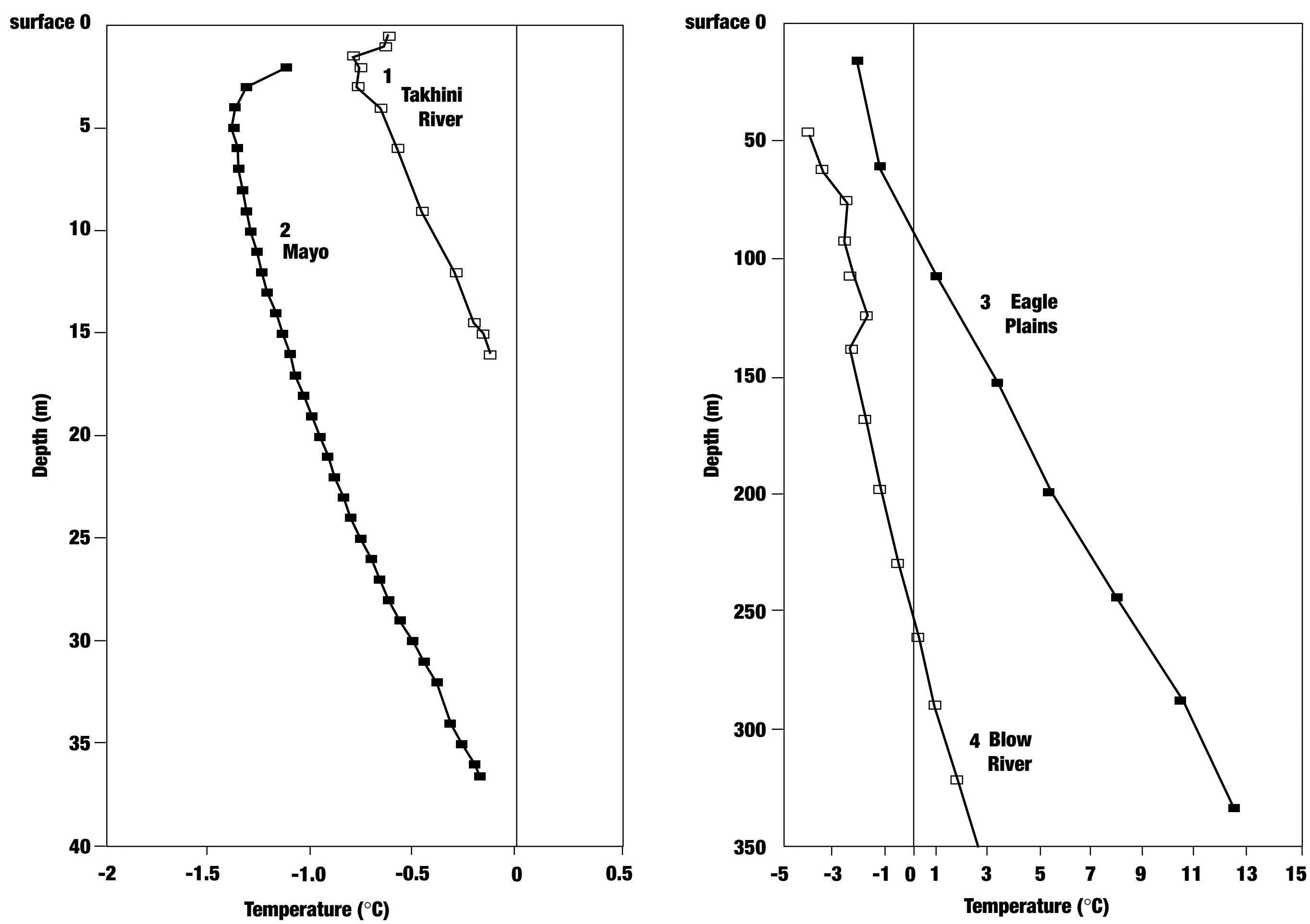


Figure 22. Equilibrium ground temperature profiles from: (1) glaciolacustrine sediments in the Takhini River valley (Yukon Southern Lakes Ecoregion; from Burn [1998]); (2) glaciolacustrine sediments near Mayo (Yukon Plateau North Ecoregion, from Burn [2000]); (3) North Cath B-62 drill hole (Eagle Plains 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.

