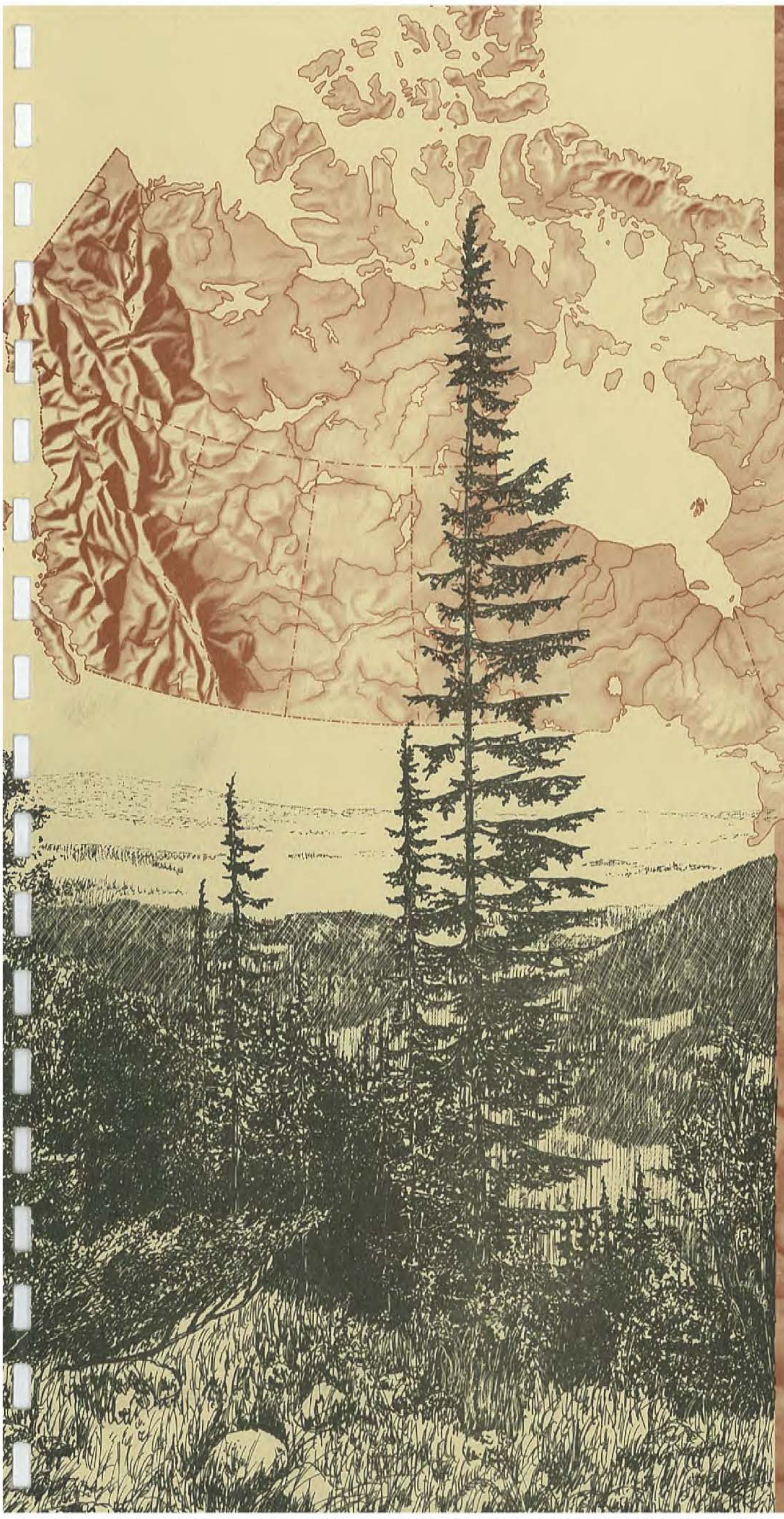

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INTERNATIONAL SOCIETY OF SOIL SCIENCE

EDMONTON, CANADA

JUNE 1978

GUIDEBOOK TOUR 3

SOIL LANDSCAPES IN THE CORDILLERAN REGION OF WESTERN CANADA

11th

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INTERNATIONAL SOCIETY OF SOIL SCIENCE

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JUNE 1978

GUIDEBOOK

FOR

A SOIL AND LAND USE TOUR

IN

THE SOUTHERN CORDILLERA OF BRITISH COLUMBIA AND ALBERTA

TOUR 3

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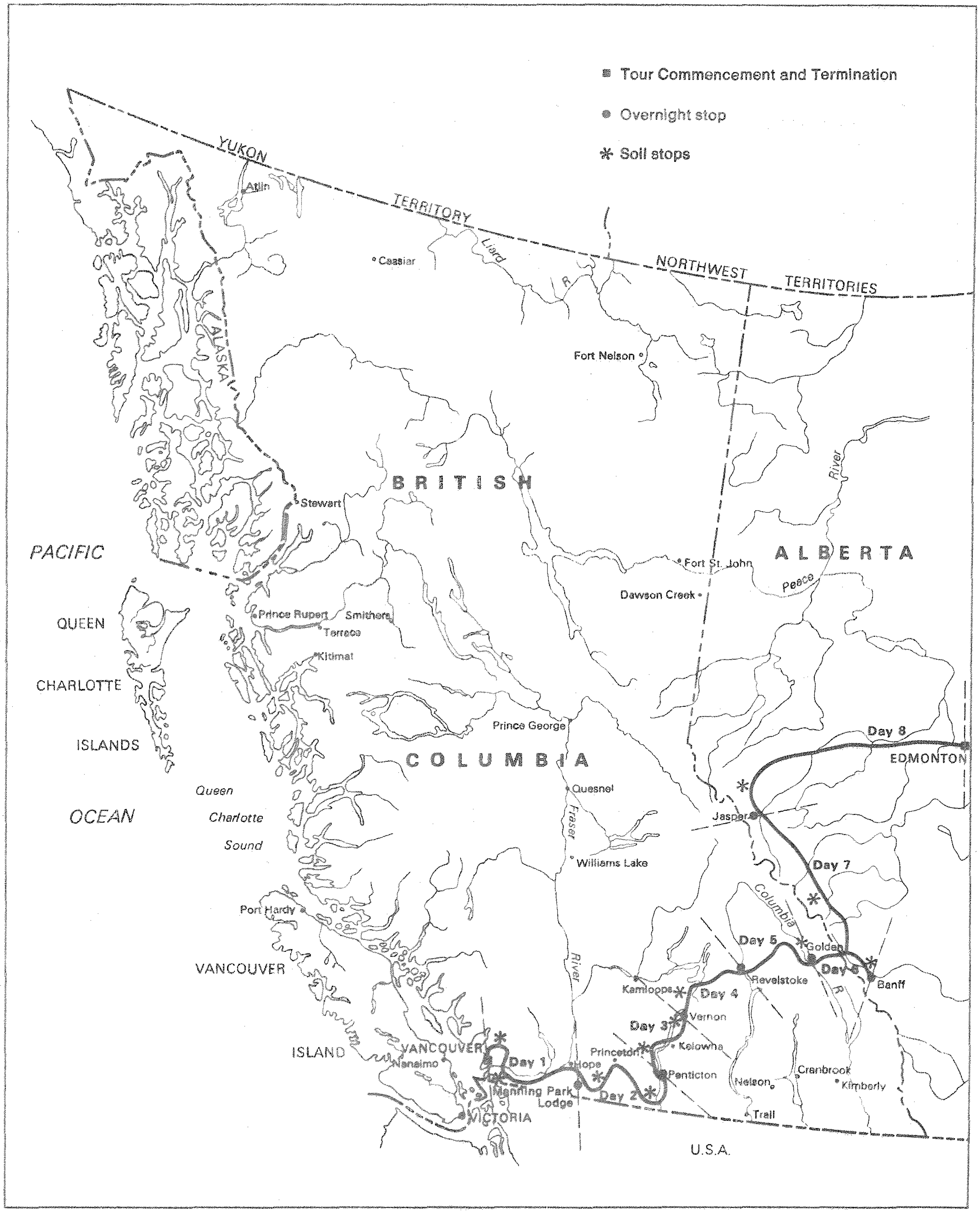

FIG. 1 ROUTE MAP IN BRITISH COLUMBIA AND ALBERTA

INTRODUCTION

Tour 3 assembles in Vancouver, British Columbia and travels east and north for eight days to terminate in Edmonton, Alberta, situated near the western edge of the Alberta Plain. During this time the tour will traverse the Cordilleran Region of Canada.

British Columbia and Alberta are the two most westerly provinces of Canada. Respectively, they encompass 948 600 km^2 and 661 188 km^2 of Canada's 9 221 016 km^2 total area. Of Canada's total population of 21 568 311 in 1971, 2 184 621 people live in British Columbia and 1 627 874 live in Alberta. In both provinces, the majority of the population is located in the southern part, mainly in a few large cities.

The physical landscapes of British Columbia and western Alberta are dominated by a series of northwest-southeast trending mountain ranges. These ranges, commonly obtaining elevations of 3000 metres, are separated by deeply entrenched valleys and rolling plateaus.

The mountain ranges (Fig. 2), lying across the general flow of weather systems from the Pacific Ocean, greatly influence the climate. Marked differences in temperature and particularly precipitation occur from the windward to the leeward sides of the mountains. Western Alberta and eastern British Columbia are also substantially influenced by weather systems originating in the Arctic.

All of British Columbia and western Alberta, with the exception of the tops of some of the highest mountain peaks, was glaciated during the Pleistocene Epoch. Surficial deposits on the land surface are the direct result of glaciation or have been deposited since the retreat of the ice, approximately 10 000 years ago.

The extreme variation in climate, relief and surficial deposits has produced very diverse and complex vegetation, soils and land use patterns. Some of these will be exhibited during the course of the tour.

The first part of the guidebook contains a general overview of the physiography, climate, vegetation, soils and land use of the region to be traversed. The second part, on a daily basis contains more detailed discussions of the landscape as it relates to the tour route. Included also are annotated road logs emphasizing landscapes, soils, land use and features of interest along the route. Detailed descriptions, chemical, physical and micromorphological data for featured soils as well as tabular and special information are included in the appendices.

GENERAL ITINERARY

ASSEMBLE VANCOUVER (June 9)

NOTE - Because of variable weather conditions likely to be encountered during the tour, participants should be prepared for cool rainy weather as well as for sunshine and hot temperatures.

DAY 1 - June 10, Vancouver to Manning Park. Assemble 0800 for 312 km bus trip to Manning Park. The trip will feature two Podzolic soils, one on the forested slopes of the Coast Mountains, the other in an agricultural setting in the Fraser Lowland. Lunch will be provided in Mount Seymour Provincial Park. Prior to arrival at Manning Park Lodge for dinner and accommodation, tour participants will pass through the rich and diversified farmlands of the Lower Fraser Valley and into the Cascade Mountains.

DAY 2 - June 11, Manning Park to Penticton. Assemble 0800 for 279 km drive to Penticton. The route is from the Cascade Mountains into the hot dry interior of the province. Two soil sites will be featured, the first a site on the Interior Plateau, and the second a mountain-top site and lunch stop at 2000 m elevation. Accommodation and evening meal will be provided at Penticton.

DAY 3 - June 12, Penticton to Vernon. Assemble 0800 for 136 km trip to Vernon. This day will be highlighted by a tour of an agriculture research station and the examination of two soils associated with irrigated tree fruits, grapes and other crops. Lunch will be provided at the Research Station. The tour will stop at Vernon for the night.

DAY 4 - June 13, Vernon to Revelstoke. Assemble at 0800 for 197 km trip to Revelstoke. The morning will feature a soil site in an area used for sewage effluent disposal by irrigation. A second soil will be examined in an area of the Shuswap devoted to dairying and field crops. Noon lunch will be provided. Accommodation and evening meal will be at Revelstoke.

DAY 5 - June 14, Revelstoke to Golden. Assemble at 0800 for 144 km trip to Golden. The tour traverses the Selkirk Mountains, a relatively rugged range of the Columbia system. Featured will be discussion and examples of snow avalanche control at Rogers Pass in Glacier National Park, and a soil site in the Rocky Mountain Trench. Lunch will be enroute and accommodation and evening meal at Golden will be provided.

DAY 6 - June 15, Golden to Banff. Assemble at 0800 for 147 km trip to Banff. The tour leaves British Columbia and enters the province of Alberta. One soil site will be examined near Banff. Free time will be available for viewing the spectacular scenery of the Rocky Mountains in the Lake Louise and Banff areas. Lunch will be provided. Accommodation and evening meal is at Banff where scenic bus tours are available.

DAY 7 - June 16, Banff to Jasper. Assemble at 0800 for the 300 km trip to Jasper. The trip features high mountain scenery, and a soil site and lunch stop at Peyto Lake, and a visit to the Columbia Icefields. Accommodation and evening meal will be provided in Jasper.

DAY 8 - June 17, Jasper to Edmonton. Assemble at 0800 for the 400 km trip to Edmonton. There will be one stop at a soil site and lunch. Arrive Edmonton and proceed to Congress headquarters at the University of Alberta.

GENERAL DESCRIPTION OF THE AREA

Canadian Overview

Physiography*

Canada is divided into seven major physiographic regions (Fig. 2).

The largest of these is the Canadian Shield comprising a massive old surface of Precambrian crystalline rock, covering almost half of Canada (4 585 199 km^2). The Shield is surrounded to the south, west, and north by the Borderlands, which make up the remaining six regions. These Borderlands consisting of younger sedimentary rocks form a ring of plains and lowlands adjacent to the Shield and an outer rim of mountains and uplands bordering on the Pacific, Atlantic, and Arctic oceans. The inner ring consists of the Interior Plains, St. Lawrence Lowlands, and the Arctic Lowlands. The outer rim of mountains and uplands consists of the Cordilleran Region in the west, the Innuitian Region to the north, and the Appalachian Region to the southeast.

In describing the physiography of Canada the dominating factor has been the effect of the Glacial Ice Age. Glaciation started over one million years ago and saw four major advances and retreats of ice, known as the Nebraskan, Kansan, Illinoian, and Wisconsin. These major glaciations were separated by the Aftonian, Yarmouth, and Sangamon interglacial periods. All of Canada was subject to the effects of glaciation with the exception of a few isolated Tertiary plateaus in the southern interior Plains and large sections of the northwest in the Yukon Territory. Glaciation left a distinct pattern of surficial deposits and glacial landform features of fundamental importance to the composition and distribution of Canadian soils.

Vegetation*

Geographically, the natural vegetation of Canada may be best described on the basis of vegetative regions (Fig. 3). These consist of large areas of apparently stable vegetation, each characterized by associations of distinctive plant communities or individual species, bearing a predictable relationship to regional climatic conditions, broad characteristics of physiography and landform, and to associated patterns of soil development.

These regional characterizations refer to the potential natural vegetation that would exist if man's influence was removed, as distinguished from the present vegetation, which may be natural, seminatural, or cultural depending on the degree and extent of man's influence. Much of the area of Canada is sparsely populated and undeveloped, and under such conditions the vegetation is essentially natural. It is only in areas of extensive agricultural or commercial forest activity, and in the more limited but intensively established urban communities that the vegetational pattern has been so changed that potential natural vegetation has to be partly inferred from association with relict areas.

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*abstracted from Soils of Canada 1977

The vegetative regions may be broadly grouped into three classes, the Tundra, Forest and Grasslands. Their spatial distribution is determined largely on macroclimatic conditions. The Tundra areas are determined in relation to Arctic and Alpine climates; the Forest areas are associated with conditions warmer than the Tundra and generally more moist than that of the Grasslands.

Soils

Figure 4 groups the soil Orders and combinations of Orders and miscellaneous land types into 12 broad regional areas across Canada. An extensive zone of Cryosols, rocks and ice lies above the 60th parallel. Roughly paralleling the line of permafrost along its southern boundary are large areas dominated by Brunisols, Organics and Podzols. Large units dominated by Luvisols wedge up from the south in the western provinces. The most southerly parts of the Interior Plains within the prairie provinces of Alberta, Saskatchewan and Manitoba are predominantly Chernozemic soils. The wet forested coastal zones of the west and east shores are mainly Podzolic soils.

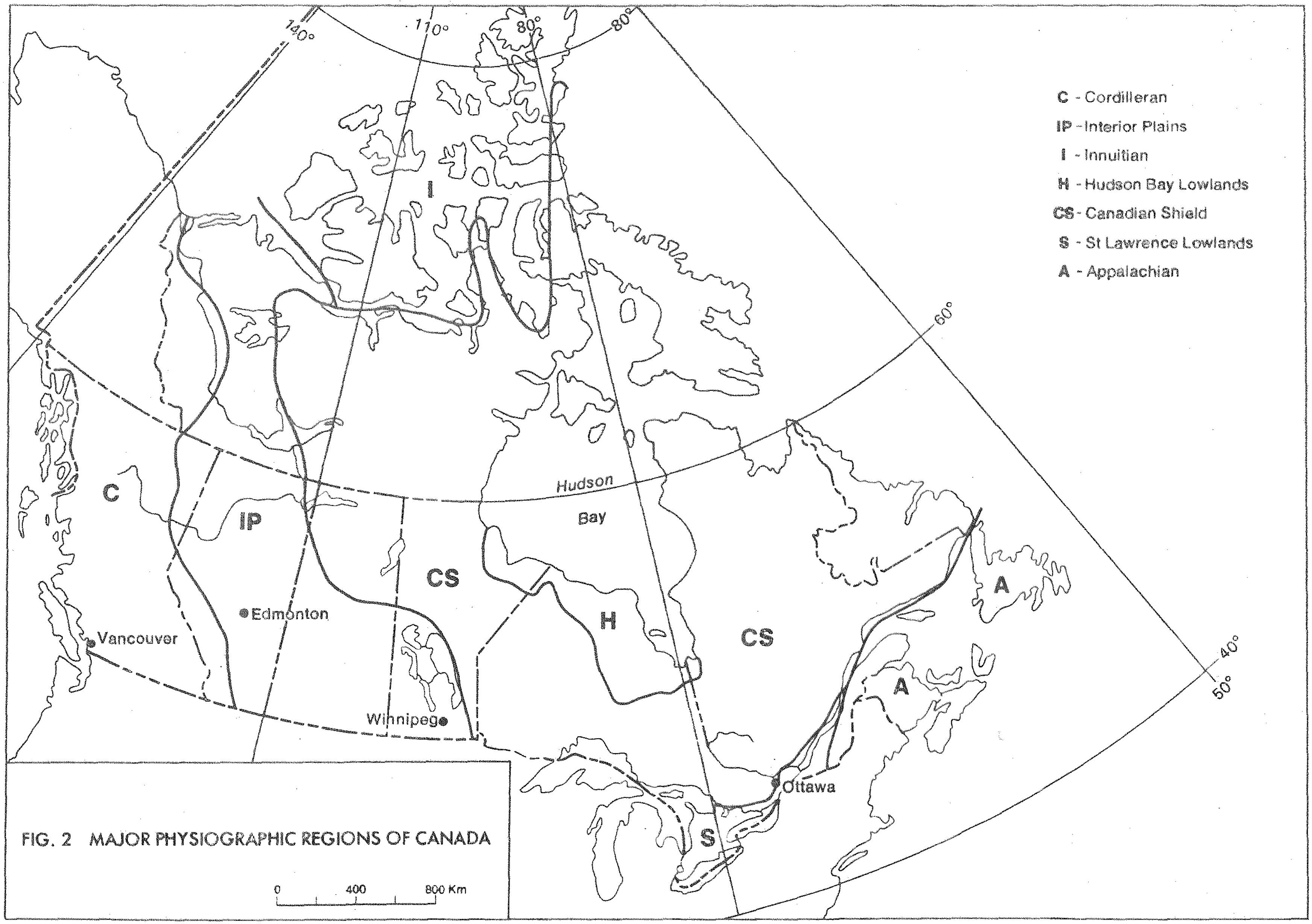


FIG. 2 MAJOR PHYSIOGRAPHIC REGIONS OF CANADA

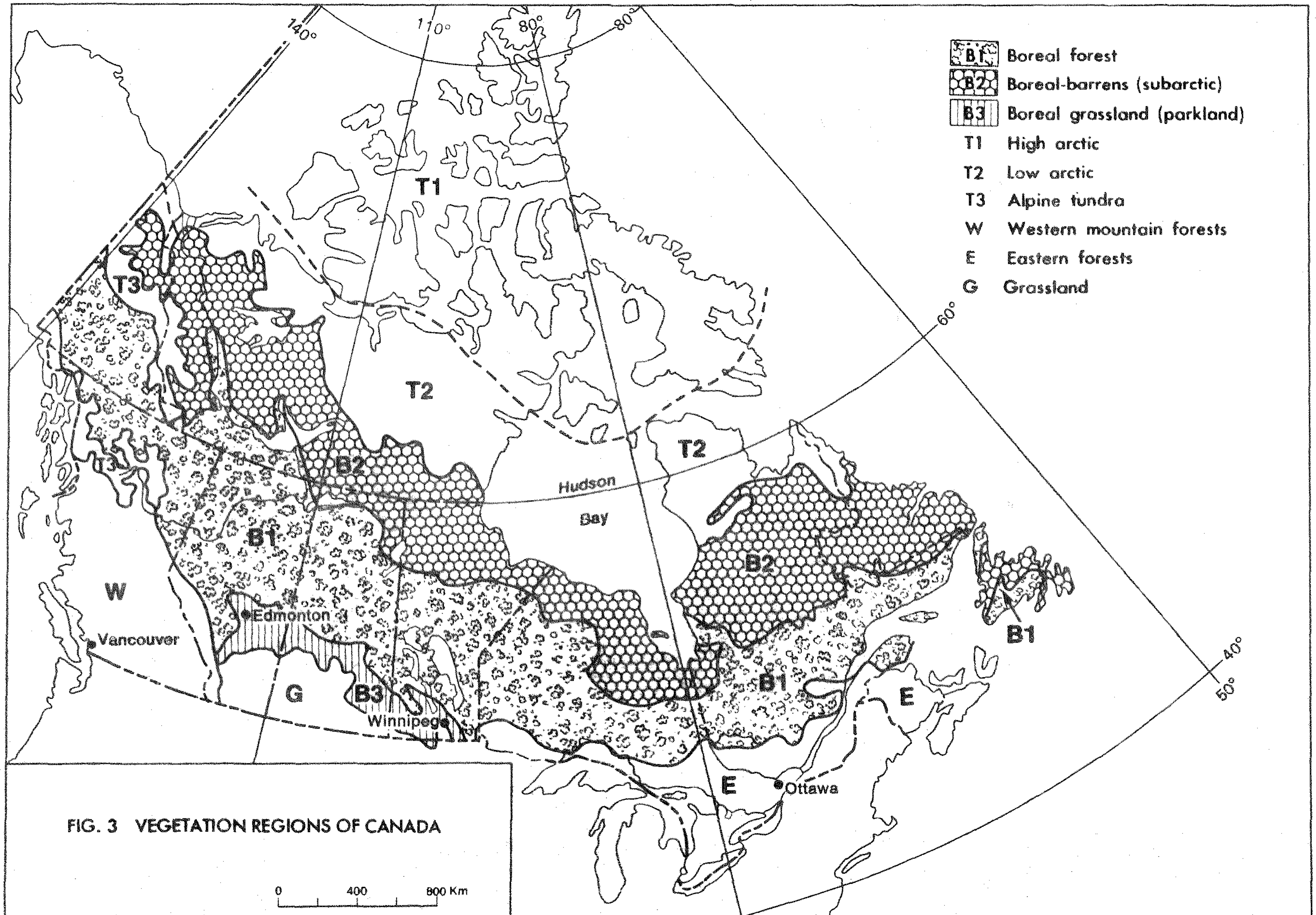


FIG. 3 VEGETATION REGIONS OF CANADA

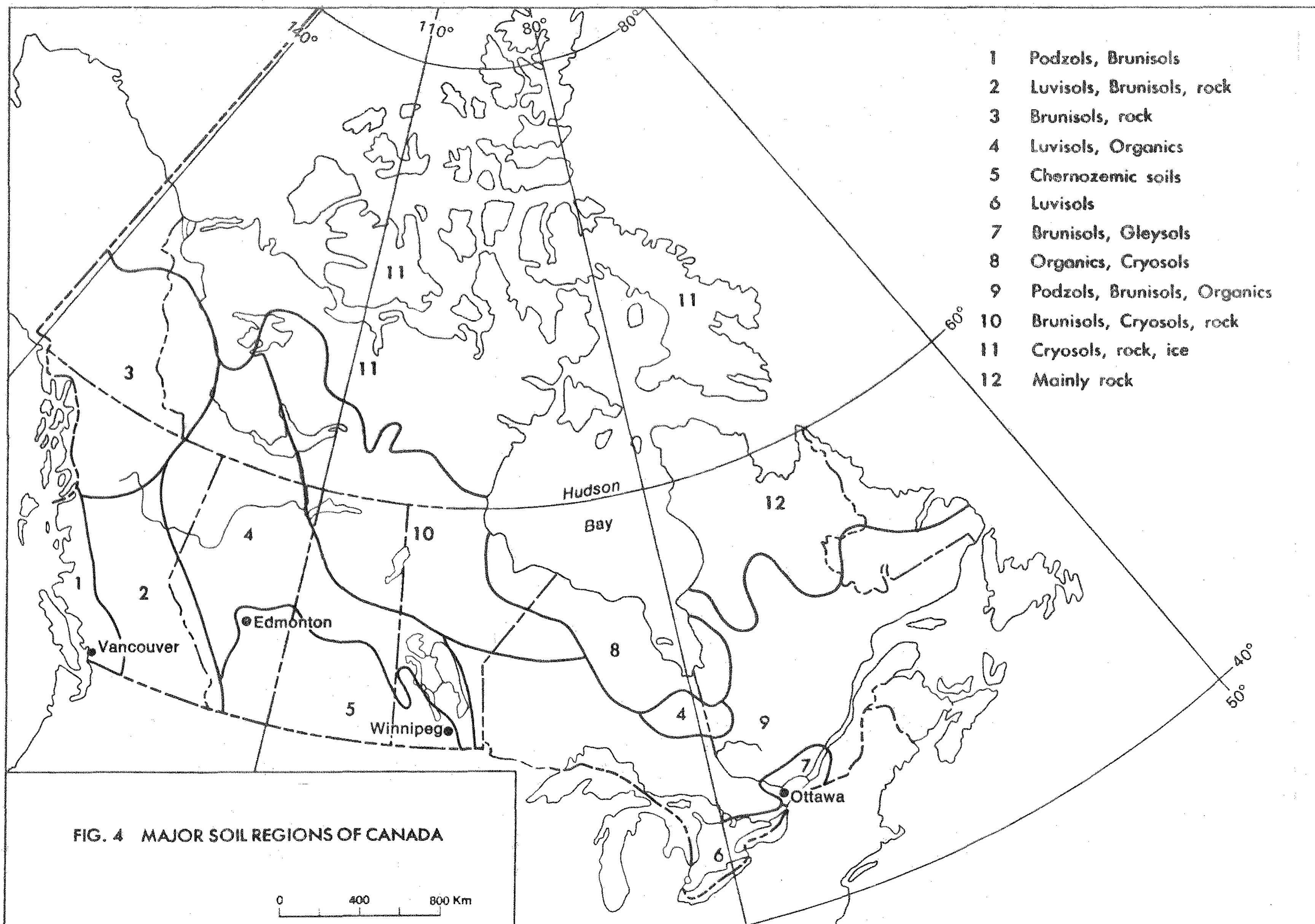


FIG. 4 MAJOR SOIL REGIONS OF CANADA

Regional Overview

In the 8 day trip from Vancouver to Edmonton the tour passes through nine main physiographic subdivisions of the Canadian Cordillera (Fig. 5). They include humid coastal mountains, semi-arid interior plateaus, dry mountain valleys, high rugged mountains and grassland plains. The tour attempts to provide a cross-section of the soil landscapes, the resources, and land use of these diverse landforms.

Fraser Lowland

Physiography

The Fraser Lowland (Fig. 6) within the Georgia Depression is part of the Coastal Trough, one of the main physiographic divisions of the Canadian Cordillera. The City of Vancouver occupies part of the Fraser Lowland.

Elevations in the Fraser Lowland, commonly referred to as the Lower Fraser Valley or Lower Mainland, range from near sea-level to about 120 metres above sea level (m. a.s.l.). The region is characterized by wide, flat-bottomed valleys and extensive areas of rolling uplands.

Drainage is dominated by the Fraser River flowing through the lowlands to discharge into the Strait of Georgia. Tributary streams and rivers occupy large U-shaped valleys in the encircling ranges of the Coast and Cascade Mountains. The Fraser River drains a substantial portion of the province. Its delta is building seaward at the rate of about 8.5 m per year.

The granitic bedrock (Fig. 7) underlying most of the Fraser Lowland is covered with deep surficial deposits over most of the valley. Tertiary formations form low hills and ridges within the Lowland.

Glacial History and Surficial Deposits (Fig. 8)

Longterm studies by Armstrong (1954 to 1977) and others indicate three major periods of glaciation between approximately 10 000 and 2.5 million years ago. Each major glaciation reached ice sheet proportion during its maximum advance (thought to be at least 2280 m thick over the valleys). Land was depressed relative to the sea by as much as 300 m. Glaciofluvial material was laid down in advance of the ice sheet with morainal deposits plastered on the pre-existing hills. During the retreat and wasting of the last major ice sheet, stony-clay glaciomarine sediments, marine clay sediments, and beach deposits of sand and gravel were laid down.

Recent surficial materials include floodplain deposits, lacustrine deposits, organic deposits and sub-marine sediments (Fig. 8).

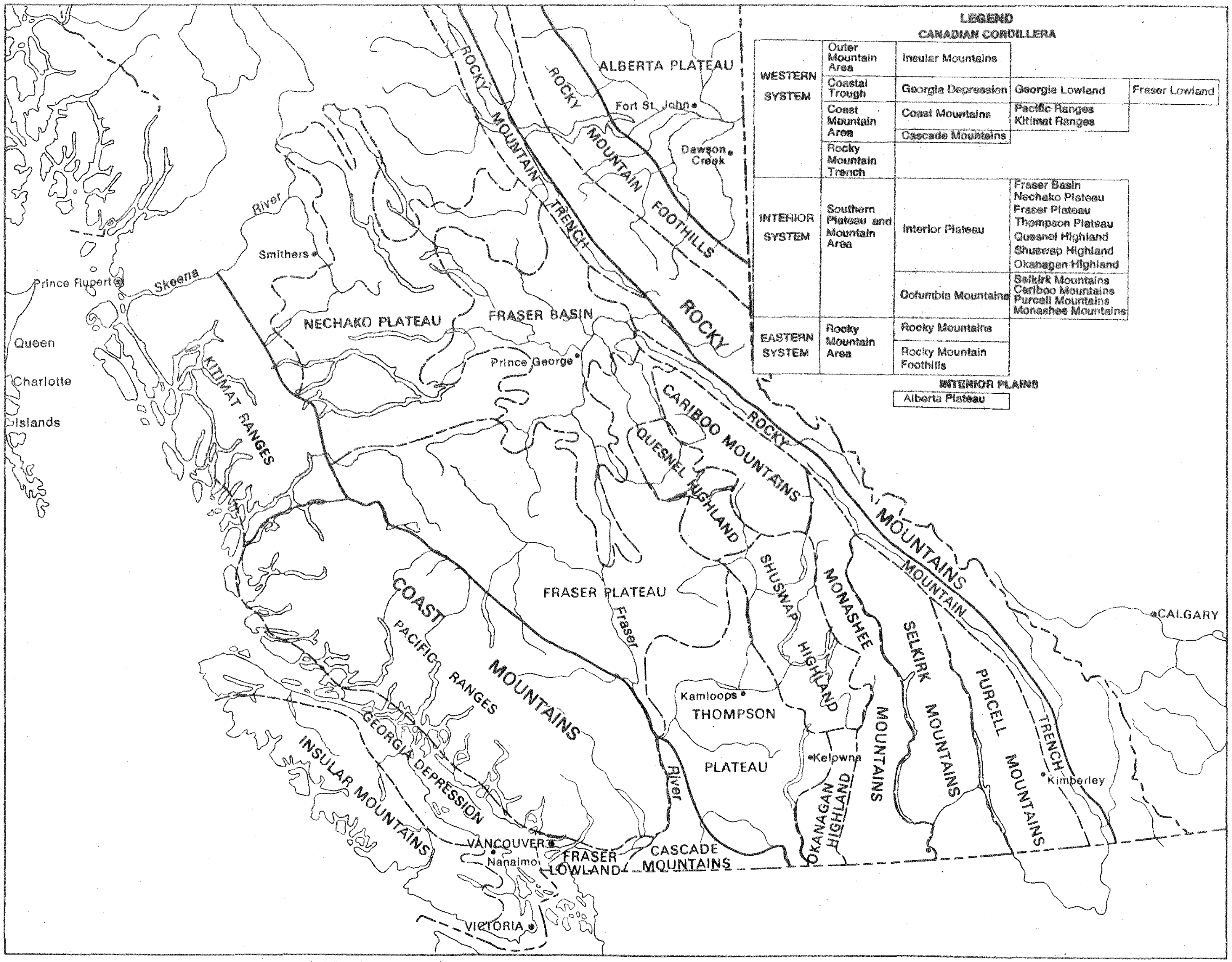


FIG. 5 PHYSIOGRAPHIC REGIONS OF SOUTHERN BRITISH COLUMBIA (ADAPTED FROM HOLLAND, 1964).

Courtesy of British Columbia Government

FIG. 6 THE FRASER LOWLAND

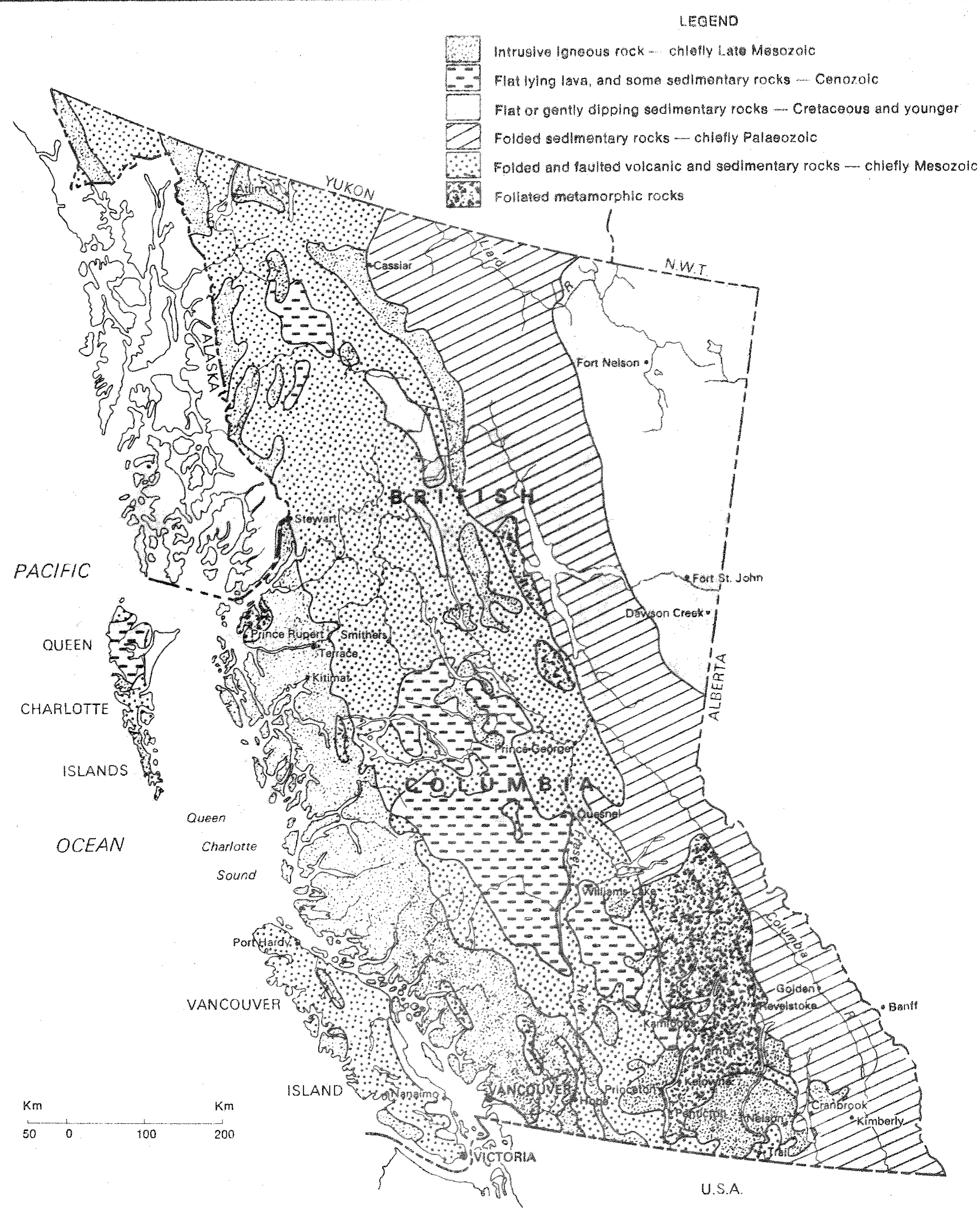
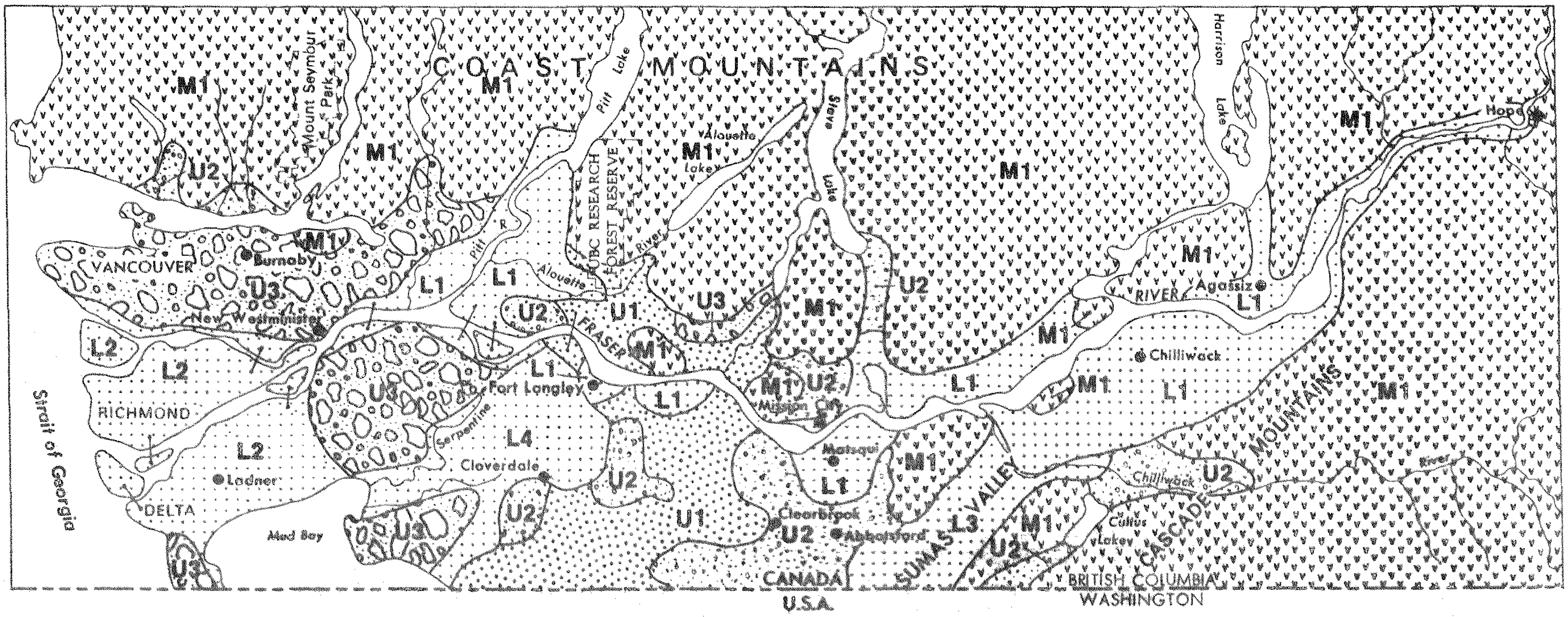


FIG. 7 GENERALIZED GEOLOGY OF BRITISH COLUMBIA
(ADAPTED FROM HOLLAND, 1964)



LEGEND

LOWLAND DEPOSITS*

- L1 Fraser River floodplain
- L2 Fraser River delta
- L3 Lacustrine deposits
- L4 Marine deposits

UPLAND DEPOSITS

- U1 Fine and medium-textured glaciomarine and till deposits
- U2 Coarse-textured glaciofluvial deposits
- U3 Coarse-textured glaciofluvial and beach deposits

MOUNTAIN SLOPE DEPOSITS

- M1 Mountain slope deposits dominantly till and glaciofluvial deposits on lower slopes and colluvial deposits on upper slopes

*Large organic deposits occur throughout the lowlands

FIG. 8 SURFICIAL DEPOSITS AND LANDFORMS IN THE FRASER LOWLAND

Climate*

As a result of the prevailing westerlies and moderating effects of the Pacific Ocean and Strait of Georgia, the Fraser Lowland has mild winters, warm but not hot summers, and a small range of temperatures. The average January minimum temperature is just slightly below freezing, becoming colder as one goes north and east from the coastline. High summer temperatures also increase in a northeastern direction away from the moderating sea breezes.

Of an average annual precipitation of 1500 cm, 78% falls in the months October to April with the remainder during the summer growing season. The average evapotranspiration rate of 350 cm exceeds precipitation rates during the summer months.

In winter, occasional outbreaks of cold air of a continental origin and the subsequent arrival of a disturbance from the west bring snow and freezing rain to the area. Snow amounts to about 3 to 6% of the total precipitation.

The Lower Fraser Valley has the longest frost free period in Canada, with the exception of Vancouver Island. Although the frost free period is localized and dependent on cold air drainage, many areas have in excess of 200 days without frost.

Table 1. Temperature and precipitation data at selected stations in the Fraser Lowland

	Temperature (C)			Precipitation (mm)		
	Mean Annual	Extreme Minimum January	Extreme Maximum July	Annual Total	Annual Snow	May to Sept.
Vancouver International Airport (5 m)	9.8	-17.8	31.7	1068	524	220
Abbotsford Airport (59 m)	9.5	-21.1	37.8	1502	783	306

(Additional climatic information is given in Appendix G)

Vegetation

The biogeoclimatic zonal system developed by Dr. V.J. Krajina (1959, 1965, 1969) is used in this tourguide as a framework to describe the distribution of British Columbia vascular plants. The Fraser Lowland lies almost entirely within the Coastal Douglas Fir Zone. The biogeoclimatic zones of British Columbia are shown in Fig. 9. The characteristic tree species found in the moister subzone division of the Coastal Douglas Fir Zone include Coast Douglas Fir, Grand Fir, Western Red Cedar, Western White Pine, Western Hemlock, Shore Pine, Arbutus, Vine Maple, Bigleaf Maple and Red Alder. Nomenclature follows that

*Source: abstracted from material supplied by R. Coligado. More detailed climatic data for stations along the tour route are given in Appendix G.

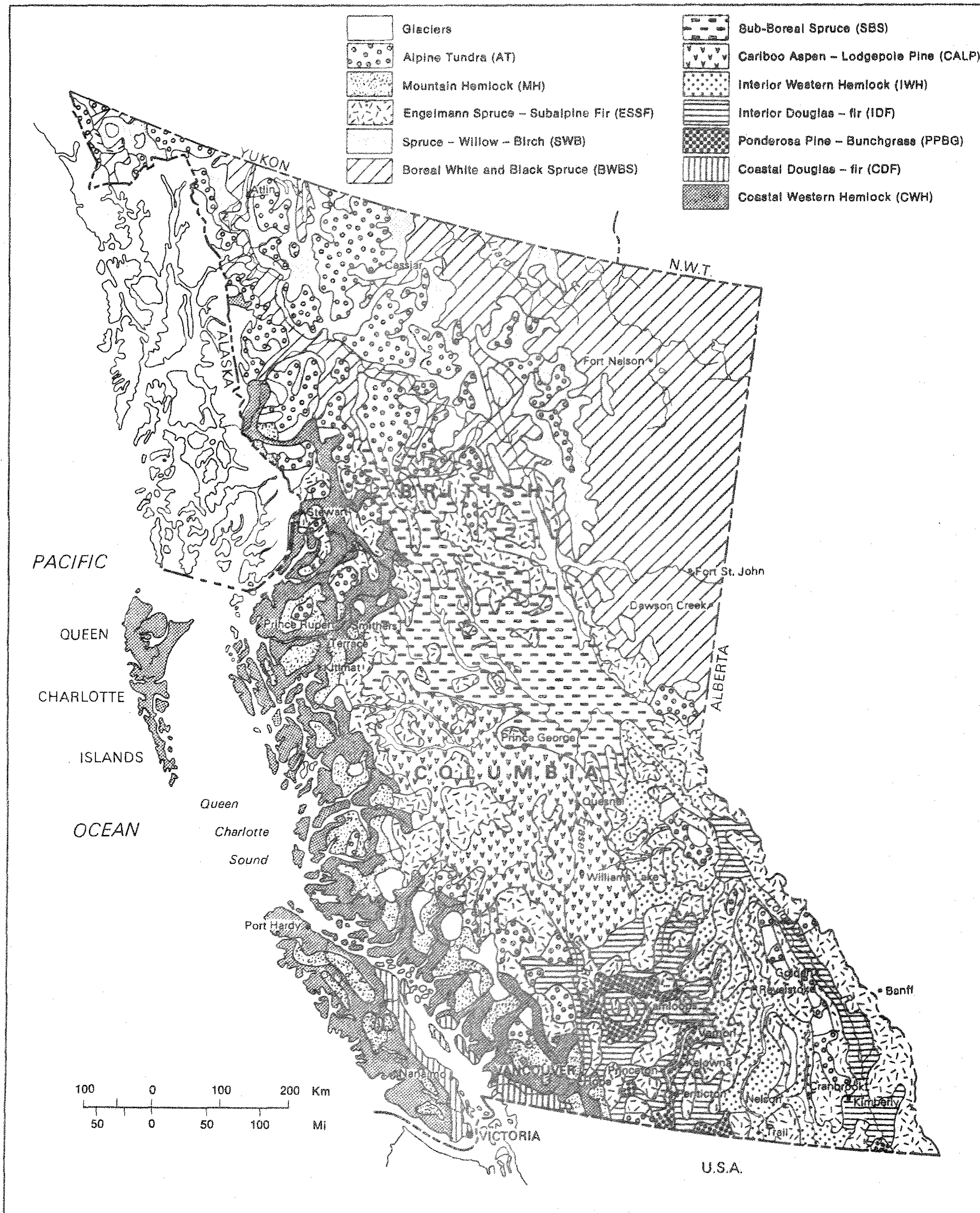
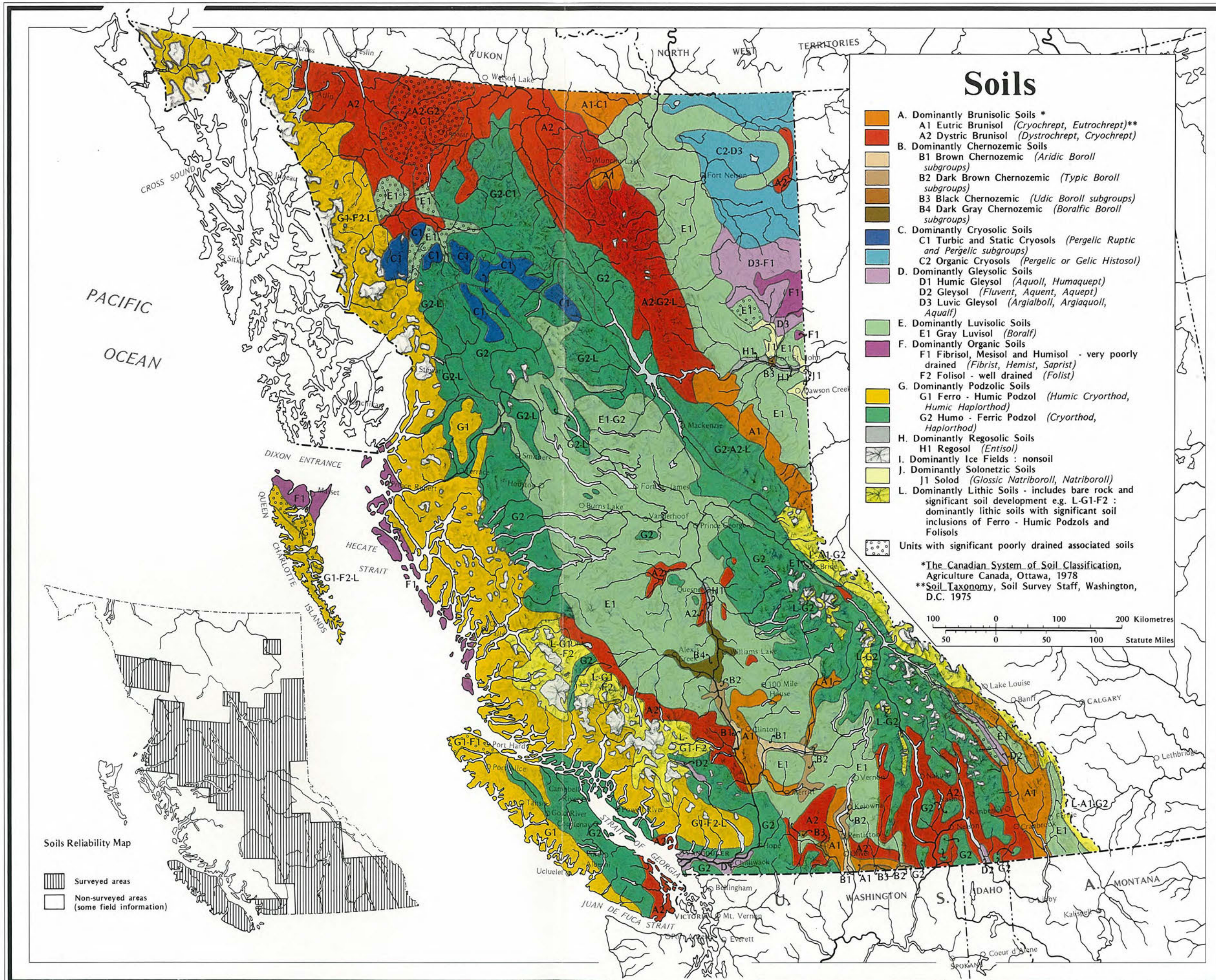


FIG. 9 BIOGEOCLIMATIC ZONES OF BRITISH COLUMBIA

Adapted from the Atlas of British Columbia (U.B.C. Press 1978). Original compilation by V. J. Krajina.

FIG. 10 SOILS OF BRITISH COLUMBIA

(See the following page for coloured soil map)



This Map is from *The Atlas of British Columbia: People, Environment and Resources* by A. L. Farley

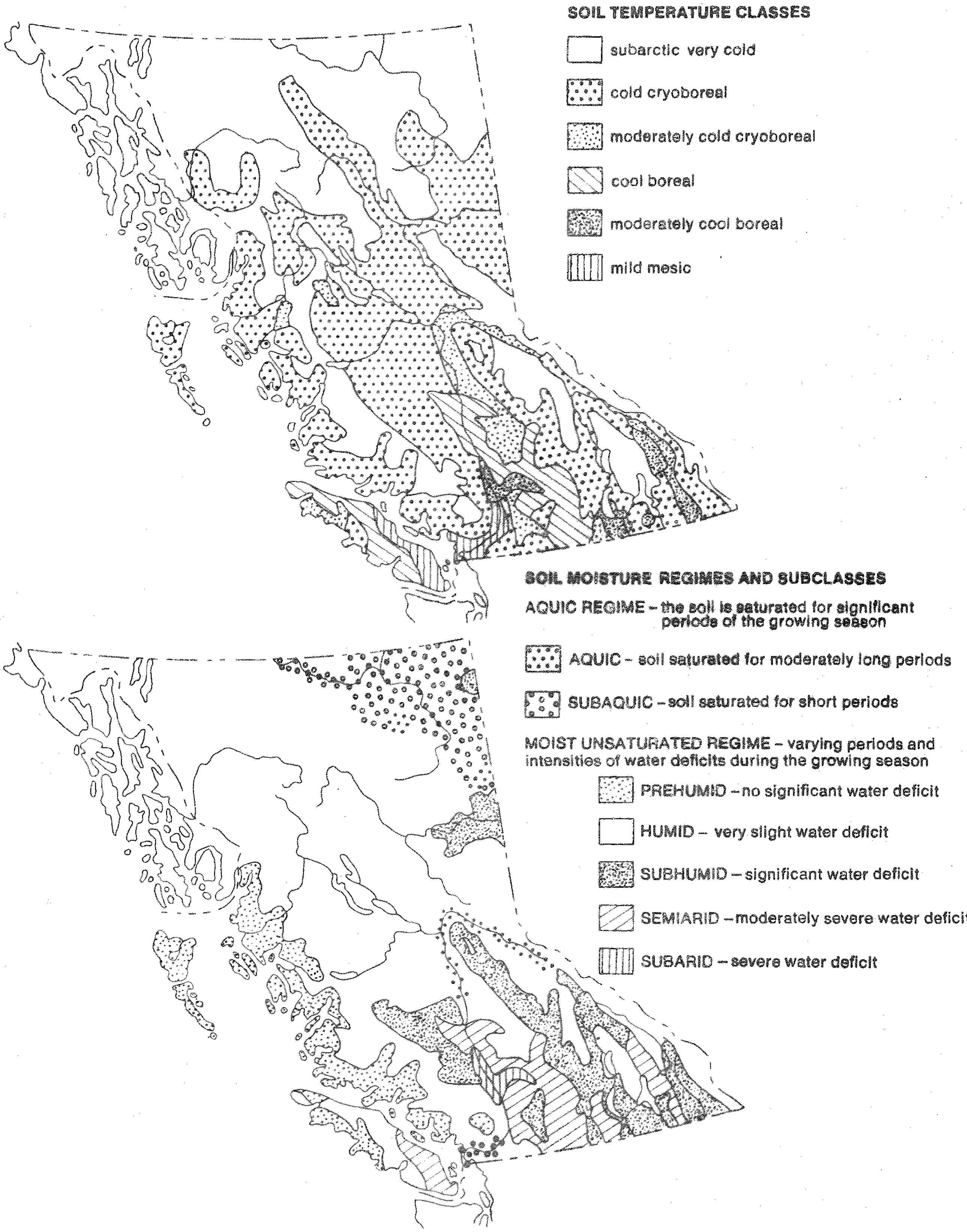


FIG. 11 SOIL CLIMATES OF BRITISH COLUMBIA (FROM SOIL LANDSCAPES OF BRITISH COLUMBIA, 1978).

Roy L. Taylor and Bruce MacBryde (1977). Appendix F lists most of the commonly occurring vascular plants and mosses along the tour route by scientific and common names. Where names are different in the two provinces, the Alberta names are shown in brackets.

Soils

Soils along the tour route through the Fraser Lowland are predominantly Humo-Ferric Podzols on the uplands and are mostly Gleysols, Brunisols or Regosols in the river floodplains (Fig. 10).

Lower Fraser Valley soils fall within the mild soil temperature class (Fig. 11) (Soil Research Institute 1975). Mean annual soil temperature at 50 cm is 8 to <15 C with mean summer temperature 15 to <22 C. Growing season degree days greater than 5 C is in the 1720 to 2220 range. The soils are in the humid to subhumid moisture class which can have significant deficits (6-12 cm) in the growing season.

Soils developed on the medium and moderately fine textured glaciomarine deposits of the uplands are mostly Podzolic Gray Luvisols or Luvisolic Humo-Ferric Podzols. Depressional areas are usually Orthic Humic Gleysols or Humic Luvic Gleysols. The moderately coarse textured till deposits are usually Duric Humo-Ferric Podzols. Coarse-textured glaciofluvial and beach deposits are generally on more level topography, and in parts of the area have a shallow capping of aeolian material. These well to rapidly drained soils are usually Humo-Ferric Podzols.

East of Abbotsford, the tour traverses recent lacustrine deposits and floodplain deposits of the Fraser River. The materials consist mainly of sand overlain by loam to silty clay loam cappings less than two metres thick. Soil drainage is generally poor to imperfect and development ranges from Regosolic to Gleysolic, Brunisolic and Luvisolic. Minor Organic areas are also present.

Land Use

Agriculture is the main land use in the Fraser Lowland. A wide range of agricultural activity occurs within the Lower Fraser Valley. The moderate climate allows for the maximum possible range of crops which can be grown in Canada. Soil variability then dictates which crop is best suited to any area within this region.

The Lower Fraser Valley is the major vegetable producing area of British Columbia. Organic and Gleysolic soils of the wet lowlands are well suited for vegetable production. Large areas of potatoes, onions, carrots, lettuce, corn and various cole crops such as cabbage and broccoli are grown annually. Small fruits, including strawberries, raspberries and blueberries are concentrated within adaptable soil areas.

The dairy industry is one of the oldest and largest industries in the Valley. The poultry business is well established in localized areas.

The major problems confronting land based agricultural operations within the Valley are those related to water management. High winter water tables create the need for internal artificial drainage to benefit good soil structure and earlier spring working. A summer moisture deficit then causes a need for irrigation systems. Regional dyking and drainage improvement programs are still needed to achieve maximum agricultural potential.

Land use conflicts are becoming increasingly more evident. This finite region must find room for its fish, wildlife, forest and agricultural industries, and its urban industry and population.

Pacific Ranges (Coast Mountains)

Physiography

The Pacific Ranges (Fig. 12), a subdivision of the Coast Mountains, form an abrupt northern boundary to the Georgia Depression. These are essentially granitic mountains with lesser amounts of metamorphic and sedimentary rocks.

The Pacific Ranges (Fig. 12) contain the highest peaks in the Coast Mountains. Mt. Garibaldi, 2674 m in elevation, is readily accessible from the Vancouver area. Mt. Waddington (4014 m), one of the highest peaks, is part of extensive ice fields several hundred kilometres north of Vancouver.

Bedrock is generally overlain by dense, compact, sandy till or unsorted colluvium. These deposits are often less than 1 m thick. On the less rugged topography of the lower slopes the gravelly sandy loam till is usually somewhat deeper; at the upper elevations bedrock is often exposed.

Climate

The maritime climate associated with the coastal mountain slopes has high precipitation, mild winters and cool summers. Mean annual temperatures range from 5 to 9 C. The mean annual precipitation has a range from >1000 to 4500 mm or more with up to 15% of the total falling as snow.

At Hollyburn Ridge station (936 m), on the mountain slope north of Vancouver, the mean annual temperature is 5 C with an extreme minimum temperature of -21.7 C for January and an extreme maximum temperature for July of 33.3 C. Annual precipitation is 2938 mm of which 8108 mm is snow. The mean May to September precipitation is 644 mm (Appendix G).