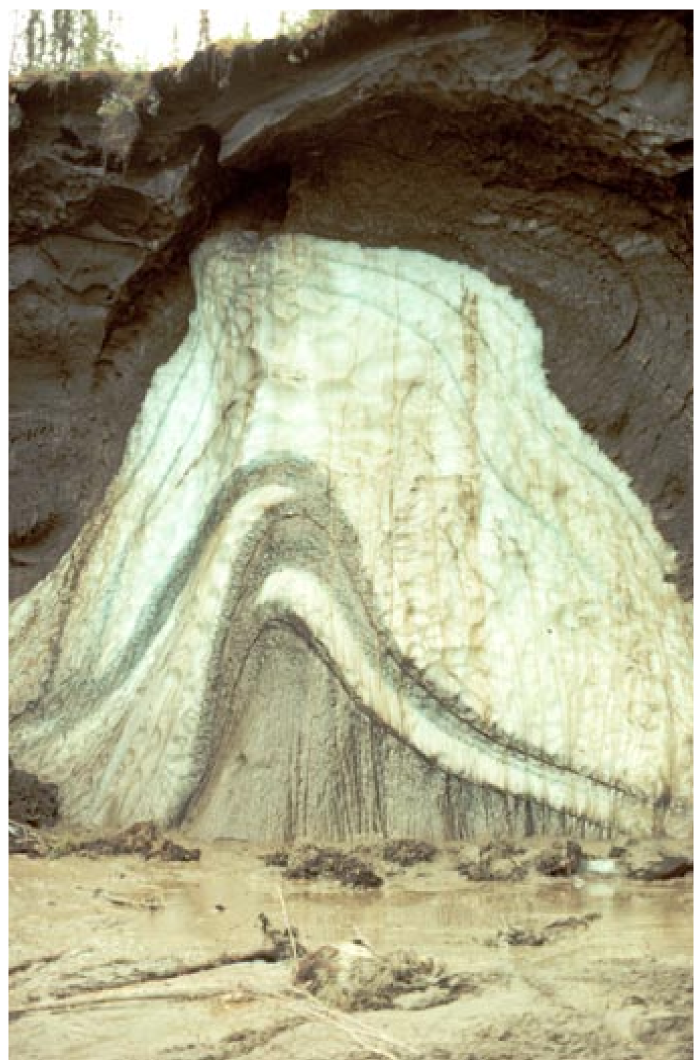
Accumulation of ground ice leads to heaving of the ground surface. Thick, laterally extensive bodies of massive, near-surface ice, probably formed by ice segregation during permafrost growth, are found in the northern Yukon (Fig. 23) and in the Klondike Plateau Ecoregion. Glaciolacustrine sediments in 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).