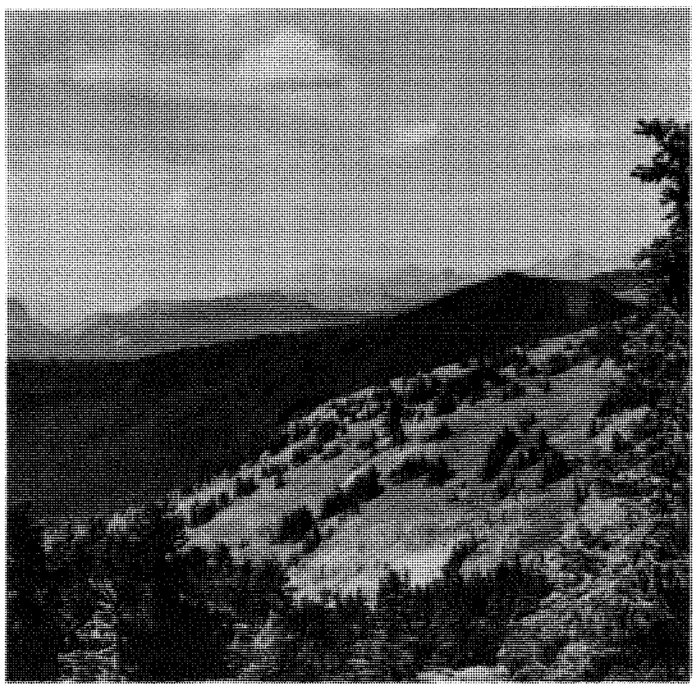
Vegetation*

The Coastal Western Hemlock Zone (Krajina 1965) occurs at low to mid elevations (up to about 1000 m) on the Coast and Insular mountains. This zone is characterized by the following trees: Coast Douglas Fir, Western Hemlock, Western

*nomenclature from Roy L. Taylor and Bruce MacBryde 1977.

Courtesy of British Columbia Government

FIG. 12 VANCOUVER AND PACIFIC RANGES



Photograph by T. Lord

FIG. 13 ALPINE LANDSCAPES IN CASCADE MOUNTAINS

Red Cedar, Grand Fir, Sitka Spruce, Western White Pine, Shore Pine, Red Alder, Vine Maple, Bigleaf Maple and Black Cottonwood. The wetter parts and higher elevations of the zone have Pacific Silver Fir, Mountain Hemlock and occurrences of Yellow Cedar. A listing by scientific and common names is given in Appendix F.

Soils

The dominant soils of the Southern Coast Mountains are Podzols. At the lower elevations Humo-Ferric Podzols and Ferro-Humic Podzols are dominant with Ferro-Humic Podzols achieving predominance above about 800 m a.s.l. Downslope seepage is present during the wetter portion of the year. Usual textures are gravelly sandy loam. A common feature of soils developed from till is the presence of a duric horizon at depths of .5 to 1 m from the soil surface. Commonly associated soils are shallow Lithosols and Folisols at the higher elevations; organic surface accumulations up to .3 m are not uncommon. Small areas of Regosolic soils occur in areas of unstable parent material.

The Podzolic soils are in the cold soil temperature class (modified by vertical zonation and aspect) (Soil Research Institute 1975). Mean annual soil temperature at 50 cm is 2 to <8 C with mean summer temperature 8 to <15 C. Growing season degree days greater than 5 C is in the 555 to <1500 range. The soils are in the humid moisture class which has only very slight deficits in the growing season (2.5-<6.4 cm).

The soil site at Mount Seymour is typical of the soils of the Coast Mountains.

Land Use

The combination of climate and soils found over much of the Pacific Ranges produces the highest forest capability in Canada. Parts of the area near large urban centres are being subjected to strong conflicting pressures involving timber harvesting, outdoor recreation, and parklands.

Cascade Mountains

Physiography

The Cascade Mountains (Fig. 13) consist of an axial core of granitic and gneissic rocks, flanked on either side by folded, faulted and slightly metamorphosed late Paleozoic to mid-Cretaceous strata. To the north, the Cascade Range broadens and merges with the granitic and metamorphic Coast Mountains. The structure of the range results from intense mid-Cretaceous and early-Tertiary deformation, forming four northwest trending structural and lithological belts. The highest Canadian peaks in the Cascade Mountains are Snowy Mountain (2592 m) and Haystack Mountain (2602 m) which represent monadnocks on an elevated erosion surface of low relief.

Surficial Deposits and Glaciation

The Cascade Mountains have been strongly glaciated and only the highest peaks and ridges escaped the Pleistocene ice sheet. Even these peaks show evidence of alpine glaciation with some horns and cirques on the north and northeast sides of the peaks. Below 2100 m the mountains are rounded and valleys show characteristic U-shapes with hanging V-shaped valleys and truncated spurs.

Because of the steep topography and glacial history, surficial deposits are highly variable. Much of the area is blanketed by morainal deposits of varying thickness. Many of the weakly compacted tills have moved significantly, since deposition, on glacially oversteepened slopes. Valley bottoms generally have deep blankets of till but these are often overlain by colluvial and fluvial deposits. Colluvial materials, although not as extensive as morainal materials, cover much of the area. They range from fairly continuous colluvial blankets, on very steeply sloping to extremely sloping areas, through infilled over-steepened lower valley slopes in the form of aprons, to isolated talus slopes and fans. The larger valley bottoms and lower slopes contain fluvioglacial kame and terrace deposits and recent alluvium, moved and redeposited by present streams.

Climate

The Cascade Mountains form the southern barrier which separates the moderate marine climate of the coast from the continental climate of the interior. Prevailing westerly winds are forced up and over the mountain range depositing much of their remaining moisture on the western slopes. On descending to the interior they are warmed adiabatically and provide a drying influence. In addition, the Cascade Mountains protect the coast from winter extremes of temperature by providing an effective barrier to arctic air masses moving south. Superimposed on this macroclimatic effect is a change in mean temperatures of approximately 5 C for each 1000 m elevation change. Table 2 presents selected climatic data from stations on the tour route as it crosses the mountains (See Appendix G for more detailed climatic information).

Table 2. Temperature and precipitation data at selected stations in the Cascade Mountains and Thompson Plateau

	Temperature (C)			Precipitation (mm)		
	Mean Annual	Extreme Minimum January	Extreme Maximum July	Annual Total	Annual Snow	May to Sept.
Hope (46 m)	9.7	-22.8	40.0	1601	1620	303
Allison Pass (1320 m)	1.8	-34.4	31.7	1452	9650	280
Princeton (685 m)	5.7	-41.1	41.7	359	1570	125

Vegetation

This section of the tour passes through a rather dramatic change in vegetation and climate. The mild, wet winters and warm, dry summers and dense coniferous forests of the coast are in strong contrast to the cold, dry winters and hot, dry summers and more open interior forests and forest-grassland transition. The western slopes of the Cascade Mountains form the transition from coastal to interior vegetation. The vegetation transition is best expressed near Hope. Ascending the west slope of the Cascades three biogeoclimatic zones (sensu Krajina) are represented. From the lowest elevation to approximately 900 m is the Coastal Western Hemlock Zone. Characterized by a Cfb climate (after Koppen) and the mildest Dfb, this represents the wettest zone in B.C. and, although in this area total precipitation is not as high as many other areas of this zone, the continental influence makes the effectiveness of the precipitation very high. Productivity of species such as Coast Douglas Fir, Western Hemlock, Western Red Cedar, and Pacific Silver Fir can be extremely high. Lying above this from about 900 m to 1800 m elevation, is the Subalpine Mountain Hemlock zone. Characterized by a Dfc climate this is an area of heavy snow pack which protects the ground from winter freezing. At the lower elevations of this zone, Western Hemlock, Pacific Silver Fir, Yellow Cedar, Western Red Cedar and Coast Douglas Fir are all moderately productive. At the higher elevations only Mountain Hemlock, Yellow Cedar and Pacific Silver Fir are commonly productive. The higher elevations, especially the parkland subzone, present serious regeneration problems following disturbance. Above the Subalpine Mountain Hemlock lies the Alpine Tundra zone where trees survive only in especially favorable habitats. In this area some krummholz Mountain Hemlock, Amabalis Fir, and White Bark Pine communities can form in areas where snow pack is light enough to allow growth by June.

The east slopes of the Cascades are again represented by three biogeoclimatic zones. Ascending from the east, the Interior Douglas Fir Zone extends to approximately 1370 m and is characterized by a Dfb climate. This is the second warmest interior zone. In this area Rocky Mountain Douglas Fir, Ponderosa Pine, and Lodgepole Pine are the dominant tree species with Ponderosa Pine being the most productive. Above the Interior Douglas Fir zone and extending to about 2200 m lies the Subalpine Engelmann Spruce-Subalpine Fir zone. Occupying an analogous position to the Subalpine Mountain Hemlock Zone of the Coast, this zone has a Dfc climate with soils often freezing before the first insulating snow fall. Only tree species such as Engelmann Spruce, Alpine Fir and Lodgepole Pine, capable of surviving extended periods of frozen ground, are common here. Engelmann Spruce and Alpine Fir are the most commercially productive species in this zone. Lying above this is the Alpine Tundra Zone, climate ET (Koppen). It is very similar to the Coastal Alpine Tundra but krummholz formation is more extensive.

Soils

Macro-climate rather than materials seems to be the dominant factor controlling soil development in this area. Within the Coastal Western Hemlock zone Humo-Ferric Podzols are the dominant soil group and occur on materials ranging from coarse glaciofluvial deposits to medium textured tills. Colluvial deposits are also dominated by Humo-Ferric Podzols but where deposition has been recent, or the slopes are active, Dystric Brunisols and Regosols occur. Alluvial deposits in this zone are often Regosols. On lower slopes or depressional areas influenced by telluric water, Gleyed Humo-Ferric Podzols are present although not dominant. Within the Subalpine Mountain Hemlock zone, Ferro-Humic Podzols are dominant although Humo-Ferric Podzols are still present. As in the Coastal Western Hemlock zone materials seem to have little influence on the soil subgroup except for alluvial and recent colluvial deposits. Unlike the Coastal Western Hemlock zone, gleyed subgroups are more common in lower slope positions and depressional areas, and some Humic Gleysols are found. Alpine Tundra is not extensive in this area and the soils of this zone have been little studied.

Forest floors in this area are almost exclusively mor humus forms with occasional moder forms on lower slope positions. The relative proportion of an H horizon tends to increase with elevation.

On the eastern slopes of the Cascades, precipitation has decreased significantly. As a result of this, organic matter content of the mineral soils, thickness of the forest floor and relative proportion of the H-layer, and translocated iron are all markedly reduced. Soils of the Interior Douglas Fir zone are dominantly Dystric Brunisols with some Eutric Brunisols on south exposures and more basic parent materials. Alluvial soils are dominantly Regosols while some of the glaciofluvial soils of the valley bottom are Humo-Ferric Podzols or Dystric Brunisols.

The lower elevations of the Subalpine Fir zone still have some Eutric and Dystric Brunisols, especially on more southerly aspects and drier topographic positions, but soils are dominantly Humo-Ferric Podzols. Ferro-Humic Podzols are rare and are generally confined to west aspects at higher elevations.

Figure 14 depicts a representative cross section through the Cascade Mountains. Due to the variability present in this area and the scale of mapping it is impossible to delineate single soil series as map units. Instead, cross sectional diagrams are presented to show the general pattern of recognized soils within each map unit.

Land Use

Forestry - Hope to Manning Park encompasses the eastern half of the Dewdney Public Sustained Yield Unit (P.S.Y.U.). This is an area of crown (public) land, managed under the supervision of the British Columbia Ministry of Forests on a sustained yield basis. While maintaining control of the land the Ministry alienates timber, under various forms of tenure, to private companies and insures that management practices are consistent with the policy of sustained yield.

As will become obvious on the tour, the terrain is very rugged and methods of harvesting are necessarily restricted. Clear cutting in blocks smaller than 80 ha is the dominant cutting pattern and timber is yarded (hauled) to a landing site using a high lead system. From the landing, logs are trucked to log dumps for redistribution to various processing plants. As harvesting continues access and transport problems are becoming more serious. Average road building costs for the Dewdney P.S.Y.U. in 1976 were \$21 500 per km and in some areas can exceed \$60 000 per km for main line construction. The foregoing statements are generally applicable also to the Pacific Ranges.

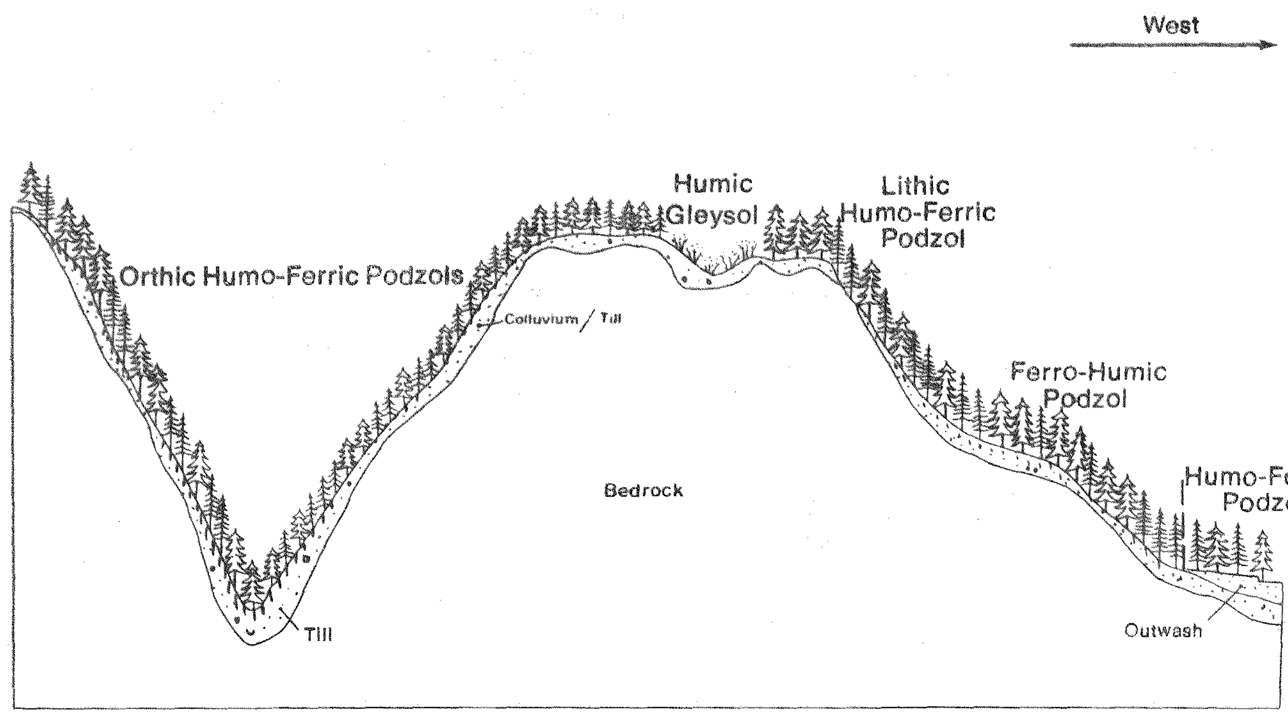


FIG. 14 SOIL MAPPING UNITS IN THE CASCADE MOUNTAINS

Photograph by A. McLean

FIG. 15 ALPINE MEADOWS MANNING PARK

Despite the relatively high precipitation on the west slopes of the Cascade Mountains forest productivity is still most strongly influenced by the soil moisture status during the summer dry period. Since rooting depth is generally restricted either by bedrock or a layer of dense, compact, often indurated till, productivity is most strongly correlated with the position on slope of the area in question. Downslope movement of water produces strong catenary sequences of soil and vegetation which can be related to productivity and management requirements. These catenary sequences have been identified and classified within the framework of the biogeoclimatic zones discussed earlier and provide the basis for site specific management recommendations.

Current soil and terrain maps are presently used more for engineering interpretations rather than for silvicultural planning. Of primary concern are questions of slope stability, road bed, cutbank and side cast stability, and erosion and channel scour potential. Terrain maps are also used to predict possible effects on stream water quality and its influence on fisheries.

Recreation - The tour route passes through Manning Provincial Park. Established in 1931 as a reserve to protect the alpine meadows (Fig. 15) from overgrazing by domestic sheep, the area was designated as a provincial park in 1941. It covers 75 300 ha. With the completion of the Hope-Princeton Highway in 1949 the park was made readily accessible to the public and has undergone continued development since then. Today Manning Park provides both winter and summer recreation facilities ranging from alpine skiing and hiking to fishing and camping.

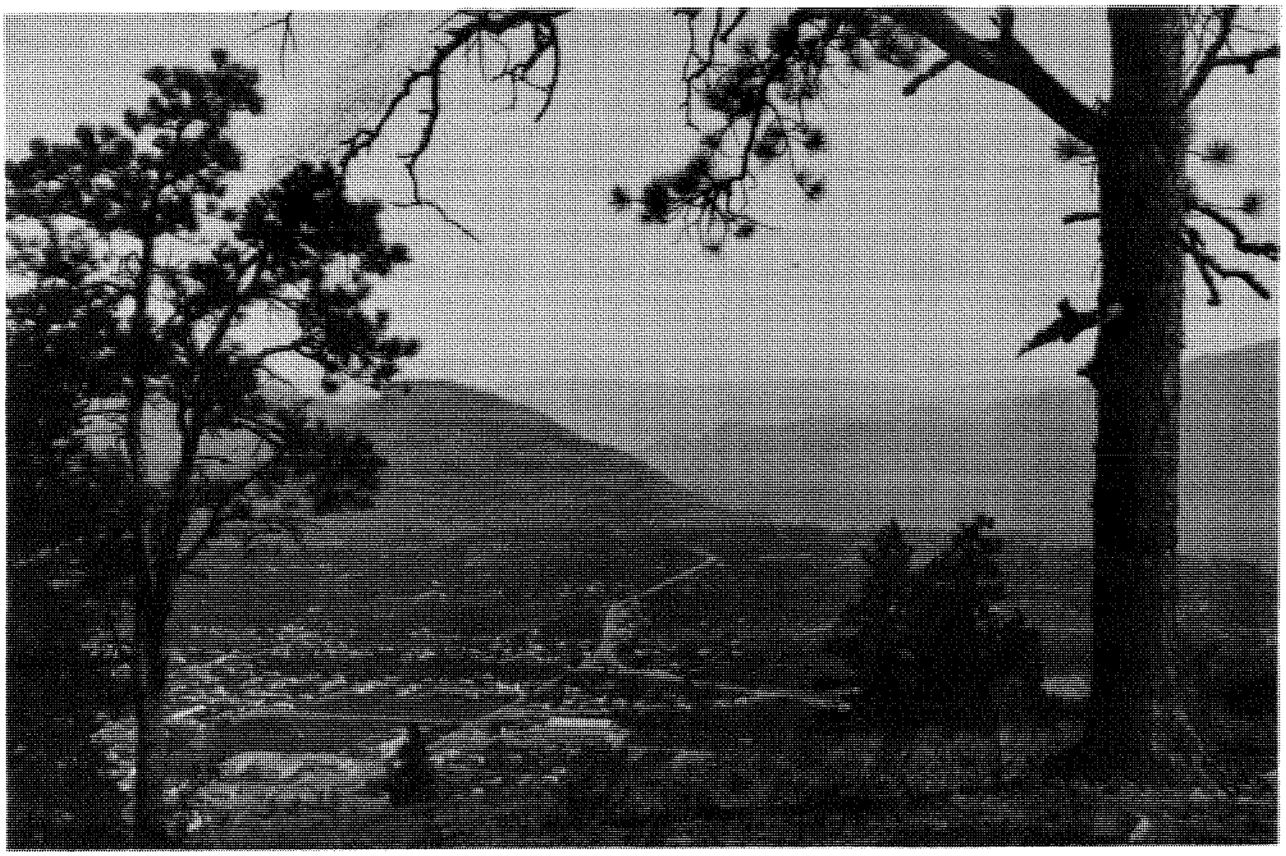
Agriculture - The Cascade Mountains have limited potential for agricultural uses due mainly to the adverse topography. Cattle and sheep graze some alpine meadows during the summer months.

Thompson Plateau

Physiography

The Thompson plateau is the most southerly plateau area of the Interior Plateau. Because of the gradual rise of the plateau towards the Cascade Mountains the area shows increased dissection by streams and the boundary is somewhat arbitrary. For the most part the plateau is a deeply incised, gently rolling upland lying between 1220 and 1520 m with prominences of more resistant rock rising as high as 2246 m. The bedrock is highly varied, stocks of granitic rock intrude sedimentary and volcanic formations of Paleozoic age. Flat lying or gently dipping Tertiary lavas cover much of the older rocks. The regional pre-Tertiary structure is poorly known but there is a progressive increase in age of stratified rocks from west to east.

The plateaus and uplands of the interior were formed by the elevation and subsequent dissection of a late Tertiary erosion surface during the Pliocene. The greatest elevation occurred in the east where almost complete dissection has produced rugged mountains with occasional flat tops. Progressing westward, where uplift was not as great, remnants of the Tertiary surface increase in size forming successively the upland and plateau areas.



Courtesy of British Columbia Government

FIG. 16 THE OKANAGAN VALLEY AT SUMMERLAND

Surficial Deposits and Glaciation

The Thompson Plateau was occupied by Pleistocene ice which left a thick mantle of glacial drift covering a large part of the bedrock. The movement of ice in a southerly and southeasterly direction produced many drumlin-like forms and is also largely responsible for the present form of the Okanagan Valley (Fig. 16). Since the end of the Pleistocene was characterized by a gradual stagnation and wasting of ice in place, many ice marginal meltwater channels were quickly cut and abandoned. A series of such channels can be seen on successively lower slope positions in many areas of the interior. As a result of the irregular melting of ice lobes occupying the major valley streams, many glacial lakes were formed. These glacial lakes were fed by streams heavily laden with silts. When they drained thick silt deposits were left, marking the front or sides of the wasting ice lobes. The deep silt banks on lower Okanagan Lake are fine examples of this feature. Also as a consequence of the general stagnation and wasting in place of the ice are the kettled outwash deposits found here. They formed as a result of outwash sands and gravels filling in around remnant blocks of ice which, when melted, left depressions in the deposits.

Following retreat of the ice and draining of the glacial lakes, many river terraces and channels, and alluvial fans and deltas which were formed at a higher base level, have been left raised above the new base level. The alluvial fans and deltas originally formed have since been down cut and partially eroded by the streams which formed them.

Climate

Denied by the Cascade Mountains the moderating marine influence of the Pacific Ocean, and unprotected from arctic air masses moving south in the winter, the Thompson plateau suffers moderate to severe winters and hot summers. Precipitation varies from 250 to 350 mm in the valleys to 750 mm or more in the uplands. Much of the variability is due to rain shadow effect. Low precipitation combined with high summer temperatures produce summer moisture deficits as high as 400 mm in the valleys.

Table 3 shows some climatic changes from south to north in the Okanagan Valley. This climatic gradient is typical of the plateau area. (See Appendix G for more detailed climatic information).

Table 3. Temperature and precipitation data at selected stations in the Okanagan Valley

	Temperature (C)			Precipitation (mm)		
	Mean Annual	Extreme Minimum January	Extreme Maximum July	Annual Total	Annual Snow	May to Sept.
Osoyoos (321 m)	9.8	-22.8	38.3	342	690	127
Penticton (336 m)	8.8	-26.8	40.6	296	690	128
Kelowna (477 m)	7.7	-31.7	37.2	336	850	140
Vernon (415 m)	8.0	-35.0	40.0	393	1030	176

Vegetation

Vegetation patterns on the Thompson plateau are well defined and correspond closely to topographic features which strongly influence the climatic pattern. Four biogeoclimatic zones are present but the Subalpine Engelmann Spruce-Subalpine Fir Zone dominates (Krajina 1969). Its general occurrence on the plateau surface relegates the other three zones to localized areas or valley systems.

The somewhat isolated prominences occurring on the plateau produce alpine tundra in their highest elevations. Vegetation here is similar to that discussed in the Cascade Mountain section but krummholz formation in the lower elevation is more extensive. The plateau areas lying generally between 1200 and 1500 m are dominated by the Subalpine Engelmann Spruce-Subalpine Fir biogeoclimatic zone. Climate is Dfc and in this area shows a wet winter and dry spring. It is representative of the southern subzone of the Subalpine Engelmann Spruce-Subalpine Fir Zone and is characterized by the great diversity of trees occurring here. Engelmann Spruce, Alpine Fir, Lodgepole Pine, Western White Pine, Whitebark Pine, Limber Pine, Alpine Larch, Rocky Mountain Douglas Fir (rarely), Western Hemlock (rarely), Mountain Hemlock (rarely), and Western Red Cedar (rarely) are all known to occur. In addition, the subzone shows altitudinal variation similar to the Mountain Hemlock Zone. On the coast, the non-forested areas of the parkland are the product of heavy snow pack limiting tree growth until well into the summer; in the interior forest, colonies develop where the snow lies longer and provides moisture into the growing season. Grassland communities form in areas where snow melts early and summer drought is experienced.

Occupying an intermediate position between the Subalpine Engelmann Spruce-Subalpine Fir zone of the plateau areas and the Ponderosa Pine-Bunchgrass Zone of the valley bottoms is the Interior Douglas Fir zone. The higher elevations of the latter zone, where effective moisture is greater, has closed forest stands while the lower elevations, which are effectively dry, have fairly open forests. This provides the basis for the recognition of dry and wet subzones in the area. The Interior Douglas Fir zone is characterized by the following coniferous trees: Rocky Mountain Douglas Fir, Ponderosa Pine, Western White Pine, Grand Fir, Lodgepole Pine, Western Larch and Western Red Cedar. The subzones can be distinguished on the basis of understory vegetation. For example, zonal sites in the Interior Douglas Fir (wet) subzone support False Boxwood and the Interior Douglas Fir (dry) subzone support Pine Grass. In both subzones Rocky Mountain Douglas Fir is the most shade tolerant tree species while Ponderosa Pine is the most productive.

Occurring in the lowest elevational limits of the valley systems is the Ponderosa Pine-Bunchgrass Zone. The dominant climate is BSk, although it also occurs in the Dsa and driest Dsb climates. Characterized by cold winters and warm summers, the area is considered semiarid to microthermal subhumid. Being the driest and in summer the warmest biogeoclimatic zone in the British Columbia forest, productivity is very limited. The dominant tree species is Ponderosa Pine which is shade tolerant on all but the wettest sites. Rocky Mountain Douglas Fir also occurs but is shade requiring on all sites in which it occurs and Western Red Cedar occurs only alongside permanent streams. Since this zone suffers a marked moisture deficit, all permanent streams originate outside the zone. The Ponderosa Pine-Bunchgrass Zone, dominated by semiarid steppe vegetation consisting of sagebrush and bitter brush communities can, when irrigated, support a variety of highly productive agricultural crops on suitable soils.

Soils

The soils of the Thompson Plateau reflect the combined effect of climate, parent material, relief, and organisms on soil development far better than do the coastal soils. Climate, especially precipitation, no longer has the dominating influence it does on the coast. At the highest elevations Regosols, disrupted by cryoturbation and solifluction, develop under patchy alpine tundra vegetation. The lower elevations of the Alpine Tundra Zone contain Sombric Brunisols and Humo-Ferric Podzols. Forming under alpine communities of grasses, sedges, willows, and herbs, these soils generally exhibit deep, turfy topsoils and in many areas contain quantities of volcanic ash. Below this, in the Subalpine Engelmann Spruce-Subalpine Fir parkland, is an area dominated by Humo-Ferric Podzols. These soils show a greater accumulation of amorphous organic matter in the upper mineral horizons than do their counterparts at lower elevations.

In the Subalpine Engelmann Spruce-Subalpine Fir zone in areas above 1675 m, Humo-Ferric Podzols and Dystric Brunisols develop. The combination of climate and coarse textured, acid parent materials in these areas contributes to Podzol formation. Below these areas, on the plateau proper, a variety of soils occurs. Controlled primarily by the nature of the parent material, three major soils occur. In areas where medium textured till is derived from base rich bedrock Gray Luvisols predominate. On parent material where textures are coarser but base status is still high Eutric Brunisols occur, but on parent materials of low-base status Dystric Brunisols occur. All of these soils can develop under vegetation which shows little gross difference from soil to soil.

Occupying the lower elevations of the plateau proper and the higher elevations of the major valley systems the Interior Douglas Fir zone also supports a variety of soils. Where soils are relatively fine textured and base rich, parent material seems to be the most important factor in forming Gray Luvisols. The distribution of Brunisols in the Interior Douglas Fir zone is governed mainly by the expression of climatic factors. Of particular interest in this area is the distribution of Chernozemic soils. Although these soils are confined primarily to the Ponderosa Pine-Bunchgrass zone, black Chernozem-like soils have been found as high as 2000 m a.s.l. in this area. Their distribution here provides excellent evidence for the theory of compensating factors as they influence soils distribution. Chernozemic soils in the Interior Douglas Fir zone are dominantly Black and Dark Brown.

The influence of parent materials in the Ponderosa Pine-Bunchgrass zone may lead to formation of Luvisols and Brunisols and on recent deposits, Regosols. Climate is for the most part the dominating influence. Where effective soil moisture is least, either as a result of warmer temperatures or lower precipitation, Brown Chernozemics may develop. Increasingly effective moisture leads to Dark Brown and Black Chernozemics. This pattern is well expressed in the Okanagan Valley. From south to north temperatures become progressively cooler, effective moisture higher, and a gradual transition from Brown to Dark Brown and Black Chernozemics occurs.

Land Use

The Thompson Plateau is a forested highland that includes open grassland areas and sparsely treed valleys.

Douglas fir, pine and spruce tree species provide an important logging industry with raw materials for lumber, pulpwood and wood products.

The cattle industry makes extensive use of both the grasslands and the open Douglas Fir forest (Appendix I). Pasture and hay are produced on wetlands and irrigated valley soils (Appendix H). Early spring grazing is practised on open rangelands supported by predominantly Chernozemic soils. From here the cattle normally move into the lower elevation forests. Before returning to the meadows and home ranges in the fall the cattle may browse on the high elevation subalpine parklands scattered throughout the plateau.

Intensive use is made of irrigated fluvial and lacustrine soils in the Okanagan and Similkameen valleys. A wide range of tree fruits including peaches, apricots, apples, pears and cherries are grown. These lands also produce crops of grapes, vegetables and small fruits.

Recreation is an increasingly important land use. Where terrain and weather conditions are suitable, large ski resorts, catering to downhill and cross country clientele, have developed near population centres. Summer activities include boating, fishing, camping, swimming and hiking. Hunting of ungulates such as deer and sheep is carried out in the forested areas.

Shuswap Highland

The Shuswap Highland, Figure 5, extends northward from Vernon and lies between the Monashee Mountains on the east and the Thompson Plateau on the west.