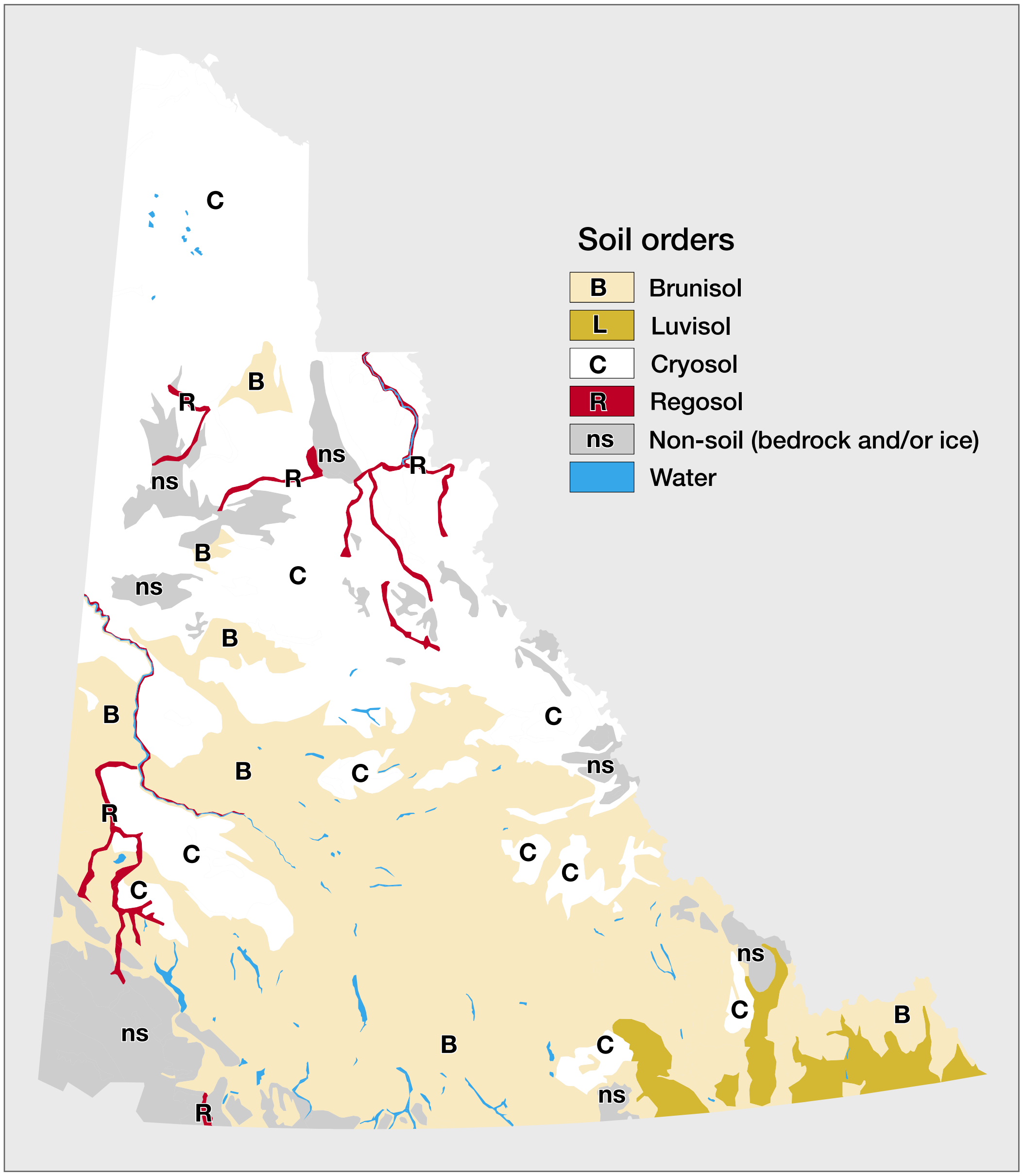

Figure 24. Distribution of major soil types (orders) in the Yukon. Adapted from White *et al.* (1992).

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.