Physiography

The Shuswap Highland consists of a rolling and sloping plateau which rises from about 1200 to over 2100 m and is dissected by four major rivers. The valley walls are steeply sloping due to glacial erosion. The ridges and summits are generally rounded, despite the height of the highland. This is in contrast to the sharp, steep-sided Columbia Mountains to the east.

Several large lakes, which include Shuswap Lake, occupy parts of the major valleys.

The composition and age of the bedrock in the Shuswap Highland is variable. Most of the terrain is underlain by strongly foliated and lineated assemblages of metamorphic rocks which are mostly of sedimentary derivation and of Palaeozoic age or earlier. Also included is a variable amount of metamorphosed igneous rock of Mesozoic age which is more resistant to erosion. Isolated areas of flat-lying or gently dipping lava flows of Tertiary age are scattered through the southern part.

Surficial Deposits and Glaciation

The Shuswap Highland, like all of British Columbia, was almost entirely covered by glacial ice during the Pleistocene. Ice movement was in a southern to southeastern direction across the bedrock-controlled terrain. The ice sheet deposited till over most of the area to variable depths. Subsequent decay and melting of the glacial ice resulted in gravelly and sandy glacial outwash and silty and clayey glacial lake deposits with the latter confined to the lower elevations in some of the valleys. With the complete retreat of the ice and drainage of the glacial lakes, many post glacial alluvial terraces, floodplains, fans and deltas were deposited. Present day rivers and streams have subsequently eroded down to their current base levels. As a result, the landforms that occur in the Shuswap Highland are predominantly the erosional or depositional products of the last ice age.

Climate

The Shuswap Highland, like the Thompson Plateau, is subject to cool to cold winters and warm to hot, dry summers. The dominant climate is Dfb.

Arctic air masses moving south during the winter often subject the area to below freezing temperatures and cold winter weather. Invasions of tropical air masses during the summer from the south often result in high temperatures and hot, dry weather. Similarly, invasions of Pacific air masses from the west, which occur in all seasons of the year, have a very significant effect on the temperature and precipitation.

Extremes of temperature recorded at selected stations in the valleys vary from -42.2 C in January to 41.1 C in July. Temperatures are usually warmer in the valleys during the winter and hotter during the summer than the surrounding highland terrain.

Precipitation data recorded at selected stations along the tour route vary from 392 mm at Vernon to 604 mm at Sicamous. Snowfall and May to September precipitation also increase in respective proportions. This is mainly due to the rain shadow effect in the valleys and the closer proximity of the higher elevations of the Monashee Mountains. Rainfall and snowfall data at higher elevations in the Shuswap Highland show higher precipitation than that recorded in the valleys.

Temperature and precipitation data in Table 4 are for stations along the tour route (See Appendix G for more detailed climatic information).

Table 4. Temperature and precipitation data at selected stations in the Shuswap Highland and Monashee Mountains

	Temperature (C)			Precipitation (mm)		
	Mean Annual	Extreme Minimum January	Extreme Maximum July	Annual Total	Snow	May to Sept.
Vernon (415 m)	8.0	-35.0	40.0	393	1034	176
Armstrong (360 m)	7.1	-42.2	40.6	448	1347	179
Salmon Arm (498 m)	7.7	-35.0	41.1	530	1562	205
Sicamous (420 m)	8.0	-30.0	36.7	604	1858	253
Revelstoke (449 m)	7.2	-34.4	40.6	1096	4116	323

Vegetation

Five biogeoclimatic zones (Krajina 1964) occurring in the Shuswap Highlands are Alpine Tundra, Subalpine Engelmann Spruce-Subalpine Fir, Interior Douglas Fir, Ponderosa Pine-Bunchgrass, Interior Western Hemlock.

The first four of these biogeoclimatic zones are similar to those described in the overview of the Thompson Plateau. The physiographic boundary between the Thompson Plateau and the Shuswap Highland does not conform to the vegetation zonation which is more closely related to elevation, precipitation and temperature.

The Interior Western Hemlock Zone occurs in the eastern part of the Shuswap Highland in the interior wet belt where it occupies an intermediate position between the Interior Douglas Fir and the Subalpine Engelmann Spruce-Subalpine Fir zones. Most of the zone occurs in the valleys and adjacent to the rivers and lakes at elevations which are similar to the Interior Douglas Fir and Ponderosa Pine zones.

The Interior Western Hemlock zone is the wettest and most productive zone in the Interior. Coniferous trees which occur include Western Hemlock, Western Red Cedar, Rocky Mountain Douglas Fir, Western Larch, Western White Pine, Grand Fir and Lodgepole Pine.

Soils

The various combinations of climate, parent material, vegetation, elevation, topography, and aspect provide a wide range in the development of soils of the Shuswap Highland.

Minor areas of Alpine Tundra are dominated by Sombric Dystric Brunisols and Podzols with inclusions of Regosols where the soils are subjected to periglacial processes.

Humo-Ferric Podzols, Ferro-Humic Podzols and Dystric Brunisols occur in the krummholz subzone of the Engelmann Spruce-Subalpine Fir zone above about 1500 m. Below this elevation in the productive forest zones soil development is mainly related to parent material, precipitation and elevation. Coarse-textured tills derived from granitic bedrock have mainly Humo-Ferric Podzol and Dystric Brunisol development whereas medium-textured tills derived from medium- to fine-textured bedrock (andesitic and basaltic lava flows) have predominantly Gray Luvisols. Soils developed on limestone and high base status parent materials vary from Gray Luvisols to Eutric and Dystric Brunisols. All of these soils can develop under similar vegetation, with minor vegetation variations related to elevation and aspect.

Soils in the Interior Douglas Fir zone also have a wide range of development which is also related to the parent material, precipitation, elevation and aspect. Most of the areas of medium to fine textured parent materials produce Gray Luvisols. Coarse textured materials, under similar vegetation, elevation and aspect are usually Eutric Brunisols. Closely related, depending on aspect, are inclusions of Dark Brown and Black Chernozemic soils where the grassland soils form a complex pattern with the forested soils.

Due to the drier climate of the Ponderosa Pine-Bunchgrass zone, the soils are mainly Eutric Brunisols and Brown, Dark Brown, Black and Dark Gray Chernozemic soils. Minor Gray Luvisols occur in the transition to the Interior Douglas Fir zone.

The Interior Western Hemlock zone has a wetter climate and occurs at elevations where heat units are conducive to forest growth. Soil development, depending on the parent material, includes Dystric Brunisols and Humo-Ferric Podzols with inclusions of Ferro-Humic Podzols.

Land Use

The Shuswap Highland is predominantly a forested area and is extensively logged.

The river valleys are used for agriculture. Mixed farms and ranches use certain sections of the highland for grazing where the terrain and vegetation are suitable.

Numerous stretches of lakeshore provide an extensive area for summer recreation. Cabins and tourist resorts have been constructed along the shorelines where the topography is favourable.

Ski hills for winter recreation are located northeast of Vernon and northwest of Salmon Arm.

Ungulates, including deer and moose, are found throughout the highland.

Columbia Mountains

The Columbia Mountains comprise a group of high relief mountains in southeastern British Columbia. They are sharply divided from the Rocky Mountain Trench on their eastern flank but merge gradually with the interior highlands on the west.

"The Columbia Mountains include a wide variety of rocks, mostly of sedimentary derivation, through Palaeozoic and Mesozoic sedimentary and volcanic formations, all of which are intruded by a considerable number of granitic stocks and batholiths of varying size. Topographic differences between individual ranges are in part due to altitude and in part due to differences in erosion of the rocks involved" (Holland, 1964).

The tour traverses three of the four major subdivisions - the Monashee Mountains, Selkirk Mountains and the Purcell Mountains - divided by river valleys.

Monashee Mountains

The Monashee Mountains occupy a northerly trending belt 40 to 50 km wide between the Shuswap Highland and the Selkirk Mountains. Elevations exceed 3000 m on numerous peaks of the northern ranges. Sedimentary and metamorphic rocks generally underlie the Monashee Mountains. "The high mountains, especially those in the northern range, are mostly massive with bold peaks separated by deep, steep-sided valleys. Peaks above 2400 m projected through the Pleistocene icesheet and were subjected to intense cirque glaciation which produced matterhorn-like peaks. Lower summits were covered by ice at one stage and subsequently have been sculptured by cirque and valley glaciers to sharp peaks and sawtooth ridges. The valleys, especially those parallel to the southerly moving ice, were intensely glaciated, with considerable modification of their longitudinal and transverse valley profiles. On the retreat of the ice a mantle of drift, deeper in the valley bottoms than on the sides, was left everywhere" (Holland, 1973).

Selkirk Mountains

The Selkirk Moutains lie within the bend of the Columbia River. They are directly east of the Monashee Mountains and are separated from them by the Columbia River at Revelstoke (Fig. 17). The highest peaks, from 3000 to 3500 m a.s.l. are limestone and form a very high and rugged mountainous landscape. Rogers Pass (Fig. 18) at an elevation of 1307 m a.s.l., has one of the heaviest snowfalls in the world (average of 925 cm).

Purcell Mountains

The Purcell Mountains are separated from the Selkirk Mountains by a long through valley occupied in part by the Beaver River. They have an abrupt eastern boundary with the Rocky Mountain Trench. Like the Selkirks, the Purcell Mountains contain some extremely high rugged mountain country. Geological reports state that the ice sheet in the area moved in a generally southerly direction, with ice on the east flank of the Purcell Mountains moving southeast and that on the west flank southwest.

Soils, Vegetation and Climate

Soil and terrain surveys are incomplete along the tour route through the Columbia Mountains. Soils data projected from surveyed areas along the Arrow and Shuswap lakes south and west of Revelstoke and extrapolated from surveys in the Selkirk and Purcell mountains south of the highway route, indicate predominantly Humo-Ferric and Ferro-Humic Podzols. The Podzols are best developed on deep, coarse-textured, acid, glaciofluvial materials on the lower slopes of the valleys. Lithic phases and the presence of rock and ice increase up-slope.

This regime is reflected in the vegetation patterns. The Interior Western Hemlock biogeoclimatic zone follows the valleys merging with the Subalpine Engelmann Spruce-Subalpine Fir zone on the mountain slopes. The highest elevations are classified as Alpine Tundra and Glacier land type. The Interior Douglas Fir Zone is encountered in the Trench.

Climatic data from three stations (Appendix G) - Revelstoke (449 m) at the western edge of the mountains, Glacier (1228 m) in the high pass midway through the mountains, and Golden (775 m) in the Rocky Mountain Trench - show

Courtesy of British Columbia Government

FIG. 17 THE COLUMBIA VALLEY AND SELKIRK MOUNTAIN, REVELSTOKE

Courtesy of British Columbia Government

FIG. 18 ROGERS PASS

interesting patterns. The moderately cold moist climate of Revelstoke with its high snowfall is contrasted with a cold, extremely high snowfall regime at Glacier and the cold, drier climate of Golden.

Table 5 shows the climate gradient from west to east across the mountains. (See Appendix G for more detailed climatic information).

Table 5. Temperature and precipitation data at selected stations through the Columbia Mountains

	Temperature (C)			Precipitation (mm)		
	Mean Annual	Extreme Minimum January	Extreme Maximum July	Annual Total	Annual Snow	May to Sept.
Revelstoke (449 m)	7.2	-34.4	40.6	1096	4116	322.6
Glacier (1228 m)	2.1	-35.6	36.7	1493	9695	409.7
Golden (775 m)	4.8	-46.1	40.0	473	2038	178.4

Land Use

Although the climate in the mountain valleys is suitable for growing a fairly wide range of agricultural crops, the amount of land of suitable texture and topography is severely limited. Lower valley slopes and bottomlands have moderate to high productivity for forestry and are being logged.

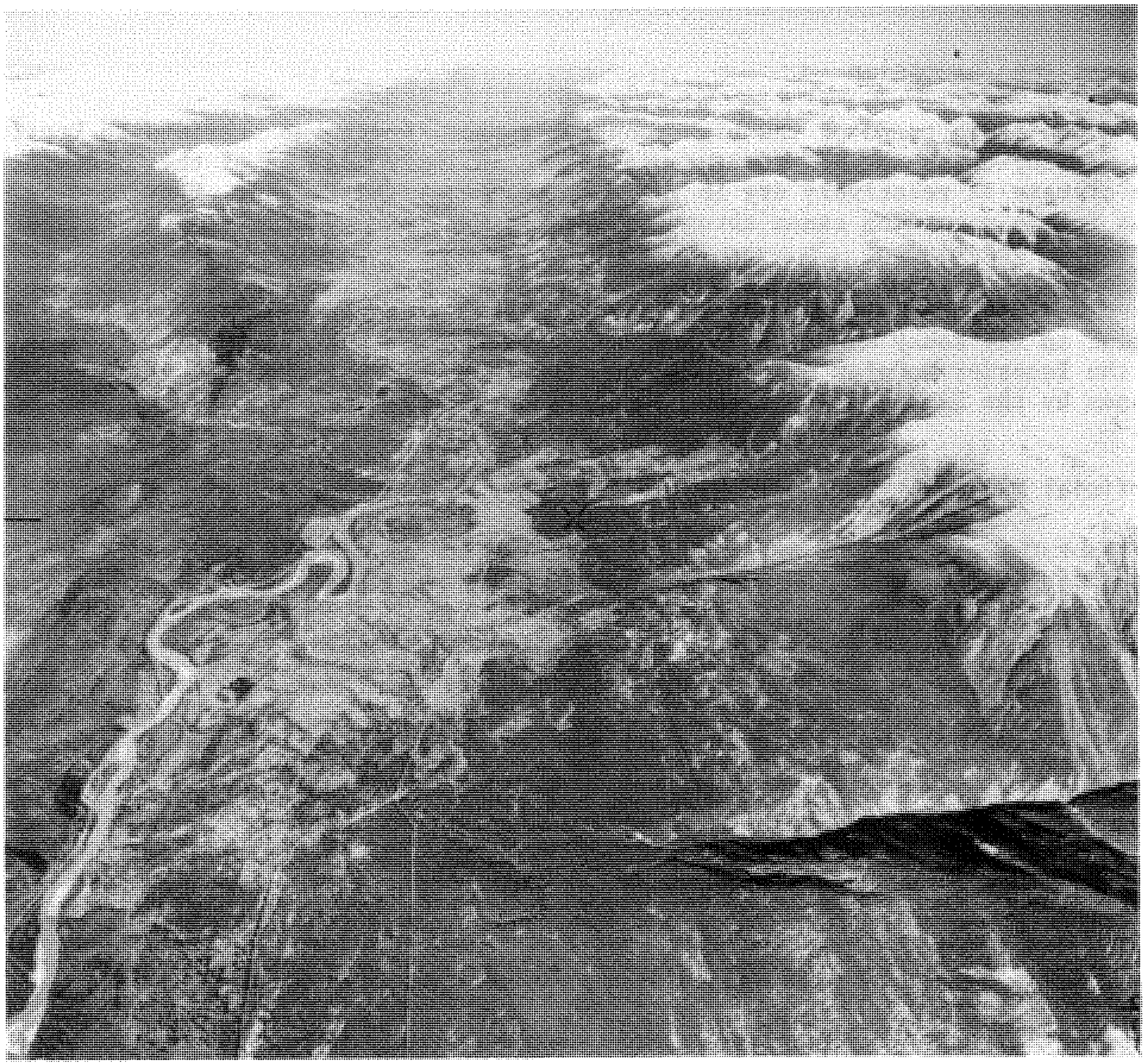
An important land use is recreation, both as intensive use (viewing sites, ski areas, camping sites) and under combined capabilities for both big game and recreation on the high elevation lands. Mount Revelstoke and Glacier National Parks are located in the Columbia Mountains.

Rocky Mountain Trench

The Trench is a structurally controlled erosional feature. This unique landform (Fig. 19) extends northward of the international boundary as a continuous valley for almost 720 km. Although it then mergest partly with the plateau lands along its western wall the structure is defined for a further 700 km north.

Where the Trans Canada Highway crosses the Trench near Golden, the Columbia River flows north into the newly created McNaughton Lake. The river passes through the Mica Dam to continue southward past Revelstoke into the Arrow Lakes chain and across the border into the United States of America.

Although the structure of the Trench is largely unknown, it is undoubtedly complex. "As a topographic feature the Trench existed early in the Tertiary, and Tertiary sediments were deposited in it. The southern Trench was probably drained by the south-flowing Columbia and Kootenay rivers. It developed as an erosional form during the Tertiary by streams whose courses were antecedent to the building of the Rocky Mountains. They were antecedent also to the uplift



Courtesy of British Columbia Government

FIG. 19 ROCKY MOUNTAIN TRENCH

of the mountains on the western side of the Trench. The erosion of the Trench was completed by the end of the Pliocene. It was occupied by ice and its form modified, but the main effect of glacial occupation was the derangement of previously established drainage systems. The streams became established in their present courses with the waning of the ice, and during the postglacial period have incised themselves to varying depths into the deeply drift-filled floor of the Trench" (Holland, 1976).

Climate and Vegetation

The north-south trend of the high mountain ranges, acting as barriers to Pacific air masses, cause the heaviest precipitation in the mountains of the Trench. The climate is relatively dry in the bottomlands of the Trench. East to west gaps in the mountains cause abrupt changes in weather and in the distribution of native vegetation.

The Interior Western Hemlock biogeoclimatic zone reaches its southern extent in the Rocky Mountain Trench near Golden. South of this area, forests of the Interior Douglas Fir zone occupy the Trench, bounded on the valley slopes by the Subalpine Engelmann Spruce-Subalpine Fir zone.

Surficial Materials and Soils

At least two glaciations affected the drainage conditions and nature of the materials laid down in the Trench. An interglacial deposit of lacustrine silty clay, lying between two tills, may be traced from south of the international border to near Golden. It is up to 17 m thick. Soils developed on this deposit are mostly Gray Luvisols (Kelly and Holland, 1961).

The tills in the Trench are derived from undifferentiated geological formations containing limestone, conglomerate, shale and phyllite. These calcareous materials are the source of the medium textured parent materials from which Orthic and Brunisolic Gray Luvisols have developed. Luvisolic development is also the dominant process on coarse and medium textured glaciofluvial and fan deposits near Golden.

Imperfectly to poorly drained, medium- to fine-textured Regosols occur on calcareous fluvial terraces and fans associated with the Columbia River and its tributaries.

Land Use

Farming in Golden began about 1883, on homesteads preempted by railway workers. Mixed farming with a few truck crops is centred around Golden. Irrigation is necessary. Cattle are grazed on forested range.

Forestry and tourism are important economic resources of the area.

The Rocky Mountains

Physiography*

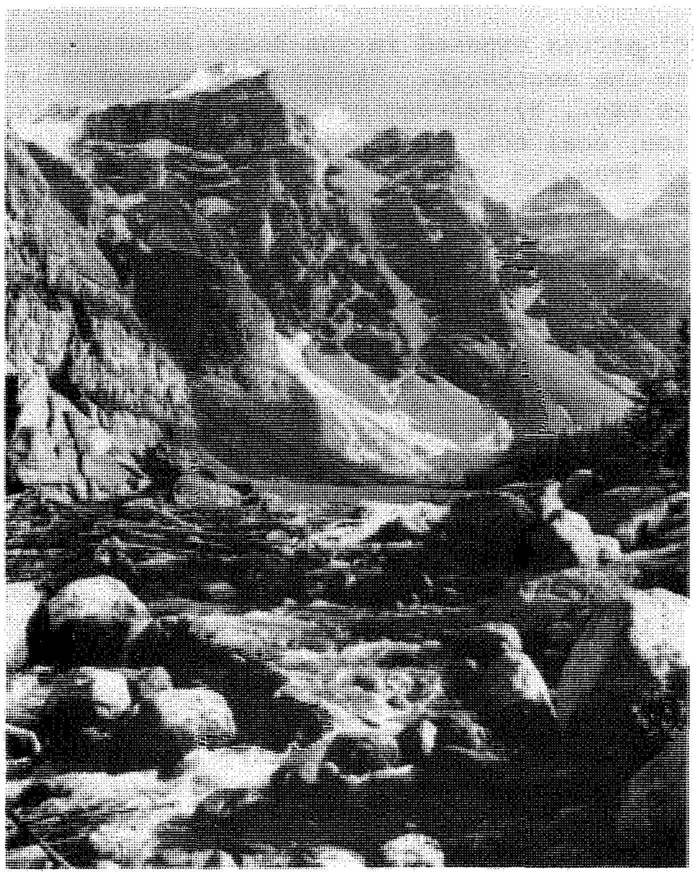
The Rocky Mountains (Figure 20) comprise the southeastern part of the 1 500 000 sq km Canadian Cordillera and are 100-500 km wide by 1500 km long. They are underlain essentially by Proterozoic to Mesozoic (Table 6) sedimentary rocks that were deformed and in places metamorphosed in late Mesozoic and early Cenozoic time (North and Henderson 1954; Price and Mountjoy 1970; Price 1971). They grade westwards into metamorphosed terrain and are bounded to the east by flat lying sedimentary rocks of the Interior Plains.

The succession of strata exposed in the Rocky Mountains thickens and becomes more complete to the southwest. It consists essentially of a) Precambrian slates, metasandstones etc., b) Paleozoic carbonates and shales, and c) Mesozoic sandstones, shales, coal etc. Sediments for the clastic rocks of units a) and b) were derived from the craton to the north east while the source area for the younger rocks of unit c) lay to the southwest.

The Rocky Mountains are divisible from northeast to southwest across their trend into the Foothills, Front Ranges, and Main Ranges (Figure 21). The low, rounded Foothills are generally composed of Mesozoic sediments which are folded and cut by numerous southwesterly dipping thrust faults. In the more rugged Front Ranges, cliff-forming Paleozoic carbonates are exposed in a repeating sequence of southwesterly dipping thrust faults. The slope morphology of these ranges generally reflects the bedrock configuration in that northeast slopes develop along the southwesterly dipping bedding planes. The Main Ranges are formed of rocks of Paleozoic and Precambrian age. The Paleozoic sediments are calcareous in the northeast and become shaly to the southwest. Rugged castellated topography occurs where the Paleozoic carbonates are gently dipping and form flat lying erosion-resistant mountain caps. The tightly folded Precambrian strata and Paleozoic shales have generally given rise to rounded slopes.

The deformed sedimentary and metasedimentary strata which form the Rocky Mountains rest on a cratonic basement of igneous and metamorphic rocks which is continuous with the Canadian Shield to the northeast. The mountains essentially resulted from a period of deformation that saw the sedimentary cover separate from this basement and move north-eastward toward the central craton due to pressure from an expanding or sliding crystalline mass to the southwest. During this movement the thin crust of sedimentary rocks was folded and piled up into the various thrust sheets that characterize its structure while the basement remained essentially intact.

*Adapted from material provided by H.A.K. Charlesworth, Dept. of Geology, University of Alberta.



Courtesy of Alberta Government

FIG. 20 THE RUGGED TOPOGRAPHY OF THE VALLEY OF TEN PEAKS IS TYPICAL OF THE ROCKY MOUNTAINS

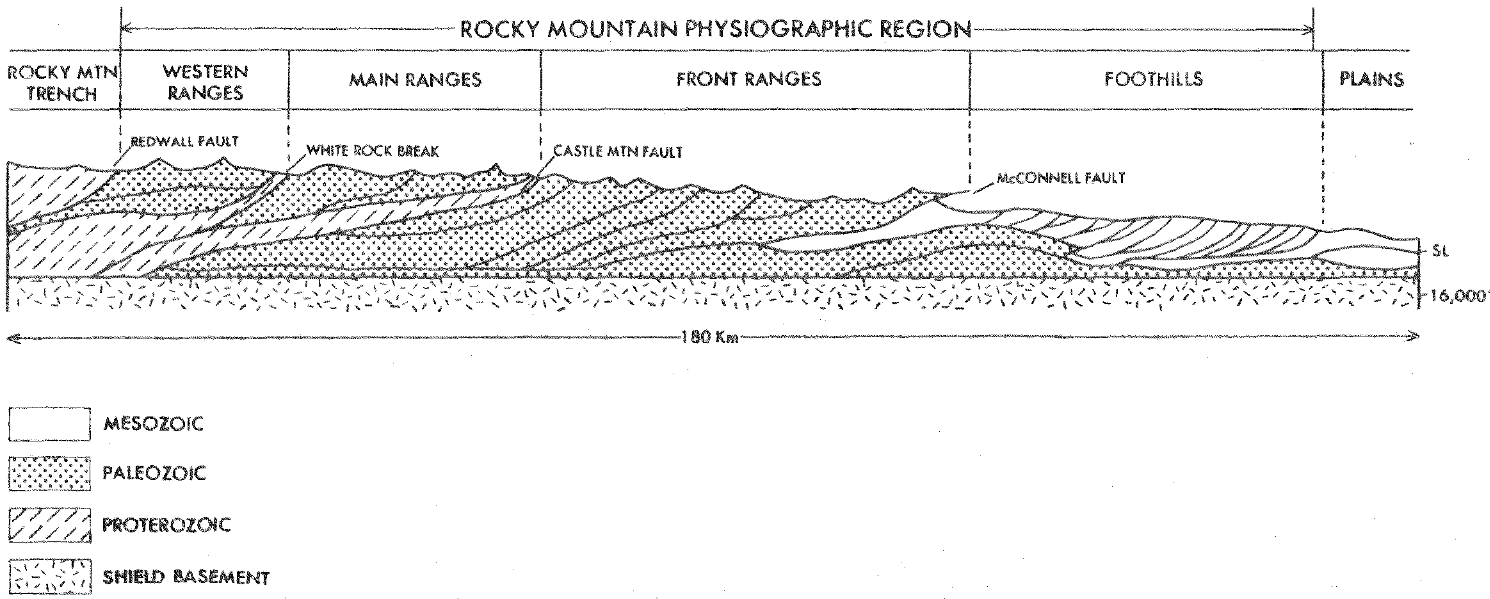


FIG. 21 REGIONAL STRUCTURE OF THE ROCKY MOUNTAINS

Table 6. Geologic time scale

ERA	PERIOD	AGE (millions of years)	COMMENTS
CENOZOIC	Quaternary	2	Glaciation
	Tertiary	64	Rocky Mountains Formed
MESOZOIC	Cretaceous	135	Canmore Coal
	Jurassic	210	
	Triassic	240	
PALEOZOIC	Permian	300	
	Pennsylvanian	320	Alberta Oil
	Mississippian	360	
	Devonian	420	
	Silurian	460	
	Ordovician	510	
	Cambrian	590	
PROTEROZOIC	Hadrynian	1000	First Fossils
	Helkian	1800	
	Aphebian	2600	
ARCHEOZOIC	Archean	3000	Canadian Shield
	Katarchean	3600	

Climate*

The climate of the Rocky Mountains and of Banff and Jasper National Parks is determined chiefly by geographical location. Located between 51 and 53 North latitude and 500 km inland from the Pacific Ocean, the macroclimate is essentially continental. Winters are long and quite cold. Summers are short and cool with occasional hot spells.

The parks are influenced by the air masses and weather systems that migrate across western Canada at mid latitudes. Local climate is related to topography and physiographic features, especially the northwest-southeast trend of the mountains and valleys. This direction is almost at right angles to the prevailing winds, giving rise to a rain shadow effect in the main valleys. The generally low wind speeds in the valleys are also related to this orientation. The occurrence of minor mountain ranges east of the main valleys is effective in preventing southward flowing arctic air masses from entering these valleys. Thus, cold outbreaks are not as severe nor as prolonged as on the prairies to the east. Exceptions are the Athabasca and Bow Valleys that pass east-west through the Front ranges. Cold arctic air penetrates the lower portions of these valleys. Thus topography gives rise to large climatic variations over distances of only several kilometers. In the vertical direction there can be large variations in less than 100 m.

*Abstracted from material provided by Ben Janz, Meteorologist, Atmospheric Environment Services, Edmonton.

Winter's extreme low temperatures in the main valleys reach -45 to -50 C 2 or 3 years out of 10. Summer temperatures have reached the 35 to 38 C range in most of the major valleys, but these maxima do not occur very far up the slopes because of the lowering of temperature with increasing elevation. Temperatures exceed 27 C at least once in July and August in most years. Mean monthly temperatures for Banff townsite, Lake Louise, and Jasper townsite are given in Appendix G.

There is considerable variability in amounts and yearly distribution of precipitation through the mountains. Along the Continental Divide (see Lake Louise data) winter precipitation exceeds summer precipitation and the total is greater than it is to the east. The townsites of Banff and Jasper are located in fairly dry valleys of the Front Ranges.

Vegetation

Within the Banff-Jasper section of the Rocky Mountains there are three major bioclimatic zones (Rowe, 1972): montane, subalpine, and alpine. These zones reflect a macroclimate gradation with elevation (Figure 22).

The montane zone is characterized by xeric grasslands in the valley bottoms and sub-xeric to mesic Lodgepole Pine ecotone to Douglas Fir and Trembling Aspen ecotone to White Spruce on the lower valley sides (Figure 23). While there are substantial areas of montane vegetation they occur in the valley bottoms near the eastern limits of the major valleys and do not constitute a large percentage of the total area of the parks.

The subalpine zone occurs above the montane zone and below the treeless alpine zone (Figure 24). The characteristic tree species of the subalpine forests are Alpine Fir and Engelmann Spruce. Lodgepole Pine forests are widespread in the subalpine zone, representing a seral stage following forest fires. The upper part of the subalpine zone contains Alpine Larch as far north as Hector Lake, and scattered pockets of Whitebark Pine and Limber Pine.

In the transition area from subalpine to alpine the tree cover becomes discontinuous, forming strips and islands separated by heath and meadow communities. Alpine Fir and Engelmann Spruce often grow in a stunted or krummholz form at their upper limit.

At Banff (51 N) the lower limit of the alpine zone is at about 2300 m on on south-facing slopes and about 200 m lower on north-facing slopes. At Jasper (52.5 N) the lower limits are at 2200 m and 2000 m on south and north-facing slopes respectively. Alpine plant communities are discontinuous and occupy a fairly narrow altitudinal zone between forest and bare rock and snow. In the lower alpine zone, false heathers, dwarf willows and various herbs, sedges, and grasses of the moist meadow communities are common (Figure 25).

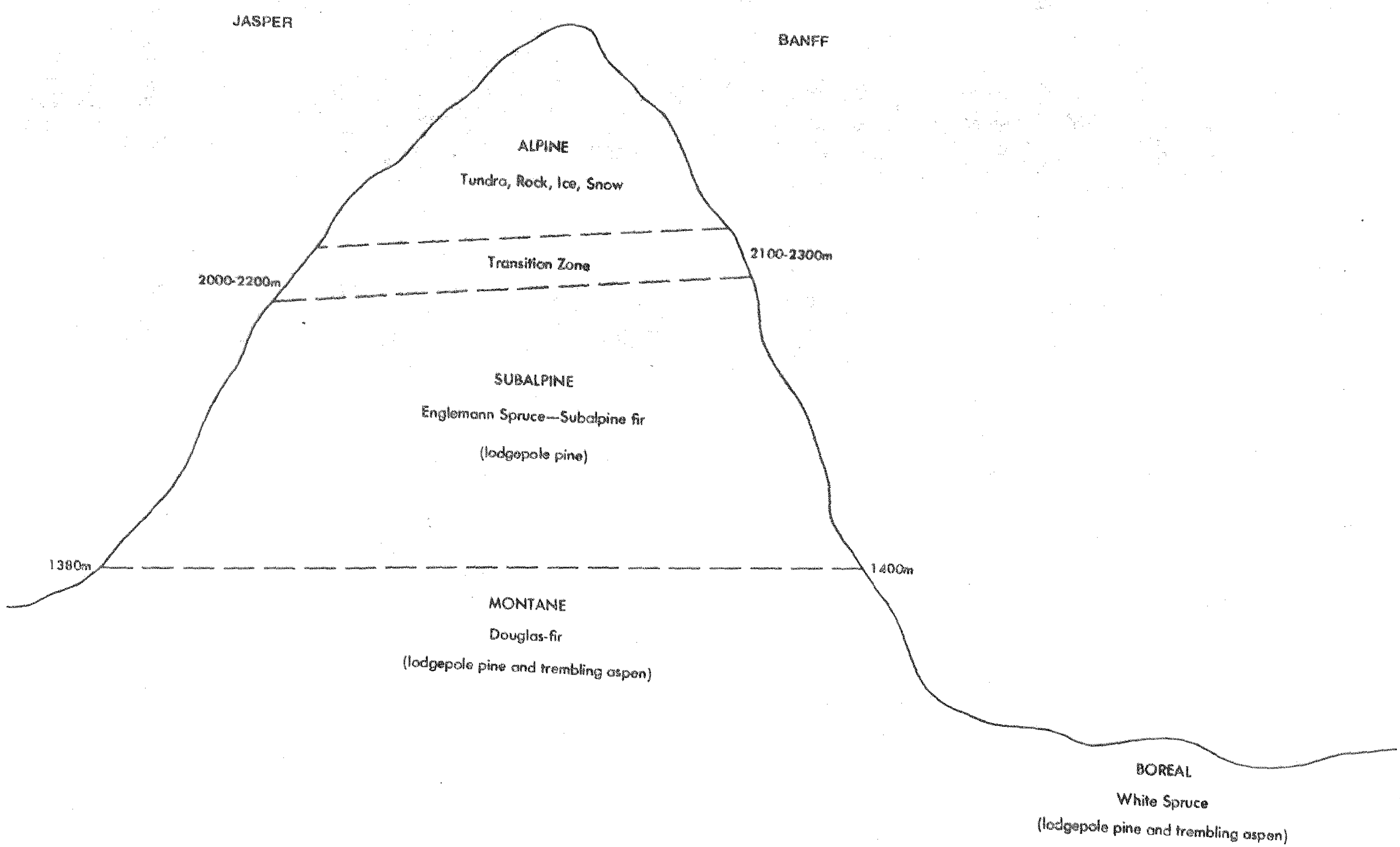
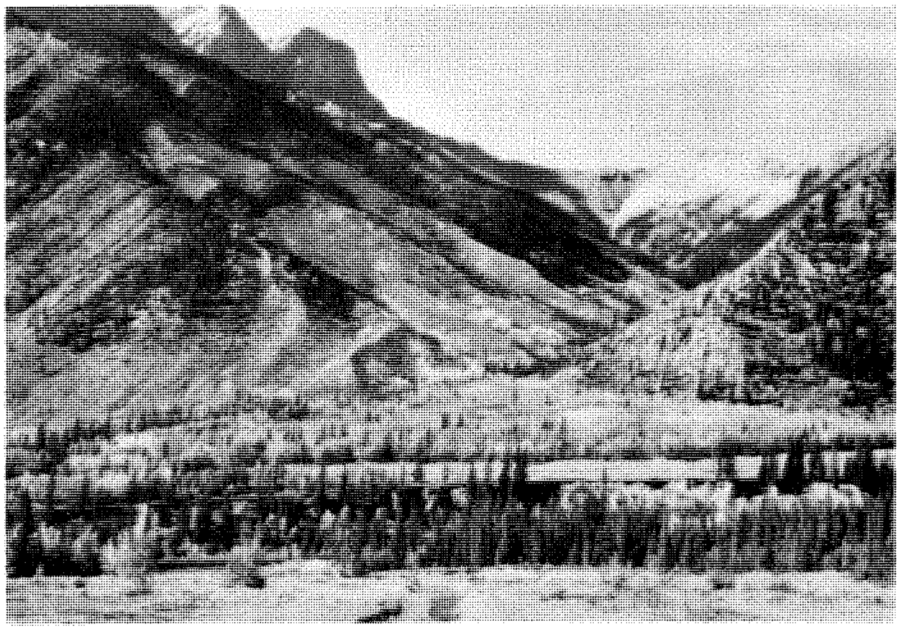
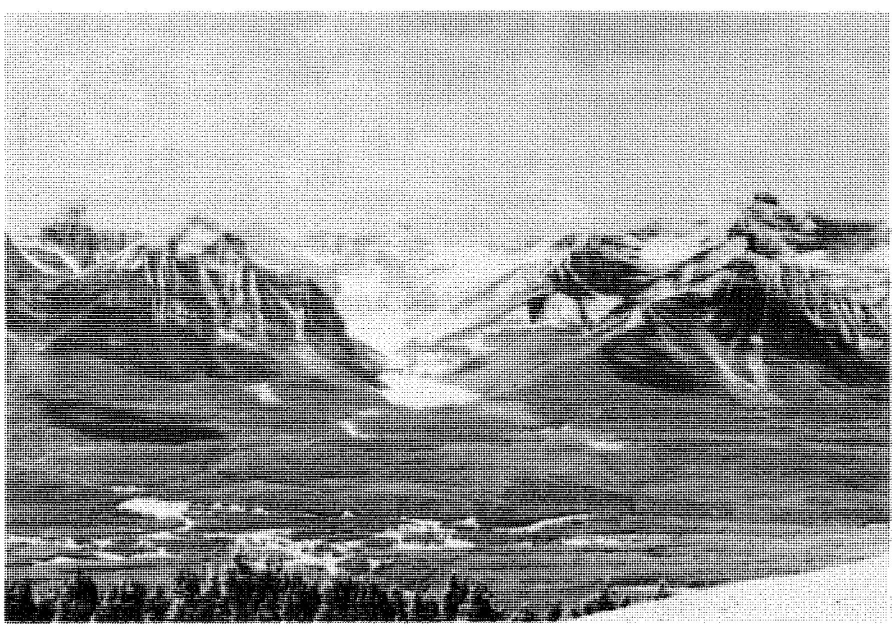


FIG. 22 BIOCLIMATIC ZONES OF BANFF AND JASPER NATIONAL PARKS



Photograph by B. Walker

FIG. 23 MONTANE ZONE TREMBLING ASPEN—WHITE SPRUCE STAND ON A FLUVIAL FAN IN THE BOW VALLEY



Photograph by B. Walker

FIG. 24 SUBALPINE ZONE AT LAKE LOUISE MADE UP ALPINE FIR— ENGELMANN SPRUCE FOREST

Photograph by A. Knapik

FIG. 25 THE SUNSHINE ALPINE AREA ALONG THE CONTINENTAL DIVIDED WEST OF BANFF

In the upper, exposed alpine areas White Mountain-avens and sedges are most common. Crustose lichen communities on rock represent the uppermost extension of vegetation (see Ogilvie 1969; Walker et al. 1976; Wells, Corns and Holland 1976 for further discussions of vegetation). The alpine zone, including barren rock, ice, and snow covers about 45% of the land area of the parks. Of this area, barren rock, ice and snow cover the major portion.

Soils

Soils in the Front and Main Ranges of the Canadian Rockies are generally formed on calcareous glacial drift, and frequently at higher elevations, on weathered colluvial debris. High amounts of $CaCO_3$ and $MgCO_3$ in the parent materials restrict depth of profile development (less than 75-100 cm). Much of the landscape is mantled with a shallow (15 to 30 cm) silty deposit, thought to be immediate post-Pleistocene loess. Volcanic ash is frequently identified as a component in this silty surficial material. The above factors, plus rapidly changing climate and slope, result in a very complex pattern of soil distribution over the landscape.

On steep, unstable slopes Regosolic soils are dominant, and in terms of areal extent, comprise a significant portion of the total. Gleysolic soils are found along narrow flood plains and occasionally are associated with seepage along valley sides. The significance of these soils is not in terms of areal extent, but in terms of land use limitations.

In the large valleys such as the Bow Valley and the Athabasca Valley, rain shadow effects result in a dry climate, with concomitant xeric and sub-xeric vegetation. In these main valleys, especially along the steep valley walls, Luvisolic soils are interspersed with Brunisolic soils. Where there is an appreciable thickness of the silty surficial deposit a Bm horizon frequently develops in the Ae of the Luvisolic profile resulting in a bisequa profile classified as a Brunisolic Gray Luvisol. Some of the Brunisolic soils on the very dry south-facing slopes are developed under an open forest canopy or grassland and are closely related to soils of the Chernozemic Order.

With increasing elevation, either up the valley walls or along the valley, the climate becomes more moist and the vegetation changes to Spruce-Alpine Fir-Vaccinium types. There is a gradual transition from the dominantly Luvisolic soils below 1700 m in Banff and about 1500 m in Jasper to dominantly Podzolic soils above these elevations. The Podzolic soils are frequently developed in calcareous parent materials, and in many instances the strong expression of the Bf horizon is in the silty surficial mantle which covers much of the landscape.

While most of the parent materials in the Front Ranges of the Rockies are calcareous there are some noncalcareous till and colluvial materials that are derived from quartzite and schist. In these noncalcareous materials the sola extend to greater depths (often greater than 1 m) and horizon development is more evident, both morphologically and chemically.

Soils in alpine environments occur in a discontinuous belt between the tree line and the barren rock. These soils are mostly Podzolic and Brunisolic. Regosolic and Gleysolic soils are also identified (Knapik, Scotter and Pettapiece 1973; Walker et al. 1976; Wells, Corns and Holland 1976).

The Rocky Mountain Foothills

Physiography

The Rocky Mountain Foothills rise quite abruptly from the Alberta Plain. They are a transitional zone between the Plains and the mountains (Figure 26). The Foothills consist of fairly linear ridges and hills of Mesozoic sandstones and shales covered with thin blankets of glacial drift. The ridges trend northwest-southeast and mark the eastern limit of the folded, faulted, cordilleran belt. Elevations range from 1300 to 2000 m a.s.l.

Climate

This region has a continental climate, with long cold winters and cool to warm summers. Precipitation varies locally depending on the rainshadow effect from the mountains, but the mean annual precipitation over most of the area is approximately 500 to 600 mm with about 50 percent occurring as snow. Snow cover persists from late September to late May in the higher areas. Precipitation is greater and summer temperatures are cooler than on the prairies. The area is subject to considerable and rapid temperature changes from season to season, from day to day, and from valley bottoms to ridge tops.

Vegetation

Rowe (1972) classifies this area as the Upper Foothills section of the Boreal Forest region. This forest type lies between the Subalpine forests to the west and the Lower Foothills to the east (Figure 27). Lodgepole Pine is dominant and White Spruce is a major species. The forest is mostly coniferous but Trembling Aspen, Balsam Poplar and White Birch are sparsely represented. Black Spruce is common in northern sections but occurs only sporadically in the south. Alpine Fir is present but is less prevalent than in the mountains and Tamarack occurs occasionally in poorly drained areas at lower elevations.

Soils

Gray Luvisols and Eutric and Dystric Brunisols are the most common soils in the Foothills region. Soil materials are generally shallow consisting mainly of till and colluvium that form veneers and blankets over the ridged bedrock. Bedrock outcrops and soils with a lithic contact are common, especially on ridge crests and steep slopes.

Brunisolic and Podzolic Gray Luvisols are common, especially under coniferous vegetation in stable slope positions. Brunisols dominate on the less stable slopes, where mass wasting has a rejuvenating effect, and on coarse textured materials.

FIG. 26 THE ROCKY MOUNTAIN FOOTHILLS

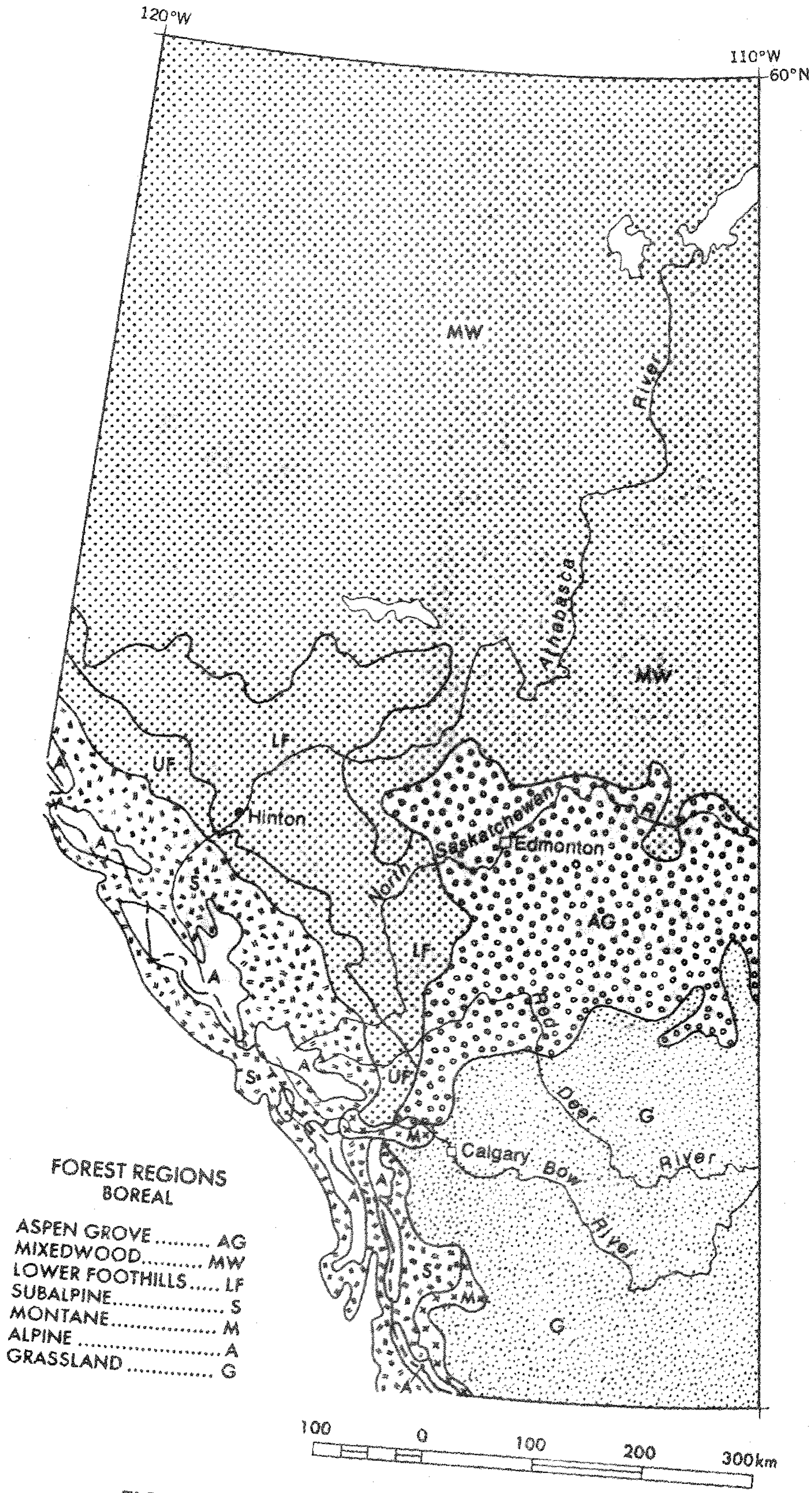


FIG. 27 FOREST REGIONS OF ALBERTA

The Foothills soils fall into the cold cryoboreal temperature class with a growing season greater than 5 C of 120 to 180 days and 555 to 1100 growing season degree days greater than 5 C. These soils generally fall within the humid moisture class, defined as soils which are not dry for as long as 90 consecutive days, and have moisture deficits of approximately 25 to 60 mm. Approximately 70 to 80 percent of the crop moisture requirements occur as growing season precipitation.

Local variation in materials, elevation, aspect, moisture conditions, and vegetation results in complex and rapidly changing soil patterns.

Land Use

The Foothills area has traditionally been a wildlands area, used primarily for watershed, wildlife production, recreation, and limited timber harvesting. Recent pressures for large scale development of timber harvesting, open strip coal mines, and petro-chemical extraction have come into conflict with public demands for wildland recreation and wilderness reserves.

Alberta Plain

Physiography

The Alberta Plain is a division of the Interior Plains Region (Figure 28). It is composed of fairly flat-lying Mesozoic and Tertiary sediments covered with glacial drift (Figure 29). Much of this plain lies at elevations near 750 m a.s.l. with rivers entrenched 50 to 100 m, and hills rising to 1200 m a.s.l. The tour route traverses the western edge of the plain across topography that varies from nearly level to hilly. Drainage of major rivers is to the east.

Climate

The Plains region of the tour route has a subhumid continental climate with long cold winters and short, cool to warm summers. The mountains on the west frequently trap cold winter air masses from the arctic and block warm Pacific air from the west. Temperature changes from season to season and even from day to day are considerable and can occur very rapidly. Warm dry Pacific air (chinook wind) can spill over the mountains replacing cold arctic air during the winter, causing sudden increases in temperatures, especially in southern Alberta.

The mean annual precipitation on the edge of the Plains is 300 to 400 mm. This decreases to the south and east (Table 7).

The frost-free period is 100 days at Edmonton and 110 days at Calgary (late May to early September).

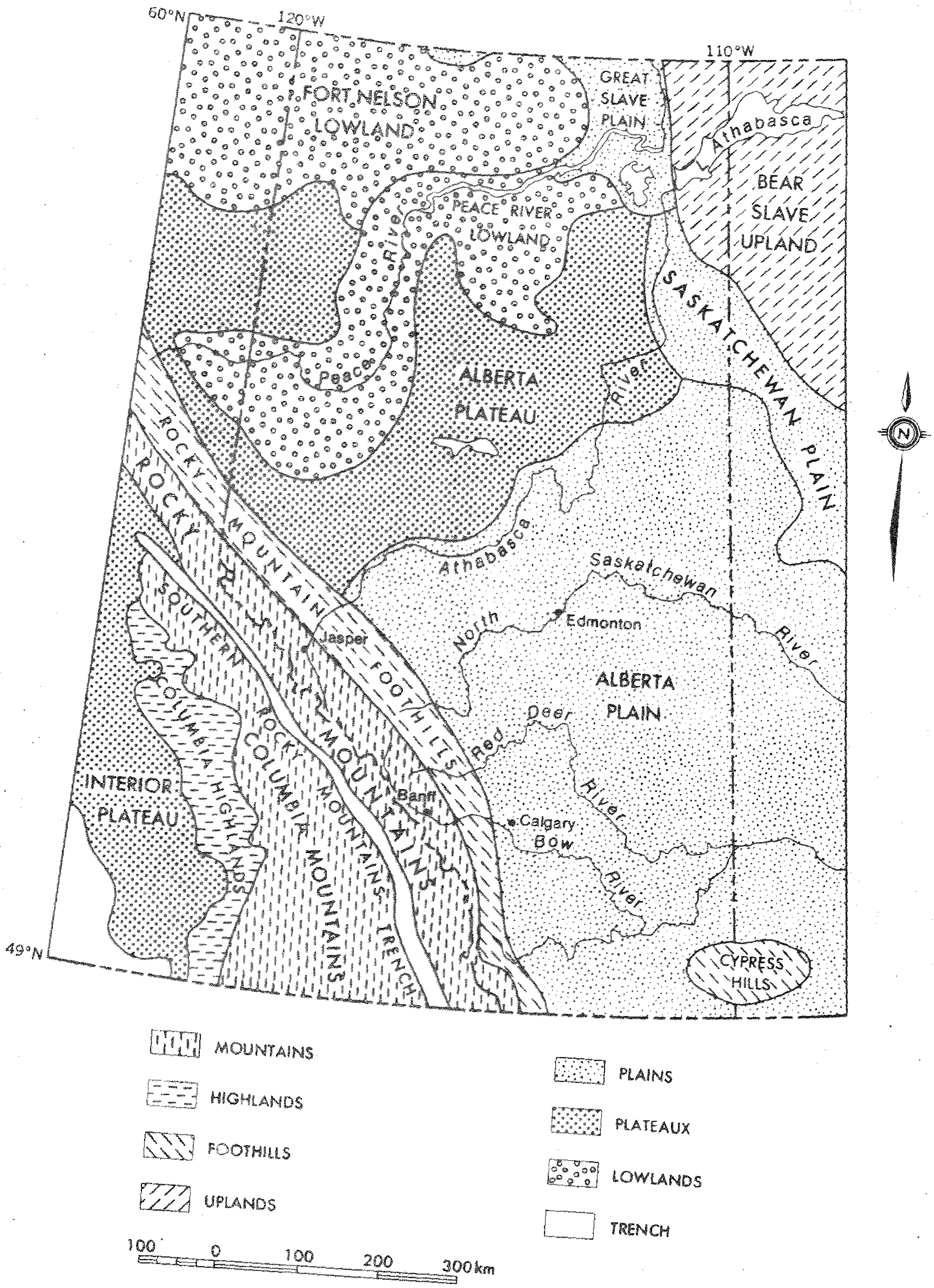
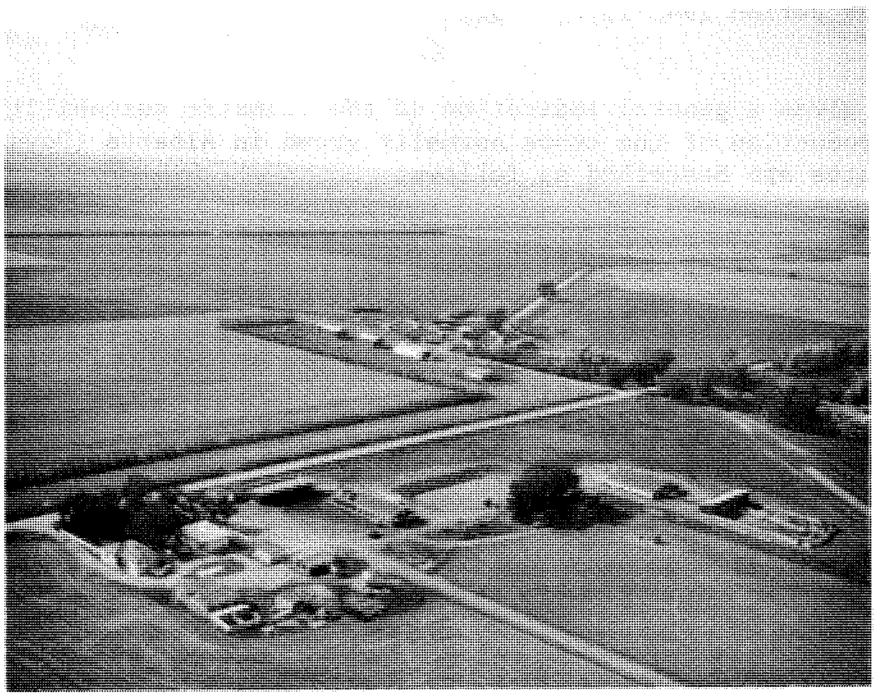


FIG. 28 PHYSIOGRAPHIC REGIONS OF ALBERTA



Courtesy of Alberta Government

FIG. 29 LEVEL TO UNDULATING TOPOGRAPHY OF THE PLAINS

Table 7. Temperature and precipitation data at selected stations in Alberta

	Temperature (C)			Precipitation (mm)		
	Mean Annual	Extreme Minimum January	Extreme Maximum July	Annual Total	Annual Snow	May to Sept.
Edmonton International Airport (719 m)	1.4	-44.4	34.4	457	1310	320
Banff (1397 m)	2.3	-51.1	34.4	477	2187	249
Lake Louise (1533 m)	-0.1	-52.9	34.4	767	4820	280
Jasper (1060 m)	2.8	-46.8	33.9	401	1370	215
Edson Airport (925 m)	1.7	-48.3	37.8	554	1680	373

Source: Atmospheric Environment Services, Temperature and Precipitation means for the period 1941-1970, Prairie Provinces.

Figure 30 gives a general indication of the climatic suitability of various areas to the production of the crops normally grown in Alberta (Bowser, 1967). These Agroclimates are described as follows:

Agroclimate 1. The amount of precipitation has usually been adequate and the frost-free period long enough to permit the growing of all the dryland crops that are typical to the prairie region of western Canada. The frost-free period has averaged over 90 days and the annual precipitation has averaged 400 to 460 mm.

Agroclimate 2A. The amount of precipitation, in approximately 50 percent of the years, has been a limiting factor to crop growth. The frost-free period has usually been long enough for wheat to mature without frost damage.

Agroclimate 3A. The amount of precipitation has usually been a severe limiting factor to crop growth; a wheat-fallow rotation is practised to the virtual exclusion of all other rotations. The annual precipitation has averaged 300 mm. The frost-free period has averaged slightly over 100 days in the northern portion of the area and over 115 days in the south central portion. Wheat is rarely damaged by frost and sweet corn can be grown, under irrigation, in the southern portion.

Agroclimate 2H. The amount of precipitation has usually been adequate but wheat has suffered some frost damage in approximately 30 percent of the years. The frost-free period is between 75 and 90 days.