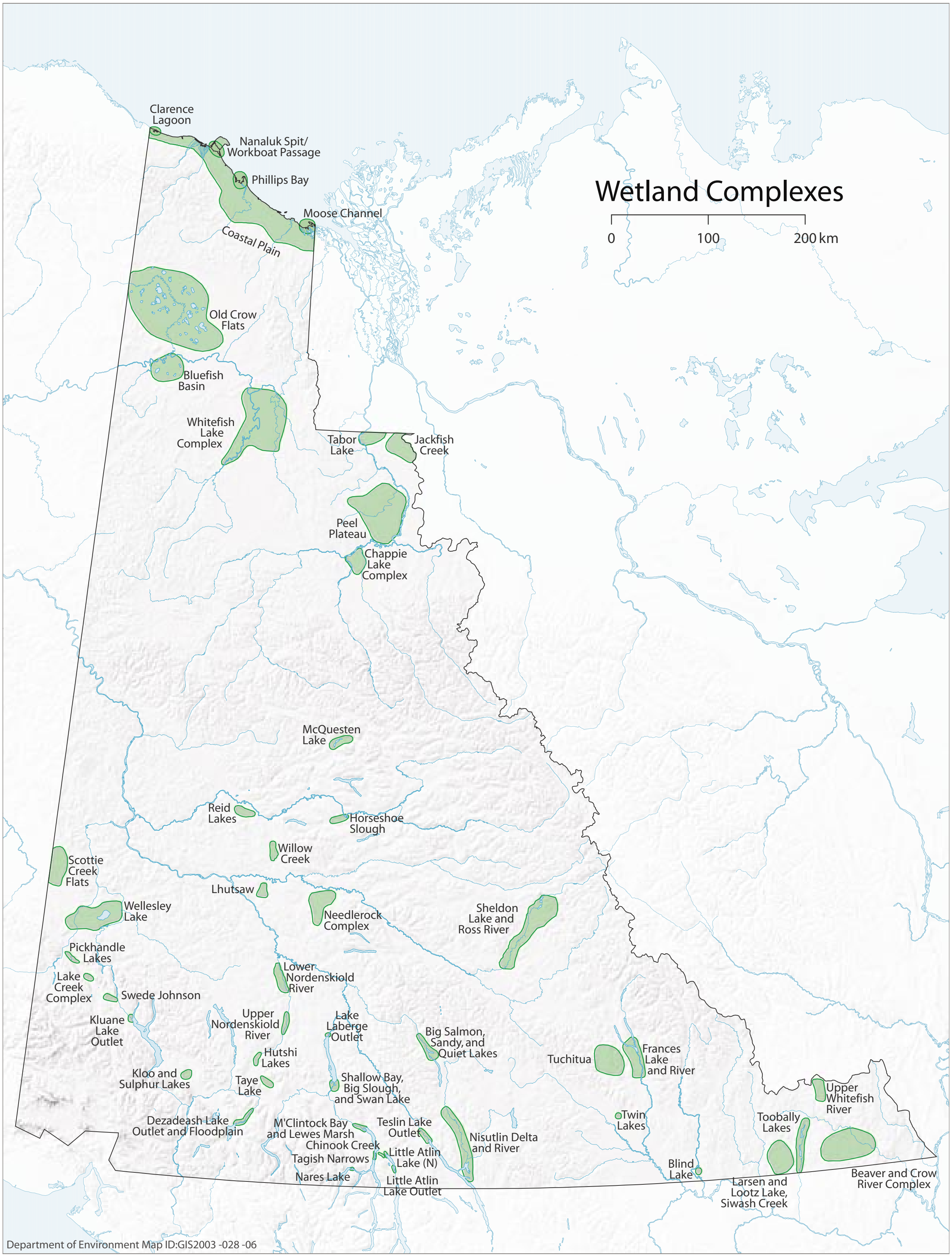

Figure 28. Distribution of major wetland complexes in the Yukon. Compared with other subarctic regions of Canada, the area of wetlands, particularly extensive peatlands, is relatively small owing to the mountainous nature of the terrain and the semi-arid climate. Map source: Yukon Wetlands Technical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