Agroclimate 3H. The amount of precipitation has usually been adequate but it is not considered practical to grow wheat because of the frequency of damaging frosts. In the areas south of Latitude 55°N the average annual precipitation has averaged 430 to 480 mm. North of Latitude 55°N there

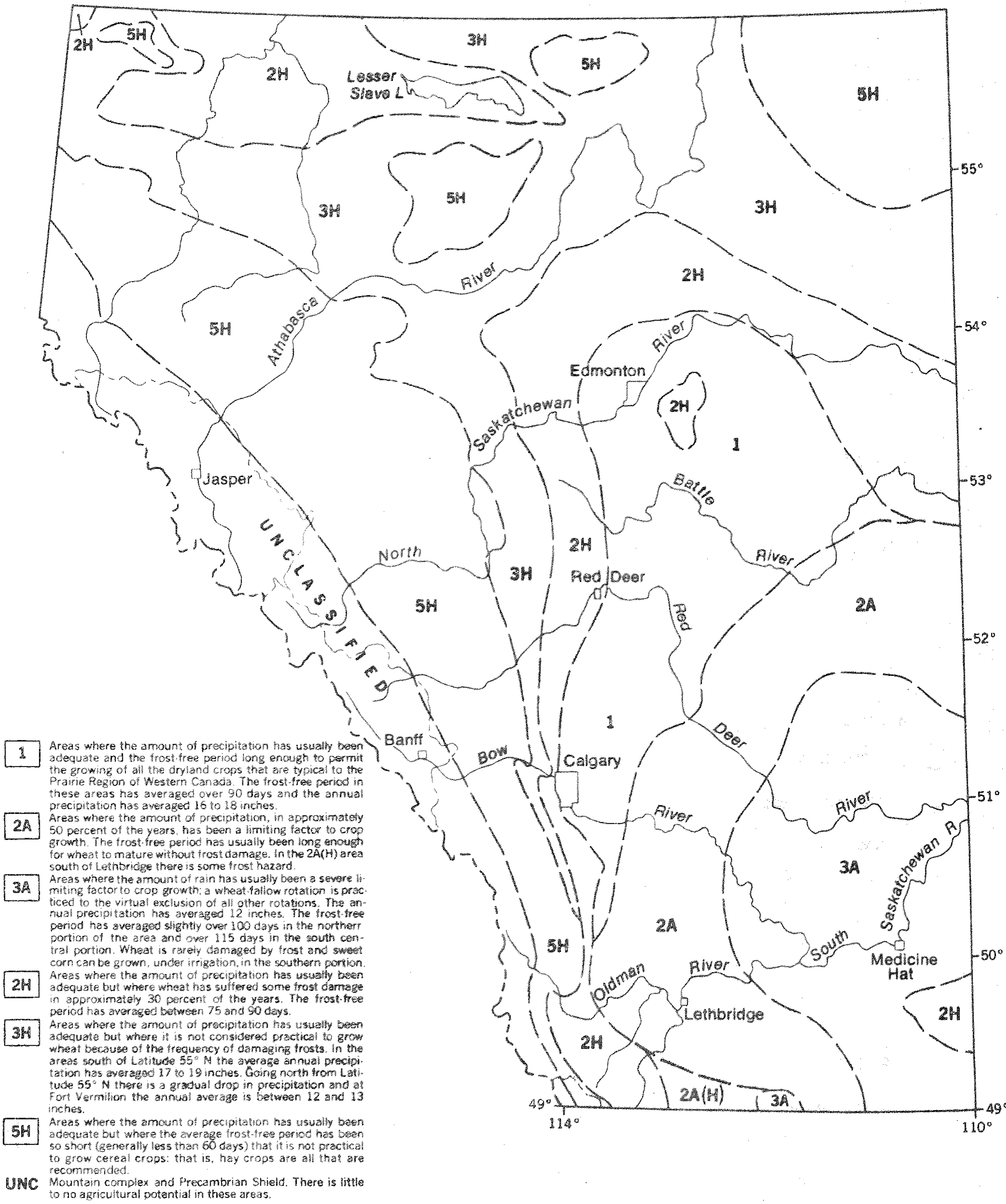


FIG.30 AGROCLIMATIC AREAS OF SOUTHERN ALBERTA

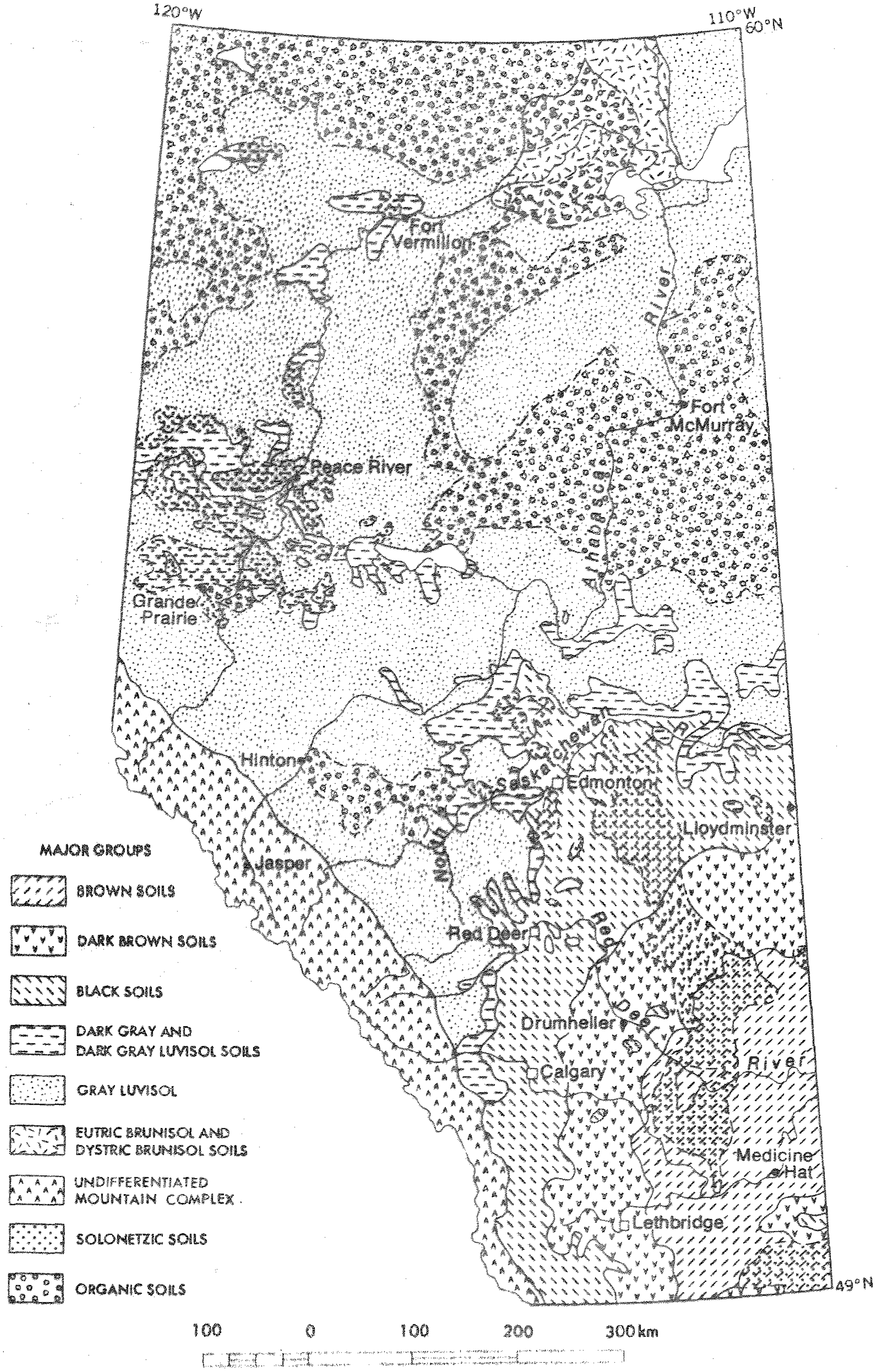


FIG. 31 SOIL GROUP MAP OF ALBERTA

is a gradual drop in precipitation and at Fort Vermilion the annual average is between 300 and 330 mm.

Agroclimate 5H. The amount of precipitation has usually been adequate but the average frost-free period has been so short (generally less than 60 days) that it is not practical to grow cereal crops, and only hay crops are recommended.

Vegetation

Two distinct phytogeographic areas are encountered in the Plains section of this tour (Figure 27). These are the Aspen Grove and Lower Foothills sections of the Boreal region (Rowe 1972).

The Aspen Grove section (Figure 27) is a region of transition between the closed boreal forest and the treeless grasslands. The area consists of grasslands dotted with groves of Trembling Aspen 4 to 8 m high with an understory of Common Snowberry, Choke Cherry, and wild rose shrubs. Closer to the closed boreal forest the aspen is larger, 15 to 20 m high, and provides more continuous cover. The grassland openings between the groves of trees are composed of dominantly wheatgrasses, needlegrasses, and koeleria.

The Lower Foothills section covers the Alberta Plain from west of Edmonton to Hinton. This forest ecotone lies between the Boreal and Subalpine Forest regions. Lodgepole Pine and to a lesser extent Trembling Aspen are dominant, due largely to fire history. White Spruce is the dominant species in older stands with Black Spruce and Tamarack present in poorly drained areas. Balsam Fir and Alpine Fir occur sporadically.

Soils

The soils in the Plains portion of this tour are predominantly Black Chernozemics in the Aspen Grove section and Gray Luvisols in the forest region (Figure 26, 31).

The soils fall within the moderately cold cryoboreal soil temperature class (Soil Research Institute 1972). The mean annual soil temperature at 50 cm is 2 to 8 C with a mean summer temperature of 8 to 15 C. Growing season degree days greater than 5 C is in the 555 to 1250 range. The soils are generally in the subhumid moisture class with growing season moisture deficits of 60-120 mm. Growing season precipitation equals 60 to 70 percent of crop moisture requirements.

The Black Chernozemic soils are developed on well drained positions on landscapes comprised of till, glaciolacustrine, and fluvial deposits. These soils are characterized by granular, well-humified, black A horizons overlying brownish, weakly prismatic, friable B horizons and calcareous C horizons. Gleyed Black Chernozemic and Gleysolic soils occur in the imperfectly and poorly drained areas. Solonetzic soils occur in areas of saline parent materials.

As tree cover in the Aspen Grove area becomes more continuous the soils show decreased depth, decreased organic matter content, increased eluviation of the A horizon, and increased illuviation in the B horizon. The soils grade from Black through Dark Gray Chernozemic, to Dark Gray Luvisols, and Gray Luvisols. Brunisolic soils occur sporadically.

Land Use

Agriculture is the major land use in the Aspen Grove areas of the plains. In the Aspen Grove area mixed farming operations are most common with each family-owned farm being approximately 200 to 250 ha. Barley, wheat, oats, and forage crops are grown. Each farm also has several cattle and perhaps a few hogs and poultry. Dairy farms are common near large cities.

LAND USE

The Canada Land Inventory

For several decades the Soil Survey organizations of Canada have been classifying and mapping soils according to their inherent characteristics and qualities as natural bodies. The soil surveys have resulted in published maps and reports which are the source of much fundamental information on the soils of Canada. Similarly, federal and provincial Departments of Forestry, Parks and Recreation, and Wildlife have been carrying out studies relating land capability to productivity. These studies have provided the essential background data necessary for subjective interpretations to assess the capability of land for various uses.

In October 1963, the Government of Canada officially approved undertaking a comprehensive national land resource inventory. The Canada Land Inventory (CLI) (The Canada Land Inventory 1970) has, accordingly, been planned and implemented co-operatively by the federal government and the provincial governments. Each province is reimbursed by the federal government for all additional direct operational and staff costs incurred in the conduct of the project.

The CLI was designed to provide a basis for resource and land use planning rather than for management. The information gathered is of a reconnaissance nature, providing information essential to land development planning at the municipal, provincial, and federal levels of government. It does not provide the detailed information required for management of individual parcels of land, nor for land planning in small watersheds, local government units, etc. The CLI, which uses a computer mapping technique, will facilitate more detailed future studies as more detailed land capability information becomes available and as socio-economic factors change.

A vast amount of information on Canada's land resources has been gathered, stored, analyzed and published in a way that permits the inventory to be a valuable working tool for rural development planning across Canada. Lands are classified according to:

- their physical capability for use in agriculture, forestry, recreation, and wildlife (ungulates and waterfowl).
- their present use.

Specific CLI guidelines are defined for each sector of the inventory.

The basis for two of the capability sectors, agriculture and forestry, are given here. Specific examples or modifications of the CLI are given in the text of the tourguide along the tour route.

Source: Federal and Provincial publications on the CLI (see Bibliography).

Agriculture Capability

In the CLI classification system, land is grouped into seven classes according to its potentialities and limitations for agricultural use depending upon inherent soils and climate characteristics. CLI Agricultural Capability ratings show ranges of crops that can be commercially grown with success. Classes 1 to 4 are considered arable for a decreasing range of crops. Class 5 lands are suitable for forage production; Class 6 lands are natural rangelands suitable for grazing use; Class 7 lands are considered incapable of use for arable culture or permanent pasture.

Excepting Class 1, the classes are subdivided into subclasses on the basis of kinds of limitations. The subclasses and their map symbols are: adverse climate (C), undesirable soil structure and/or low permeability (D), erosion (E), low fertility (F), inundation by streams or lakes (I), moisture limitation (M), salinity (N), stoniness (P), consolidated bedrock (R), adverse soil characteristics (S), topography (T), excess water (W), cumulative minor adverse characteristics (X). The interpretive classification does not apply to Organic soils.

Table 8. Agriculture Land Capability Classes, Provincial Summary
Source: Agriculture Land Capability in B.C. 1976

	Agriculture Land Capability Classes									
	1	2	3	4	5	6	7	Water Surfaces	Other*	Total
				(,000 of ha)						
Unimproved	21	236	692	1 703	6 677	5 423	15 267	2 346	63 504	95 908
Improved**	70	398	1 000	2 133	6 143	5 361	14 912	2 346	63 544	95 908
				Percent						
Unimproved	0.02	0.25	0.73	1.78	6.97	5.66	15.92	2.45	66.22	100.0
Improved**	0.07	0.41	1.04	2.22	6.41	5.59	15.55	2.45	66.26	100.0

* Other includes unclassified urban areas, national parks and unmapped portions of the district

** Rating if land unit is irrigated and/or drained.

The Agricultural Land Resources of British Columbia

Less than 5% of the land area of B.C. has the capability for agricultural use (Fig. 8). It was this scarcity of agricultural land and the increasing expansion of urban uses onto some of the best agricultural land that led to provincial legislation designed to preserve agricultural land in B.C. for food production.

The Land Commission Act, passed in spring 1973, established a five member, independent, quasi-judicial Commission to establish and administer agricultural zoning throughout the province. The agriculture zone - commonly referred to as the Agricultural Land Reserve (A.L.R.) - was drawn on bio-physical parameters and is intended to protect the land from irreversible used in the long term.

As its technical base for the A.L.R.'s the Land Commission adopted the Canada Land Inventory classification system. In general, all Class 1 to 4 lands not already urbanized or irreversibly alienated in some manner, as well as some key forage and grazing lands were included within the Agricultural Land Reserve. Maps are produced at a scale of 1:50 000 with constituent maps at larger scales available around most of the main cities and towns. For administrative purposes, natural boundaries were converted to straight line legal boundaries.

Within the Agricultural Land Reserve no subdivision or non-farm use is allowed without application to the Agricultural Land Commission. There is also provision under the Act for application for exclusion of land from, and inclusion of land into the Agricultural Land Reserve.

As well as preserving agricultural land through provincial zoning, the Commission also works to create a positive atmosphere for agriculture in B.C. through encouragement and protection of the farming community. This is based on the premise that in the long-run, preservation of agricultural land means preservation of the expertise of the farmer and the agricultural infrastructure as well.

Forestry Capability

The objective of the land capability inventory for forestry (Kowall, 1971) is to describe the potential forest capability of the land under indigenous tree species. Full stocking and good management are assumed. The classification serves to indicate the lands on which intensive management practices might be justified. The capability or production potential is in terms of mean annual increment per hectare, expressed in cubic metres. The forest capability classes are based on total tree volumes of all trees 7.8 cm or greater in diameter at brest height. Rotation ages are 100 years for conifers and 50 years for deciduous species. Application of the data can be used for regional planning, preliminary appraisals for designated timber land lease areas, a basis for land assessment purposes, wildlife and recreational land use planning and teaching of forest land management.

In this classification, all mineral and organic soils are grouped into one of seven classes based upon their inherent ability to grow commercial timber. The best lands for commercial tree growth are found in Class 1 and those in Class 7 cannot be expected to yield timber in commercial quantities. The classes are based on the natural state of the land without improvements such as fertilization, drainage, or amelioration practices. The classification is based on known or inferred information about the unit including subsoil, soil profile, depth, moisture, fertility, landform, climate and vegetation. Associated with each capability class is a productivity range based on the mean annual increment of the best species or group of species adapted to the site at or near rotation age. Factors not considered are location, access, distance to markets, size of units, ownership, present state, or special crops.

Except for Class 1, subclasses indicate the kind of limitations for each class. Examples of limitations are: droughty or arid conditions, exposure, deficiency or excess of soil moisture, restrictions of rooting zone, and low fertility. Indigenous tree species which can be expected to yield the volume associated with each class are shown as part of the mapping symbol.

National Parks

There are 28 national parks in Canada, covering approximately 130 000 km^2. These parks represent sea shores, prairies, boreal forests, arctic islands and mountains.

The tour traverses five national parks lying within the Columbia and Rocky Mountain regions of British Columbia and Alberta. The parks are Revelstoke, Glacier, Yoho, Banff and Jasper.

Although Revelstoke National Park is much smaller in area than the other national parks of British Columbia and Alberta, its alpine summit areas are readily accessible by road or hiking trails. Named for one of the early backers of the railway, Lord Revelstoke, it grew in 1906 from the enthusiasm of a small group of Revelstoke people to its dedication as a national park in 1914.

Glacier National Park encompasses a 1350 km^2 area of the Columbia Mountains. It is named for the more than 100 glaciers within its borders. A specially trained staff runs the largest direct avalanche control area in the world.

Yoho National Park contains the Kicking Horse Pass, a major transportation route through the Rocky Mountains. The park contains 1313 km^2 of prime mountain country along the great divide west of Alberta.

Banff National Park covers an area of 6500 km^2 including high mountains, quiet lakes, wild rivers and hot springs - which were the centre of the original Public Reserve established in 1885.

Jasper National Park is larger than Banff, with an area of 10 900 km^2. Among its many scenic attractions are the Columbia Icefields, Maligne Lake and several waterfalls.

Section 4 of the National Parks Act (1930) states that National Parks are "dedicated to the people of Canada for their benefit, education and enjoyment ... and shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations". This two-fold mandate of preservation and use results in several problems for park planning and management.

Banff was established as a National Park in 1887, at the time the transcontinental Canadian Pacific Railway was being built through the area causing considerable change in the landscape and land use. Then came an era of building lavish facilities to attract tourists to the "mountain playground" for commercial gain, with the demand for motels, campgrounds, skilifts, and roads steadily increasing. Currently there is growing public concern for preservation of the parks wilderness areas to use for non-commercial recreation.

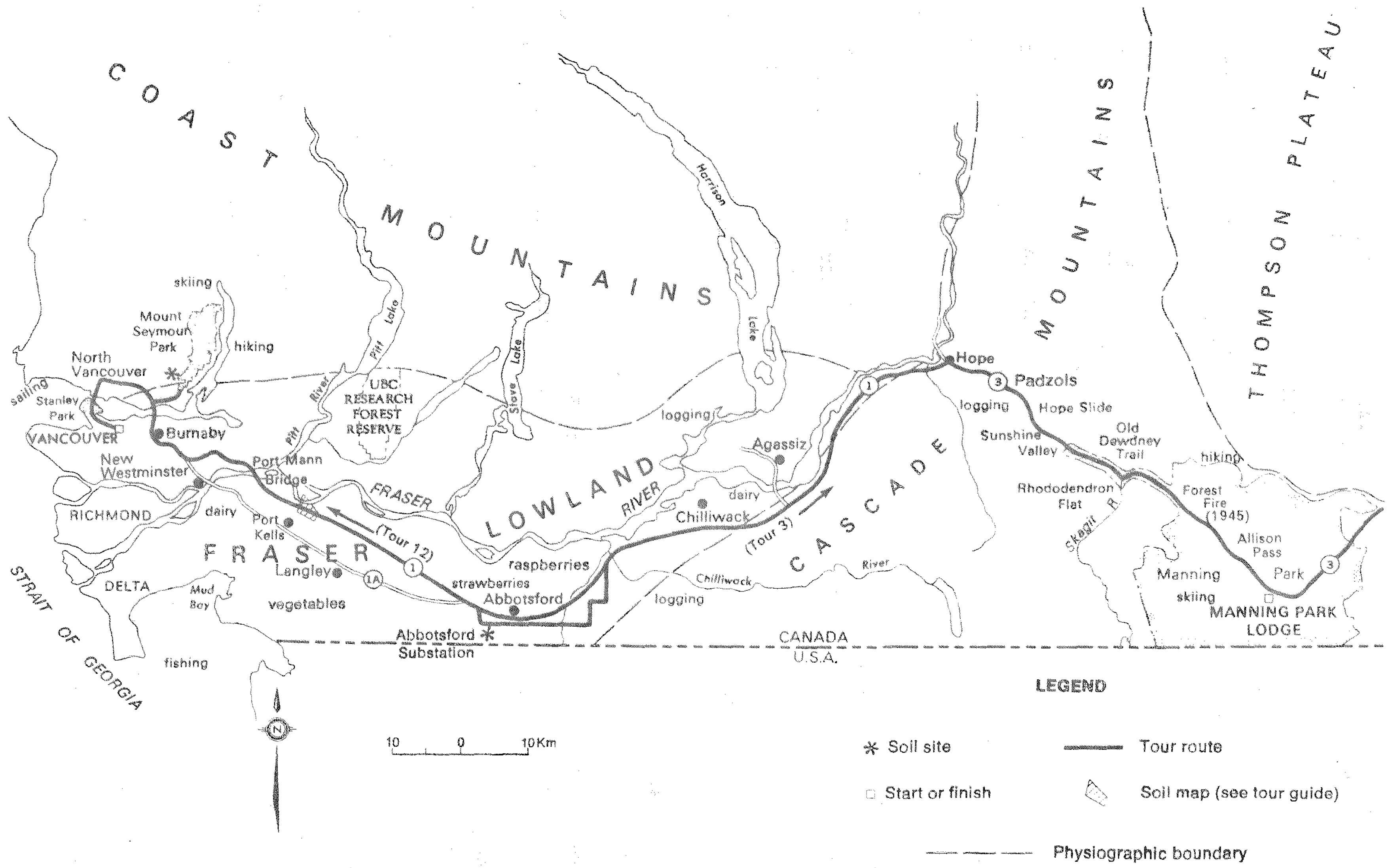
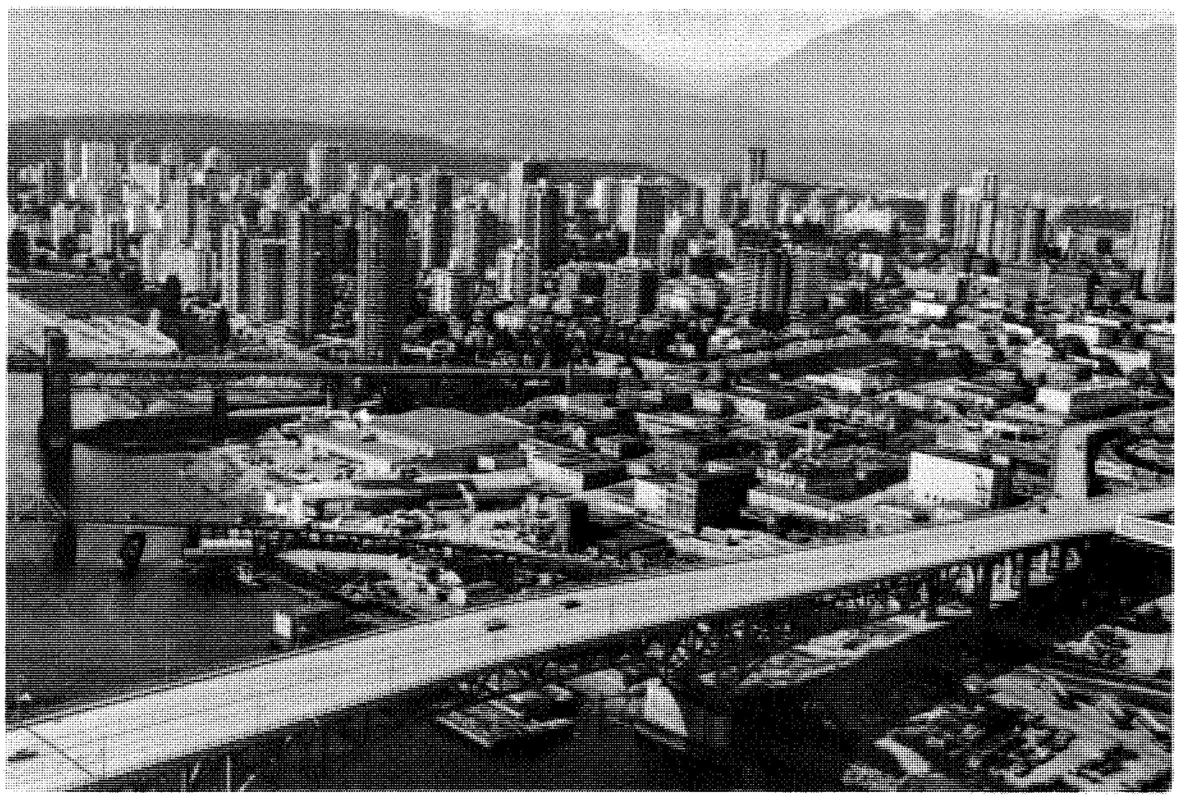


FIG. 32 ROUTE MAP DAY 1



Courtesy of British Columbia Government

FIG. 33 VANCOUVER CITY

DAY 1 VANCOUVER TO MANNING PARK

The Route

The tour leaves Vancouver (Figure 32) on Highway 99 travelling north and west through the city and Stanley Park to cross Burrard Inlet on the Lions Gate Bridge. The route is then eastward across the lower mountain slopes to examine a soil in Mount Seymour Park. From North Vancouver the route follows the Trans Canada Highway eastward through the glaciomarine, floodplain, moraine, loessial, outwash and lacustrine landforms of the Fraser Lowland. After leaving the recreational and timber areas of the mountain slopes, the main feature is the great diversity of agriculture in the Fraser Lowland. A soil will be examined en route to Manning Park, and a brief stop will be made at the Hope Slide.

Road Log 1: Vancouver to Manning Park Lodge (312 km)

Km (Mile)

Vancouver

Almost to this month 186 years ago, Captain Vancouver explored and charted Burrard Inlet and adjacent waters. In the summer of 1808 Simon Fraser, after exploring down the river named after him, reached the Pacific at the present site of the city. The little town of Granville was incorporated as the City of Vancouver on April 6, 1886. In 1976 the metropolitan population was 1.2 million.

0 (0) LEAVE hotel by bus travelling northwest on Georgia Street (Hwy 99).

1.6 (1) APPROACH to Stanley Park with Coal Harbour, its pleasure boats and fishing vessels; Lost Lagoon to the west of the causeway. The 400 ha comprising the peninsula of Stanley Park was made a military reserve in 1863 and 26 years later was formally dedicated as a park by Lord Stanley, the Governor General of Canada.

4.0 (2.5) LIONS GATE BRIDGE was built as a private toll bridge in the 1930's to develop the British Properties on the mountain slopes (directly ahead) as residential suburbs of Vancouver (Fig. 33). The suspension bridge, crossing Burrard Inlet at the First Narrows, affords a panoramic view of the deep sea port and Vancouver Harbour. The route from the bridge is west across Capilano River, past Park Royal shopping centre and north onto the Upper Levels Highway (Highway 1). From here east to Mosquito Creek (3.5 km) the route traverses a number of raised marine deltas.

20.9 (13) LYNN VALLEY ROAD. From near here the route descends a long steep hill to the Second Narrows Bridge. The vegetation on the deep road cuts masks a sucession of 3 tills, the upper two separated by peat lenses dated at more than 36,000 years B.P.

The Quaternary deposits (Fig. 8) associated with the raised deltas of Lynn and Seymour creeks at the base of the hill are coarse and medium textured glaciofluvial and glaciomarine deposits of Late Wisconsin age. Source: J. E. Armstrong, 1977.

24.5 (15.2) EXIT Upper Levels Highway to Mount Seymour Parkway. The route passes through recently developed suburban areas of the District of North Vancouver. Exposures of compact sandy loam till may be seen in roadcuts.

30.1 (18.7) JUNCTION Mount Seymour Scenic Drive

30.7 (19.1) GATE to Mount Seymour Park. The route climbs the slopes of Mount Seymour, passing from the Coastal Douglas Fir biogeoclimatic zone into the wetter Western Hemlock Zone. The dominant trees along the roadside, Western Hemlock and Western Red Cedar, are generally associated with Ferro-Humic Podzols on sandy or loamy till on these slopes. Drier sites may support Coast Douglas Fir and Humo-Ferric Podzols or Dystric Brunisols. Duripans are common.

33.3 (20.7) HIKING TRAILS are developed and maintained by the Parks Branch and by groups such as the Boy Scouts.

37.2 (23.1) TILL is exposed as a thin mantle on bedrock or as thick deposits in gullies and channels. Up to about 200 m a.s.l. the surficial deposits are a complex of till, beach deposits and solifluction materials. Ablation processes are more active above the 200 m level. The road banks have been seeded with grass mixtures to stabilize the soils.

39.6 (24.6) SWITCHBACK. A good exposure of the local bedrock and a view of the city below may be glimpsed.

41.0 (25.5) MOUNT SEYMOUR SITE: Duric Ferro-Humic Podzol (See Appendix D)

This soil will be examined in an exposure along a side road near the microwave transmission tower. Note: Collecting of soils, rocks, plants and animals is not permitted in Provincial Parks without a permit. Please disturb the soil exposure as little as possible. The tour will proceed from here to the Park Lodge.

The mountainous terrain finds intensive use during the skiing season. A number of local mountain recreation areas may be reached easily by automobile or aerial tramways.

43.6 (27.1) LUNCH at the lodge. After lunch the tour will travel over the same route to rejoin the Trans Canada Highway.

62.7 (39.0) SECOND NARROWS BRIDGE. From the bridge there is a good view of the grain terminals, docks and shipping in the harbour with the city of Vancouver in the background. To the east the fiord of Burrard Inlet cuts deeply into the Coast Mountains.

66.8 (41.5) PACIFIC NATIONAL EXHIBITION. To the right is the main sports complex, fairgrounds, and exhibition park for the Lower Mainland and the province.

68.9 (42.8) BURNABY MUNICIPALITY. Simon Fraser University is sited on top of the low mountain directly ahead. The freeway passes through an industrial and residential area before reaching Burnaby Lake.

77.4 (48.1) BURNABY LAKE, a large shallow lake that had been seriously threatened by pollution from industrial wastes and rank weed growth, is now preserved as a natural park, bird sanctuary, and water sports facility. Sediments, including organic deposits up to 12 m thick, underlie the highway through this section. Where the present highway traverses these deposits, the peaty materials were preloaded with sand to form the roadbed. This experiment has resulted in a stable base for the road.

79.0 (49.1) CARIBOO INTERCHANGE. Trial plots with ground covers were established on highway slopes over a five-year period by the B.C. Ministry of Highways in cooperation with the Botanical Garden, University of British Columbia. Plantings were made directly into the sandy loam or loamy sand till of the cut and fill slopes. In general the study showed that fill slopes provided better growth than cut slopes, rhizomatous plants faired better than those that spread above ground, and that massed low shrubs eventually proved superior to prostrate material. Both native and exotic plants were used. Some of the most satisfactory plant materials were: *Cotoneaster, Mahonia, Arctostaphylos, Vinca, Hypericum and Pachysandra.*

80.1 (49.8) COQUITLAM MUNICIPALITY

81.7 (50.8) MAILLARDVILLE-NEW WESTMINSTER Highway Exchange. Maillardville is the main centre of French Canadian culture in British Columbia. The area was settled early in the century by Canadians who came from Quebec to work in the lumber mills on the Fraser River.

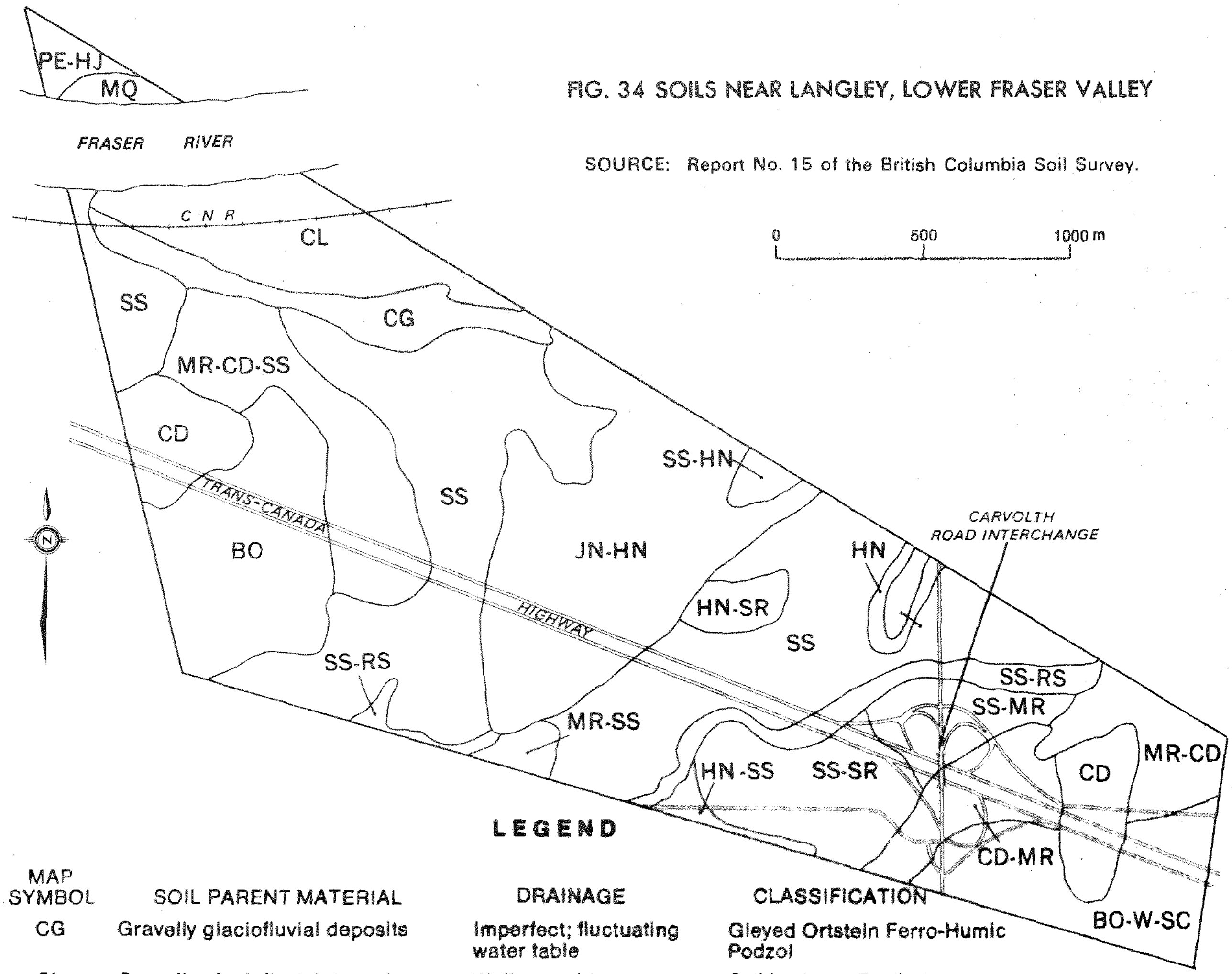
86.6 (53.8) PORT MANN BRIDGE. From this highway interchange traffic may swing north onto the Lougheed Highway to traverse the north shore of the Fraser River, or it may carry on across the bridge on Highway 1 on the southern route to Hope. From the centre of the bridge span one may view the port city of New Westminster downriver, the railway yards and industry along the river banks, and salmon fishing boats in the main river channel. The south bank rises abruptly from the floodplain of the Fraser River to the uplands. In this area the predominant soils are Duric Humo-Ferric Podzols developed on a thin mantle of gravelly loam over moderately fine textured glaciomarine or coarser textured deposits. They are associated with Luvisolic Humo-Ferric Podzols and Gleysols on glaciomarine materials.

97.0 (60.3) DOUGLAS FIR STUMP. The slight jog in the road was made deliberately to bypass a huge Douglas Fir tree during construction of the highway. The tree was a memorial by the former owner of this land to some of those who died in the Second World War. Highway construction caused the death of the tree and only the stump remains.

100.2 (62.3) CARVOLTH ROAD (200th St.) INTERCHANGE. From here in the District Municipality of Langley, roads lead to Fort Langley, (the first capital of British Columbia in 1858 on the Fraser River), and south to the farming community of Langley. A section from the soil map (Fig. 34) of the Lower Fraser Valley illustrates the pattern of soils and Quaternary deposits in the Langley area. Agricultural Capability is dominantly Class 4M, 4W with some 3^{S}_{T} and 5^{M}_{P} (unimproved ratings).

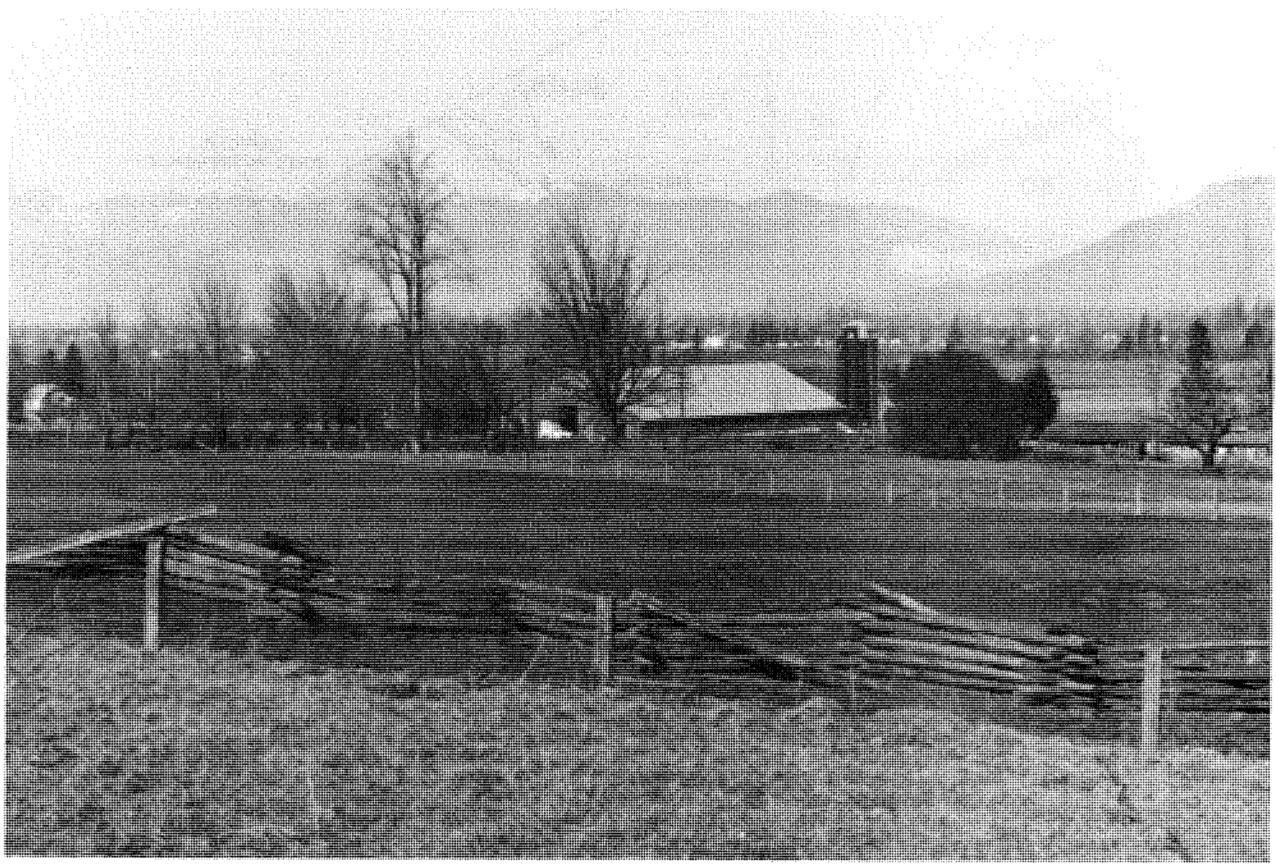
FIG. 34 SOILS NEAR LANGLEY, LOWER FRASER VALLEY

SOURCE: Report No. 15 of the British Columbia Soil Survey.



LEGEND

MAP SYMBOL	SOIL PARENT MATERIAL	DRAINAGE	CLASSIFICATION
CG	Gravelly glaciofluvial deposits	Imperfect; fluctuating water table	Gleyed Ortstein Ferro-Humic Podzol
CL	Gravelly glaciofluvial deposits	Well to rapid	Orthic Humo-Ferric Podzol
SS	Sandy littoral and glaciofluvial deposits	Well	Orthic Humo-Ferric Podzol
BO	Up to 160 cm of gravel over silty glaciomarine or sandy till deposits	Well to moderately well; telluric seepage	Duric Humo-Ferric Podzol
HN	Sandy littoral deposits over silty glaciomarine or sandy till deposits	Poor; perched water table	Rego Humic Gleysol
SR	Sandy littoral and glaciofluvial deposits over glaciomarine and marine deposits	Imperfect; perched water table	Gleyed Ortstein Humo-Ferric Podzol
JN	Up to 160 cm of organic material over silty glaciomarine deposits	Very poor; perched water table	Terric Humisol
SC	Silt glaciomarine deposits	Poor; perched water table	Orthic Humic Gleysol
W	Silty glaciomarine deposits	Moderately well; telluric seepage	Luvisolic Humo-Ferric Podzol
CD	Silty and clayey marine deposits	Poor; perched water table	Humic Luvic Gleysol
MR	Clayey and silty marine deposits	Moderately well	Luvisolic Humo-Ferric Podzol
HJ	Silty floodplain deposits	Poor to moderately poor; high groundwater table	Orthic Humic Gleysol
MQ	Up to 50 cm of silty floodplain deposits over sand	Well to moderately well	Eluviated Eutric Brunisol
PE	Silty floodplain deposits	Poor to moderately poor; high groundwater table	Orthic Gleysol
RS	Silty local stream deposits	Very poor; subject to flooding	Rego Gleysol



Courtesy of British Columbia Government

FIG. 35 FARM, LOWER FRASER VALLEY

112.6 (70.0) STRAWBERRIES. This is an important crop in the Valley. The plants are grown on a range of soil materials that include Gleysols on silty deltaic deposits to Podzols on glaciomarine and littoral sand deposits. There is an increasing trend to mechanized harvesting and "U-pick" practices to offset the scarcity and high cost of hand labour.

117.9 (73.3) DAIRY FARM. Small mixed farming operation and dairy herds are common to this rolling landform of silty textured Podzolic soils on glaciomarine uplands (Fig. 35). Agricultural Capability Class 3^{S}_{T}, 4^{T}_{S} (unimproved).

127.6 (79.3) PEARDONVILLE ROAD overpass on the outskirts of the town of Clearbrook. The tour is entering an extensive area of gravelly glaciofluvial and till deposits frequently covered with 10 to 50 cm or more of silty aeolian materials. The Humo-Ferric Podzols developed on these materials support a thriving agriculture based on small fruits and vegetables - mainly strawberries, raspberries and cole crops.

129.2 (80.3) CLEARBROOK INTERCHANGE. The tour leaves the freeway and travels south on Clearbrook Road passing large fields of raspberries, strawberries, and dairy farms.

136.0 (84.5) ABBOTSFORD SUBSTATION SITE: Sombric Humo-Ferric Podzol (See Appendix D).

This is the second and last soil site of the day. The Abbotsford Substation is part of Agriculture Canada Research Station, Agassiz. Agassiz lies about 55 km east of here, on the north side of the Fraser River. A scientist from the Research Station will discuss the work of the substation and its place in the agriculture of the Lower Mainland. Light refreshments will be available. The U.S.A. border is about one km due south of here.

Agricultural Capability ratings on this area of loess over gravel is Class 2M and Class 3^{M}_{T}. Under irrigation most of the Class 2M would improve to Class 1.

136.6 (84.9) LEAVE Substation on Huntingdon Road, travelling east.

137.7 (85.6) DAIRY FARM, typical of the area.

138.5 (86.1) STEEP ridge of coarse and medium textured eolian deposits overlying gravelly outwash.

139.2 (86.5) MATSQUI CORRECTIONAL CENTRE on the north.

141.1 (87.7) GRAVEL PIT. Deep bedded gravels capped with eolian deposits. From this point is a good view of the bed of former Sumas Lake. This valley was occupied by the sea throughout Wisconsin time becoming a shallow lake in postglacial time. The lake sediments are generally less than 5 m thick and consist of fine sand, silt and clay. They overlie up to 300 m or more of medium-textured materials, believed to be largely of marine origin. SOURCE: G.A.C. Field Trip 10, 1977. Drainage is provided by the Sumas River and the Sumas Lake Drainage Canal to the Fraser River.

Large scale land reclamation was undertaken between 1890 and 1920 with the dyking and draining of much of the floodplain within the Lower Mainland. Sumas Lake was drained and dyked in 1926 to provide an additional 12 000 ha of farmland. After a disastrous flood in 1948 many sections of the Fraser River dykes were rebuilt. The most recent Fraser River flood control program was initiated in 1968 to improve existing sea dykes in the delta area and to upgrade dykes on smaller rivers in the Lower Mainland.

143.5 (89.2) SUMAS WAY. The tour crosses this highway which links the United States to Canada through the border crossing at Huntingdon, 1.6 km to the south. From this junction the route is east across the Gleysols and Gleyed Luvisols of the lake bed.

Agricultural Capability ratings for the lacustrine soils range from Class 2W to 5W (ratings unimproved by drainage or irrigation). Note the elongated ridges of sand, up to 8 m in elevation, in the Sumas Valley. These originated as spits and offshore bars in former Sumas Lake. Soils developed on these well to rapidly drained beach deposits are classified as Brunisolic Gray Luvisol. Cross Sumas River, turn north on Cole Road and travel for 3.2 km.

153.2 (95.2) CAMPBELL ROAD. The route is due east through large fields of forage crops, corn, peas and various special crops.

159.6 (99.2) TOLMIE ROAD. Agriculture is mainly concerned with dairying enterprises which are based on Gleysolic lacustrine soils. Forage and field crops are grown under soil moisture conditions which are carefully controlled by subirrigation and surface irrigation. Agricultural Capability Class 3^{S}_{W}.

167.3 (104.0) LEAVE Sumas Valley via No. 1 Road and the Trans-Canada Highway.

168.1 (104.5) VEDDER CANAL. This large drainage ditch was dug and dyked between 1924 and 1926 as a flood control measure on the Chilliwack (Vedder) River. The canal was the site of the British Empire Games rowing events in 1954.

169.3 (105.2) YALE ROAD. The freeway here intersects the route of the old wagon road that led from the Coast through the Lower Mainland and up the Fraser Canyon to the interior of the province.

176.7 (109.8) HOP FARM. This crop is restricted to a few hectares in the Chilliwhack area.

180.2 (112.0) CHILLIWHACK. The rich farmlands of the Chilliwhack area are traversed for the next 8 km to the eastern boundary of the Fraser Lowland. The area is a major centre for dairying and forage crop production. Most of the soils are Gleysolic, formed on medium-textured vertically accreted Fraser River floodplain deposits. Significant areas of Gleyed Gray Luvisols occur and Gleysols on recent fluvial deposits occupy part of the area. Agricultural Capability classes are dominantly Class 2X and Class 3W with areas of Class 4 & 5.

191.5 (119.0) BRIDAL FALLS-POPKUM DISTRICT. The highway here follows the edge of the Fraser Lowland. The extensive cover of large deciduous trees (Bigleaf Maple and Red Alder) on the lower slopes of the mountains is partly the result of logging practices in the early 1900's.

204.9 (127.4) AGASSIZ INTERCHANGE (Route 9). Highway 9 goes north, crossing the Fraser River via the Rosedale-Agassiz Bridge to join the Lougheed Highway. One may travel west to Vancouver or east to Hope on this recently completed road link to the interior of the province. The tour route follows the Trans-Canada highway.

208.4 (129.5) GRAZING LAND. After the timber had been logged off this land, it was seeded to grasses and legumes and used for cattle grazing. From here the valley narrows rapidly as the Fraser Lowland physiographic unit merges with the mountains. Soils on the adjacent mountain slopes and on those across the valley are Humo-Ferric Podzols or Ferro-Humic Podzols. Lower slopes are covered by coarse textured glaciofluvial and till deposits. The colluvial deposits on steep slopes occur as veneers of rock fragments, reworked till and other materials that move downslope under the force of gravity.

216.9 (134.8) JADE. This semiprecious gemstone is mined in British Columbia and occurs as boulders in the canyon of the Fraser River.

233.0 (144.8) PIPELINE CROSSING. The white and red striped pipeline spanning the river carries oil from the Peace River area in northern British Columbia to refineries near Vancouver and in the United States of America.

239.4 (148.8) SASQUATCH CAVES. The name Sasquatch refers to a legendary hairy creature said to roam the mountain backwoods of the Pacific Northwest. From near here there are good views of the Fraser River and the mountain setting of Hope in the boundary zone between the Coast and Cascade mountains.

242.0 (150.4) HOPE (pop. 3700) Logging and tourism are the chief industries in this area. Logs are boomed in the Fraser River and towed down stream for processing. Recreation activities include swimming, boating and fishing. A number of mines are located in the immediate vicinity.

The tour takes Highway 3 eastward from Hope passing a B.C. Ministry of Forests Ranger Station on the outskirts of town. The town is built on a large glaciofluvial deposit at the confluence of the Fraser and Coquihalla rivers. Bedrock over the next 10.5 km is Tertiary granodiorite.

252.0 (157.0) EIGHT MILE CREEK. Granodiorite-Hozameen group contact. The Hozameen group consist of pellites, chert, basic volcanic rocks and limestone. The southwest dipping beds of this group may partly account for the instability of the north side of the valley as evidenced at the Hope Slide.

256.4 (159.3) GLACIOFLUVIAL DEPOSIT, exposed by the road cut. Particle sizes over very short distances range from boulders to almost pure sands in close contact with colluvial slopes.

This kind of variability, common in our mountainous terrain, makes mapping of homogeneous management units difficult at all but the largest map scales.

Courtesy of British Columbia Government

FIG. 36 HOPE SLIDE

From this point the effects of the Hope Slide may be seen in the newly vegetated valley floor. The tour will stop briefly to view the slide some 4 km ahead.

260.2 (161.7) HOPE SLIDE (Fig. 36). "On January 9, 1965, some 130 million tonnes of greenstone rubble swept down the mountain side onto a valley floor composed of swamp, meadow, ancient landslide debris, glaciofluvial sand and gravel and a small lake. A mixture of sliderock, mud and lake water was driven up the opposite (southwest) slope; some flowed back and came to rest on the valley floor against the lower slopes of the slide; much was deflected northwestward and rushed more than 5 km down valley as a mud-flow and some was deposited to the southeast as a 14 m thick apron, thinning in that direction (Mathews and McTaggart, 1969)." (Morgan and Preto, 1972).

Two earthquakes about 3 hours apart and of magnitudes 3.2 and 3.1, the epicentres of which are placed within 1.5 km of the site occurred at the time of the slide.

264.2 (164.2) SUNSHINE VALLEY. Much of the valley bottom consists of Organic soils and Gleysols. Attempts at dairy production have not been very successful due to limited forage production. Soils are dominantly Class 5 for agriculture with adverse climate and excess water being the main limitations.

Because of the expansion of winter recreation in Manning Park the area is now coming under pressure for recreational residences. Most of this development has been on the lower slopes adjacent to the valley bottom but pressures will increase as both summer and winter recreation facilities develop. Two major problems can be expected: 1) the infringement of residential development on marginal agricultural land and 2) the problem of sewage disposal on lands unsuited to septic fields. Drainage from this area is south into the Skagit River, a major river of western Washington State, U.S.A.

264.7 (164.5) SPRUCE BUDWORM. For the next 29 km the route passes through a serious spruce budworm infestation which could cause serious timber losses. Plans by the B.C. Ministry of Forests to control the outbreak through spraying in 1977 were opposed by environmentalist groups and the program was not carried out.

269.7 (167.6) MANNING PROVINCIAL PARK entrance. Alpine Fir begins growing in the valley bottom near here. Although this is still the Coastal Western Hemlock zone the combination of slowly warming soils and cold air drainage favors this tree.

272.0 (169.4) OLD DEWDNEY TRAIL (Engineers' Trail)

Prior to the establishment of the United States-Canada boundary in 1846 transport to the coast from the interior followed the river systems to the coast. Since all of the routes, with the exception of the Fraser River which was too dangerous, crossed the International Boundary into the United States the need for an alternate route was foreseen. By 1849 a pack trail from Fort Hope to Tulameen (near Princeton) was completed. The discovery of gold in 1859 brought new pressures for access to the interior, and by the next year a narrow road (1.2 m wide) was built from Fort Hope (now Hope) to Princeton by Edgar Dewdney, a contractor. By 1926 the old Dewdney trail was so obscure that a hiker trying to follow it was lost for over 30 days. In 1942 the original trail was improved as far as Sunshine Valley to provide access to an internment camp for Japanese-Canadians during the Second World War. Despite this unfortunate page in Canadian history the people of the Tashme camp proved their loyalty by volunteering to fight the major forest fire of 1945, which will be discussed later in this section of the tour. Finally in 1949 Highway 3 was opened to Princeton.

277.6 (172.5) INVERMAY ANNEX AERIAL TRAMWAY. Directly ahead the cleared line down the mountain is the inactive tramway which provided access to a silver lead deposit. The buildings along the river are reminders of former mining activity. Near here the route crosses a steeply dipping fault, separating the Dewdney Creek group from the Hozameen group.

280.5 (174.3) RHODODENDRON FLATS. Extensive glaciofluvial deposits lead up to Rhododendron Flats where very coarse textured soils with low water holding capacity and now nutritional status produce areas of limited productivity. Coast Douglas Fir can be expected to form an eventual edaphic climax. Here as well the Pacific Rhododendron will be flowering. This shrub is of rare occurrence in Canada and is protected by law.

293.5 (183.6) FOREST FIRE, for 4 km along the highway.

On August 8, 1945 pilots of Canadian Pacific Airlines reported a fire about 24 km east of the Tashme camp. The only access was a survey trail. It took the Royal Canadian Engineers and volunteers from the Tashme camp 3 days to reach the fire. On August 26, with the aid of a five-hour rain, the fire was extinguished. The fire had consumed 2370 ha of valuable timber. Much of the area required planting. The white and yellow-flowered plants along the roadside are sweet clovers, often sown after a fire.

302.1 (188.9) ALLISON PASS approach (1342 m a.s.l.) - marks the end of the Coastal Transition zone. The ridge profile to the south is typical of the Subalpine Engelmann Spruce-Subalpine Fir Zone. The characteristic profile is given by the narrow conical crowns of Engelmann Spruce and Alpine Fir.

304.0 (189.7) SIMILKAMEEN RIVER source. The tour route follows this river southeastward until it turns south to join the Columbia River in the U.S.A.

311.3 (194.6) INTERIOR DOUGLAS FIR ZONE begins on the southfacing slopes of the valley.

312.0 (195.4) MANNING PARK LODGE. OVERNIGHT STOP AND MEALS. From the highway a paved road leads up the mountain slope to the subalpine parkland. It passes through a sequence of biogeoclimatic zones (Fig. 9, 37) and soil groups (Fig. 10, 14). The valley bottom has Humo-Ferric Podzols developed on coarse textured glaciofluvial terraces, the lower and midslope positions to 1370 m a.s.l. are occupied by Dystric Brunisols of the Interior Douglas Fir biogeoclimatic zone. Lying above this is the Subalpine Engelmann Spruce-Subalpine Fir Zone with its Humo-Ferric Podzols. At the highest elevations (1800 to 2250 m a.s.l.), Sombric Podzols, Regosols and Rockland form map units in the krummholz and treeless Alpine Tundra zone. This is also the boundary of the Hozameen formation and the grits and shales of the Pasayten group.

This is a prime recreational area - skiing in the winter and camping, fishing and hiking in the summer.

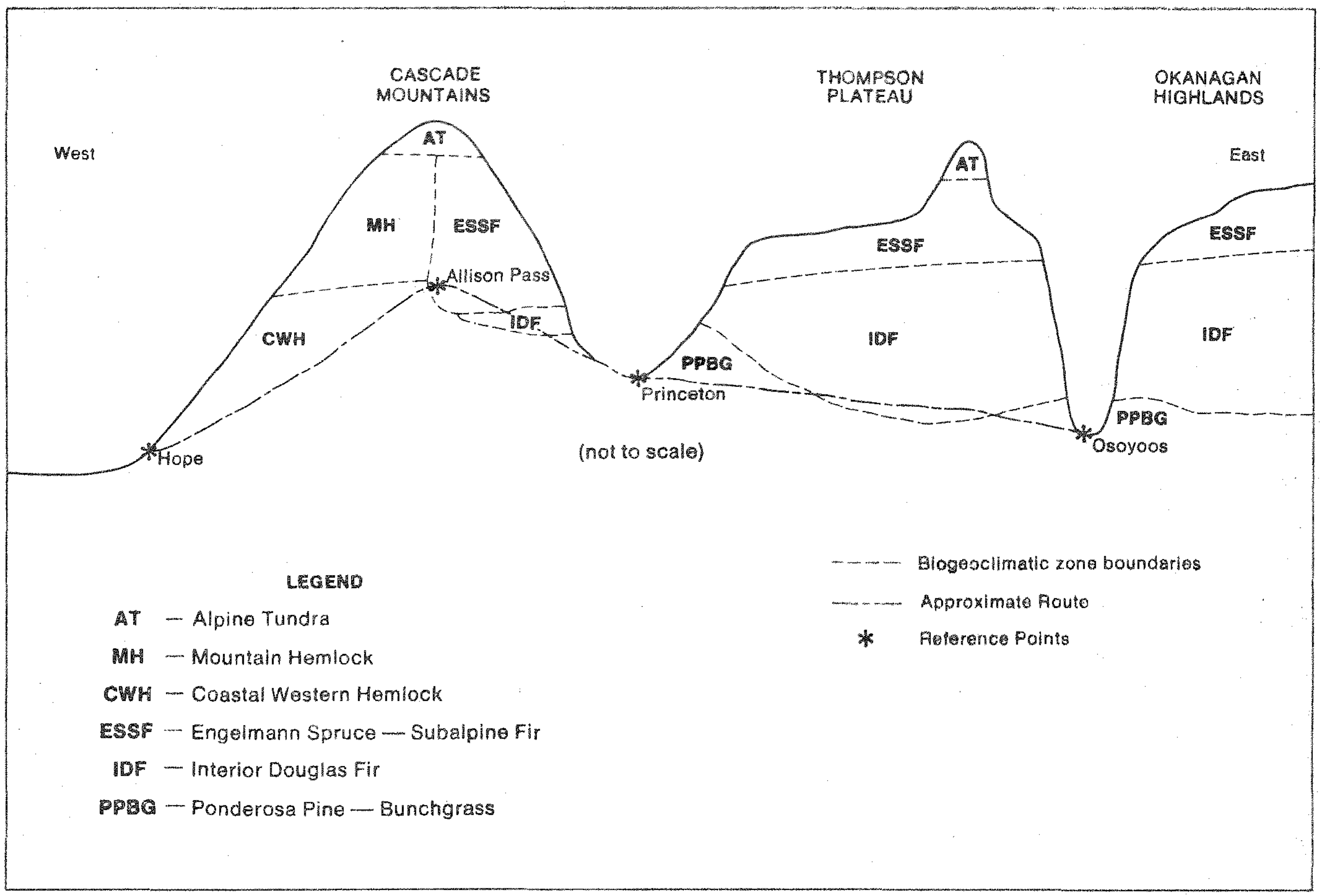


FIG. 37 CROSS SECTION OF APPROXIMATE TOUR ROUTE SHOWING BIOGEOCLIMATIC ZONES

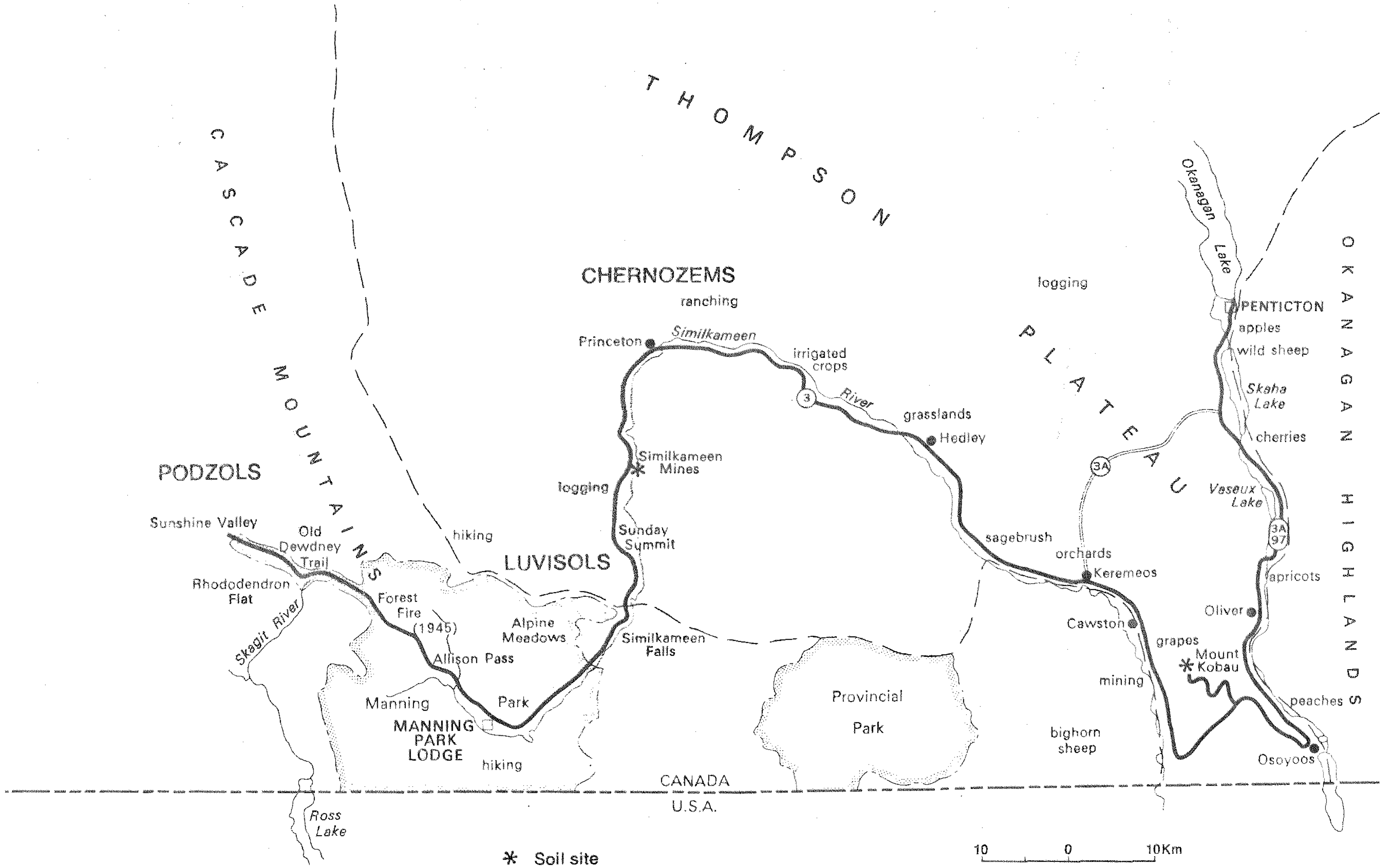


FIG. 38 ROUTE MAP DAY 2

DAY 2 MANNING PARK TO PENTICTON

The tour continues eastward on Highway 3, (Figure 38) passing through the Cascade Mountains to the Thompson Plateau. The route follows the Similkameen River to Cawston, then crosses the divide and enters the Okanagan Valley at Osoyoos, just north of the International Boundary. A wide range of soil and land use environments is traversed - from the mountain Podzols to the Chernozemic soils of the interior grasslands. Two soil stops will be made in the plateau.