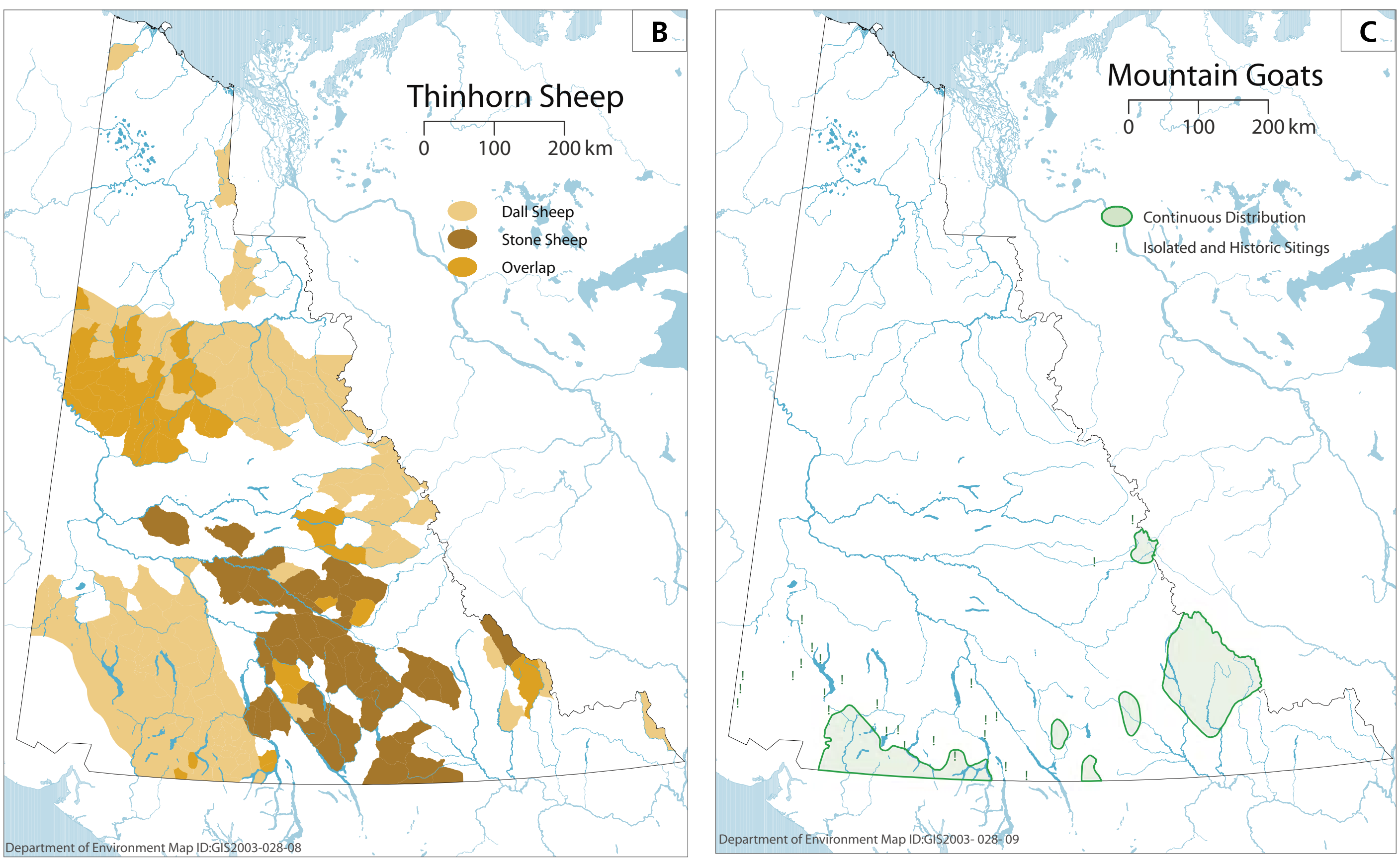
Table 4. Terrestrial mammalian species known to occur in the Yukon and their known or expected distribution by ecoregion.

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.



M. Hoefs

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.

W.J. Schick

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.

Taxonomy	Yukon Total	Yukon Endemic	Canada approximately	North America approximately	Yukon species as % of Canadian species 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**


J. Meikle, Yukon Government

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.

Heritage Branch, Yukon Government

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.

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.

Heritage Branch, Yukon Government

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.

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.

Heritage Branch, Yukon Government

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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