Road Log 2 Manning Park Lodge to Penticton (279 km)

Km (mile)

0 (0) LEAVE Manning Park Lodge for Penticton

16.8 (10.0) EAST GATE of Manning Park

18.3 (11.0) MILL. A small milling site where Lodgepole Pine (found in dense stands near here) are processed to form prefabricated log houses, fence posts and poles. The name Lodgepole Pine in fact derives from their use by Indians and early settlers for housing construction.

21.9 (13.3) VARVED lacustrine deposits can be seen on the north side of the road.

22.7 (13.8) SIMILKAMEEN FALLS, formed when the Similkameen River was superimposed from glaciofluvial deposits onto bedrock, has cut the canyon into bedrock of the Nicola Group. The falls mark a convenient boundary between the Cascade Mountains and the Thompson Plateau.

25.4 (15.4) VARVED lacustrine deposits, the remnants of a former glaciofluvial lake, are overlain by gravels in the riverbank exposure.

29.6 (18.0) ROAD CUTS on the north side of the road provide a good cross section of topography and soils in this area and mark the beginning of large units of Gray Luvisols.

33.0 (20.1) SUNDAY SUMMIT (1278 m a.s.l.) Vegetation is comprised of dense, even-aged Lodgepole Pine stands which apparently seeded in following extensive forest fires. Individual tree productivity is low due to overstocking and severe competition for available water.

46.3 (28.4) SIMILKAMEEN MINES SITE: Orthic Gray Luvisol (see Appendix D)

The tour will stop here to examine an Orthic Gray Luvisol.

49.4 (30.3) VIEW into the Princeton basin provides the first sight of the interior grasslands. The Black and Dark Gray Chernozemic soils are typical of this part of the Ponderosa Pine - Bunchgrass Zone. The road passes by old overburden deposits from mining operations. Seen across the Similkameen River, the Copper Mountain mine produced 30.6 m tonnes of 1% copper ore between 1923 and 1957. The Copper Mountain stock itself is about 1.2 km across.

54.9 (33.8) YELLOW PINE ECOLOGICAL RESERVE. The route has left the Interior Douglas Fir Zone (Fig. 39) and is now in the Ponderosa Pine-Bunchgrass Zone (Fig. 40). The Yellow Pine Ecological Reserve was established to maintain an ecological benchmark for undisturbed ecosystems in this area. The site is one of the most productive for Ponderosa Pine (Yellow Pine) in the area.

From here into Princeton the route crosses the sandstones, shales, coal, and minor bentonitic tuff and lava deposits of the Princeton Group. The bentonite beds in this area are often marked by Big Basin Sagebrush communities which are frequently associated with Dark Gray Chernozémic soils.

60.0 (36.9) TERRACES on the route are composed of ice or lake marginal glaciofluvial deposits laid down during the Pleistocene when this area was covered by an ice-dammed lake. Soils are classified as Eutric Brunisols and Gray Luvisols (Figure 41).

69.5 (42.8) PRINCETON AND THE SIMILKAMEEN VALLEY

Long before the arrival of the white fur traders, native Indians lived in the Similkameen Valley. These people, who lived by both hunting and fishing, exchanged ochre pigment for dried salmon and candlefish with coastal tribes. The ochre came mostly from Vermilion Forks, which was later renamed Princeton.

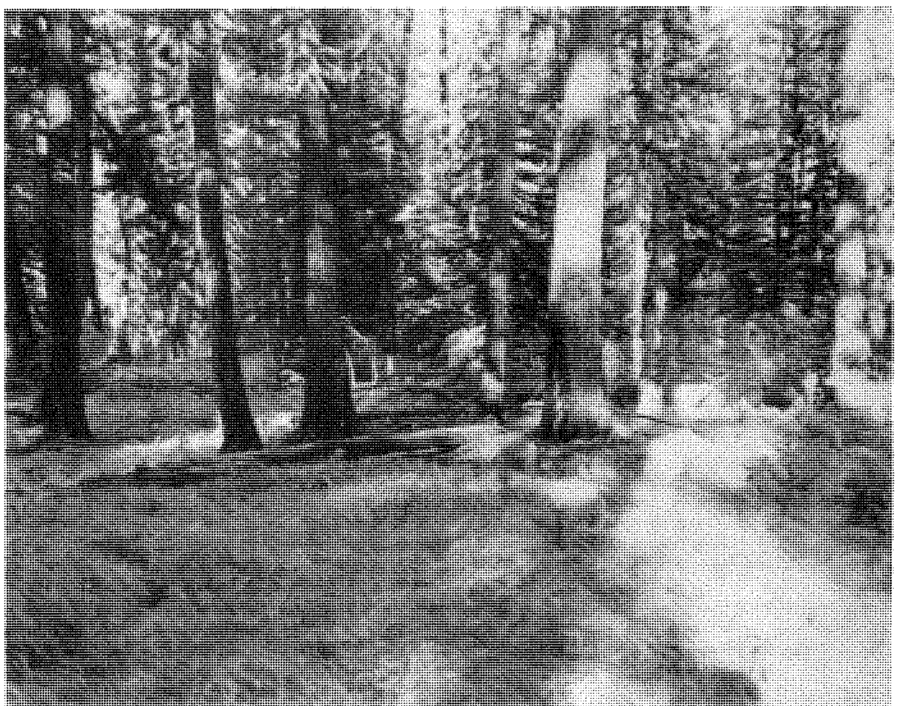
The search for furs and gold brought the first white men to the Similkameen Valley. In 1813 Alexander Ross of the Pacific Fur Company journeyed through part of the valley on his way from Kamloops to Fort Okanagan located at the junction of the Okanagan and Columbia rivers.

The area is sparsely populated. The total population in 1973 was estimated to be between 6000 and 7000. The ups and downs of the mining industry caused population fluctuations.

Princeton, the main centre, had a population of 2601 in 1971. Smaller centers are located at Hedley, Manning Park, and Allison Pass.

The people are engaged in ranching, transportation, manufacturing (chiefly sawmilling), mining, and servicing the tourist industry. The rural population is the smallest even though ranching is the most stable industry. "In the interior section of B.C., ranching constitutes a major form of land use and permits stable settlement of large areas which cannot support more intensive forms of agriculture, as well as providing a sound economy for them. Conversion of range forage to meat, both from domestic stock and wildlife offers a means of converting an unusable form of energy into a usable form". Source: A.McLean - see Appendix I.

Agriculture in the area is greatly restricted because most of the land is nonarable and the annual rainfall on arable soils seldom exceeds 350 mm. Most of the arable land occurs in the valleys where irrigation water is available for forage production and pasture. The arable soils



Photograph by A. McLean

FIG. 39 DOUGLAS FIR AND PINEGRASS WITH WHITE SPRUCE REGENERATION

Photograph by A. McLean

FIG.40 PONDEROSA PINE, IDAHO FESCUE AND BALSAMROOT ON A DARK GRAY CHERNOZEMIC SOIL

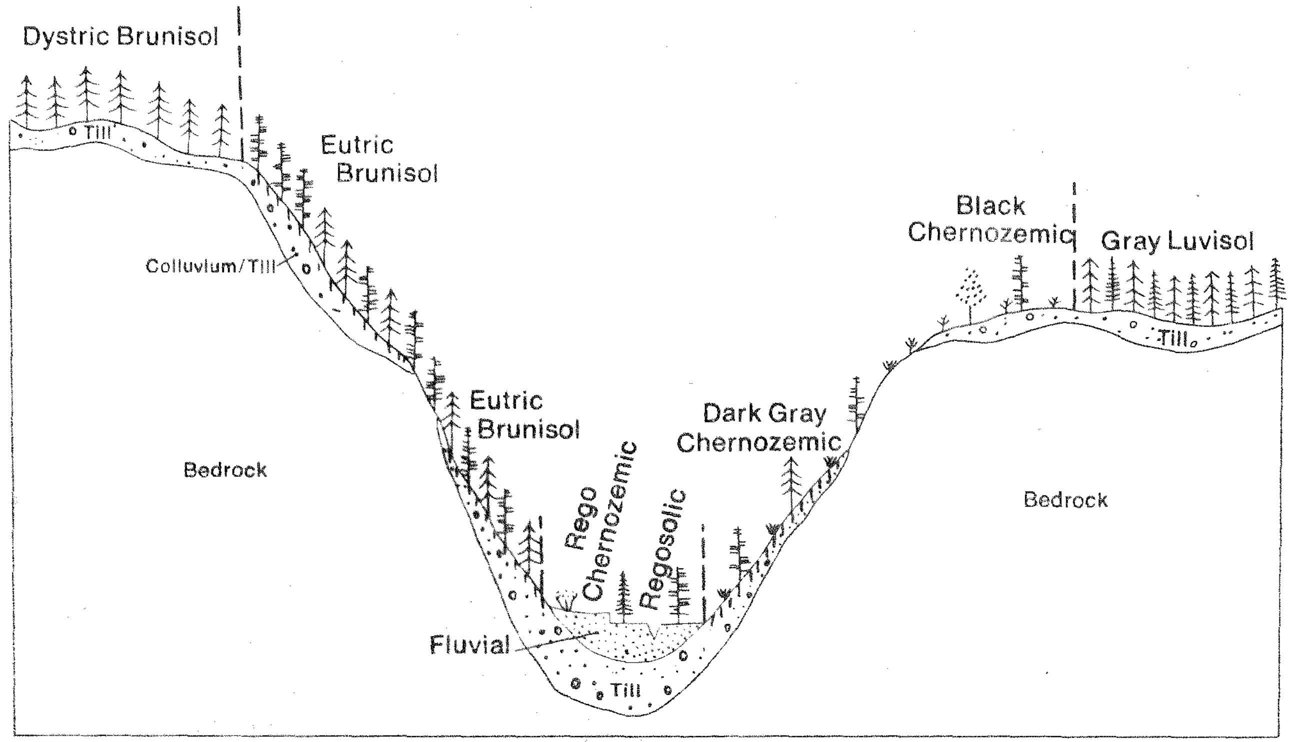


FIG. 41 SOIL GROUPS NEAR PRINCETON, SIMILKAMEEN RIVER VALLEY

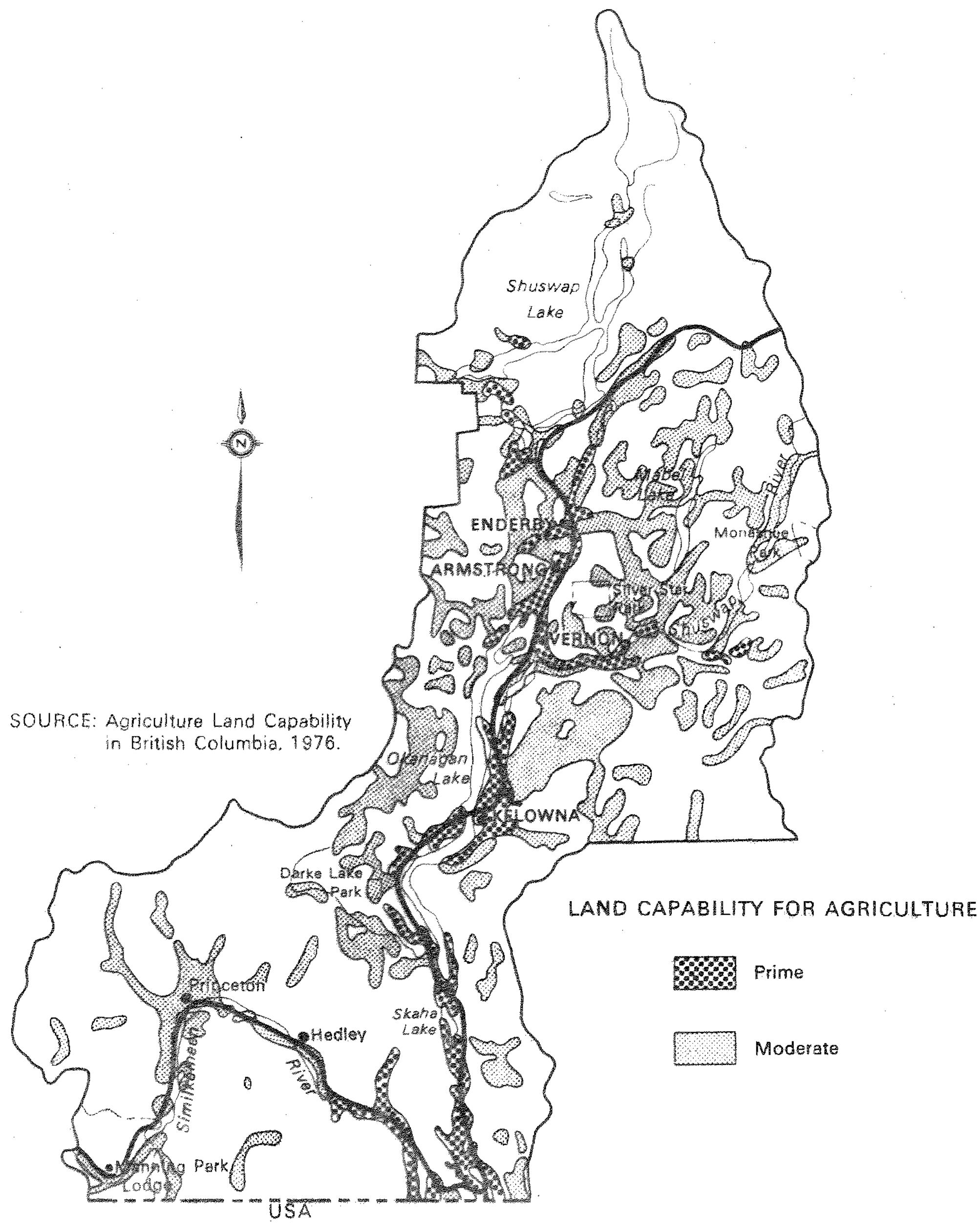
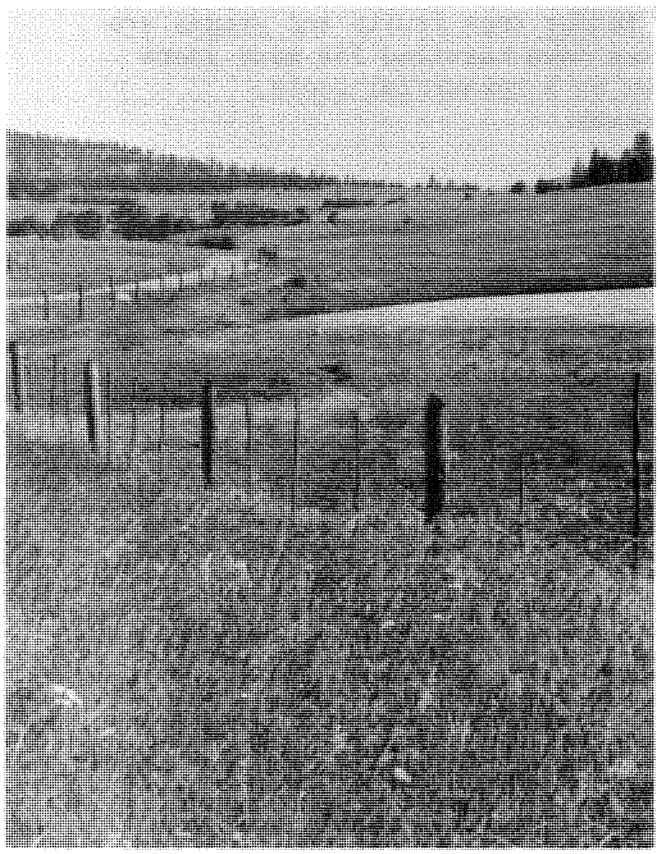
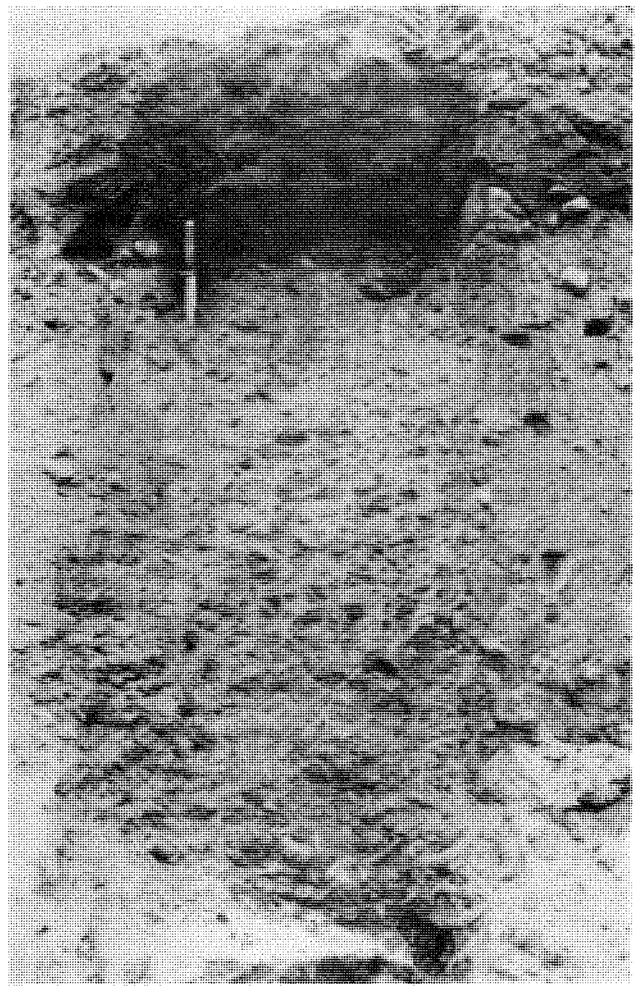


FIG. 42 PRIME AND MODERATE LAND CAPABILITY FOR AGRICULTURE CLASSES IN OKANAGAN AGRICULTURE REPORTING REGION



Photograph by A. McLean



Photograph by T. Lord

FIG. 43 a) CHERNOZEMIC SOILS ON OPEN AND SEMIOPEN RANGELANDS

b) PROFILE OF A BLACK CHERNOZEMIC SOIL ON TILL are Chernozemic, Luvisolic, and Brunisolic, and occur mainly in the Princeton basin. The Princeton basin lies in the western most part of the Okangan Agriculture Reporting Region (Fig. 42). Large expanses of open and semiopen rangeland occur on the valley slopes and the plateau (Fig. 43).

The main agricultural enterprise has been cattle ranching since the first settler arrived in Princeton in 1858. Approximately 30 ranches of varying sizes are located in the area.

The main crops are grass and legume forages, combined with pastures. Wheat was grown in the early days, but production declined after 1900. A limited amount of dairying and market gardening was carried on until the big mines closed during the nineteen fifties.

Potatoes and hardy vegetables can be grown. Because of the risk of intensely cold periods during the winter, tender tree fruits and grapes are unsuitable crops. Hardy varieties of apples have survived for many years in the region, but they have not been grown on a commercial scale.
Source: Report No. 14. B.C. Soil Survey.

71.6 (44.1) GRASSLANDS

75.0 (46.2) REENTERING the Interior Douglas Fir Zone. Here the valley narrows into rock and colluvial slopes.

76.9 (47.4) RANCHING operation producing irrigated forage on sandy fluvial deposits. These Dark Gray Chernozemic soils and Eutric Brunisols are rated Class 4 M for dry land farming and Class 2 under irrigation.

81.2 (49.1) FLOODPLAIN shows evidence of repeated channeling. The alluvial fans are Eutric Brunisols or in some cases Gray Luvisols.

88.6 (53.7) ASPECT controls soil development. The steep valley slopes show either Chernozemic or Brunisolic development while the slope break to the plateau surface provides the transition to Brunisols and Podzols.

97.0 (58.9) GRAY LUVISOLS developed on lacustrine deposits.

99.4 (60.4) CLASS 4 and 5 soils - because of adverse topography, very coarse texture and stoniness these soils would show little or no improvement under irrigation.

101.2 (61.5) STERLING BRIDGE. From near here the agricultural climatic class improves to Class 1 downriver.

103.5 (62.9) LARGE FANS. Coarse textured Rego Black and Rego Dark Brown Chernozemic soils.

106.8 (65.0) DARK BROWN CHERNOZEMIC soils develop on terraces and fans in the Ponderosa Pine-Bunchgrass Zone.

107.3 (65.3) NICKEL PLATE MINE at Hedley. Opened in 1904 this mine yielded 47 million dollars in gold. Remnants of the towns lost prosperity can still be seen in the stone retaining walls and some of the old houses. In recent years, the favorable climate and location have attracted a number of families to the town. The view of the old mine also provides an excellent exposure of the lower portion of the Nicola geological formation.

Soils developed on the fluvial terraces along here are rated as Class 1 for agriculture with respect to both soils and climate. The gray coloured shrub, Common Rabbitbrush, is indicative of dry conditions.

115.2 (70.2) HIGH ELEVATION Black Chernozemic soils extend to 1500 to 1700 m a.s.l.

117.0 (71.1) BIG BASIN SAGEBRUSH (*Artemesia tridentata*) shows up on dry slopes.

119.9 (74.0) VOLCANIC ASH is exposed in colluvial deposits along the road for several km. A number of separate falls from sources in the American northwest have been dated to 6600 years B.P.

126.0 (77.4) COVERED BRIDGE. This is one of the last remnants of the early railroad lines in southern B.C.

?29.8 (80.2) KEREMEOS, and the first view of the fruit orchards. Cherries, apricots, peaches and apples are the main tree fruits grown here. Large active colluvial fans are characteristic of this area. Extensive high elevation grasslands may be seen across the valley.

138.5 (85.6) CALCAREOUS and saline soils occur in the Cawston area.

145.0 (89.6) GRAPES are grown on some of the coarse textured apexes of alluvial fans.

152.2 (94.1) SALTS are leaching out of road cuts. Soils in this area are used primarily for hay production.

155.3 (96.0) SOME of the upslope soils are irrigable but the summer water supply is limited by a Canadian-American water treaty which requires that any additional water used on the Canadian side of the border must be the result of increased water yield through Canadian watershed management.

163.6 (101.1) JUNCTION of Highway 3 and road south into the United States The tour continues east into the Richter Pass, an area favored by turkey vultures, rattlesnakes and other desert fauna and flora.

166.7 (103.1) SHALLOW lakes evaporate during the summer leaving salt crusts on the soil surface. Soils in the Richter Pass area are loamy textured Brown and Dark Brown Chernozemics.

174.4 (107.9) JUNCTION with Mount Kobau road. The bus leaves the highway to climb to the summit of Mount Kobau (1868 m). From this vantage point the tour will examine an interesting soil and view the surrounding panorama of plateau and mountains. This will also be a lunch stop.

MOUNT KOBAU

Mount Kobau was originally chosen as the site for a proposed Canadian National Observatory. This institute was to have featured 12 astronomical instruments of various sizes and types, the largest of which was to have been a 150-inch (375 cm) telescope presented to Queen Elizabeth II in commemoration of her visit to Canada in the autumn of 1964. This concept was cancelled in 1968 on economic grounds, precipitated in part by disagreement within the astronomical community as to the site's astronomical potential. It has, however, remained in operation since then as an observing site operated by the Dominion Astrophysical Observatory in Victoria.

192.1 (118.6) MOUNT KOBAU SITE: Sombric Dystric Brunisol (see Appendix D) This soil is associated with base-saturated Chernozem-like soils that occur on south and west facing, high elevation mountain slopes throughout the area (Fig. 44).

209.8 (129.3) JUNCTION Highway leaving the Richter Pass for the Okanagan Valley.

211.9 (131.0) SPOTTED LAKE shows an unusual pattern of round clear areas surrounded by whitish crystalline material. Two salts, magnesium sulphate and sodium sulphate form crystals from a very concentrated brine. The epsomite chemical has been used commercially in the tanning industry.

215.1 (133.0) LOOKOUT. From this point, one looks south toward Osoyoos Lake (Fig. 45) lying across the International Border. The shallow lake is notable for the beaches and spits that contribute to its recreational value. On the coarse textured glaciofluvial terraces (Fig. 46) surrounding the lake, soft tree fruits, apples, cherries, and grapes are grown under irrigation. Evapotranspiration rates may be very high (7.5 mm/day over a 5-10 day period in the heat of summer). Irrigation intervals for tree fruits range from 4½ to 21 days depending on soil texture and depth. Agricultural capability is mainly Class 5C dry farmed and Class M irrigated. The vineyards below the road and across the lake represent recent experiments in growing vinifera grape varieties developed in California and Washington from French stock, and such varieties as Johannisberg Riesling and Ehremfesler from the Rhine Valley of Germany (Fig. 47). Chernozemic soils occupy the high elevation grasslands beyond Osoyoos Lake.

220.3 (136.2) JUNCTION Highway 97 and Highway 3, turn north through orchards first developed in the 20's to assist World War 1 veterans. It is now a grower-operated irrigation district. From here to the town of

Photograph by T. Lord

FIG. 44 MOUNT KOBAU SOIL SITE

Courtesy of British Columbia Government

FIG. 45 OSOYOOS LAKE

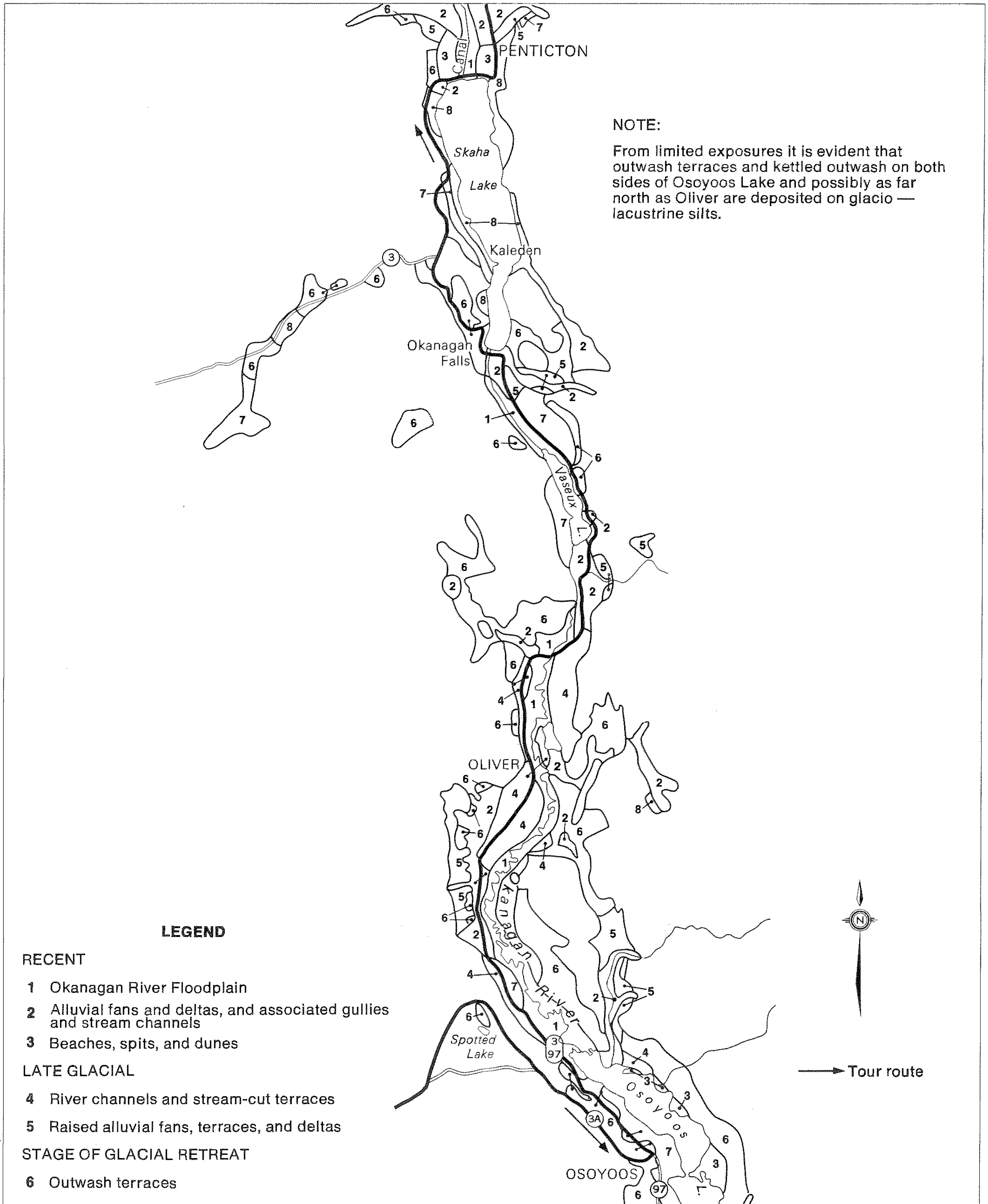


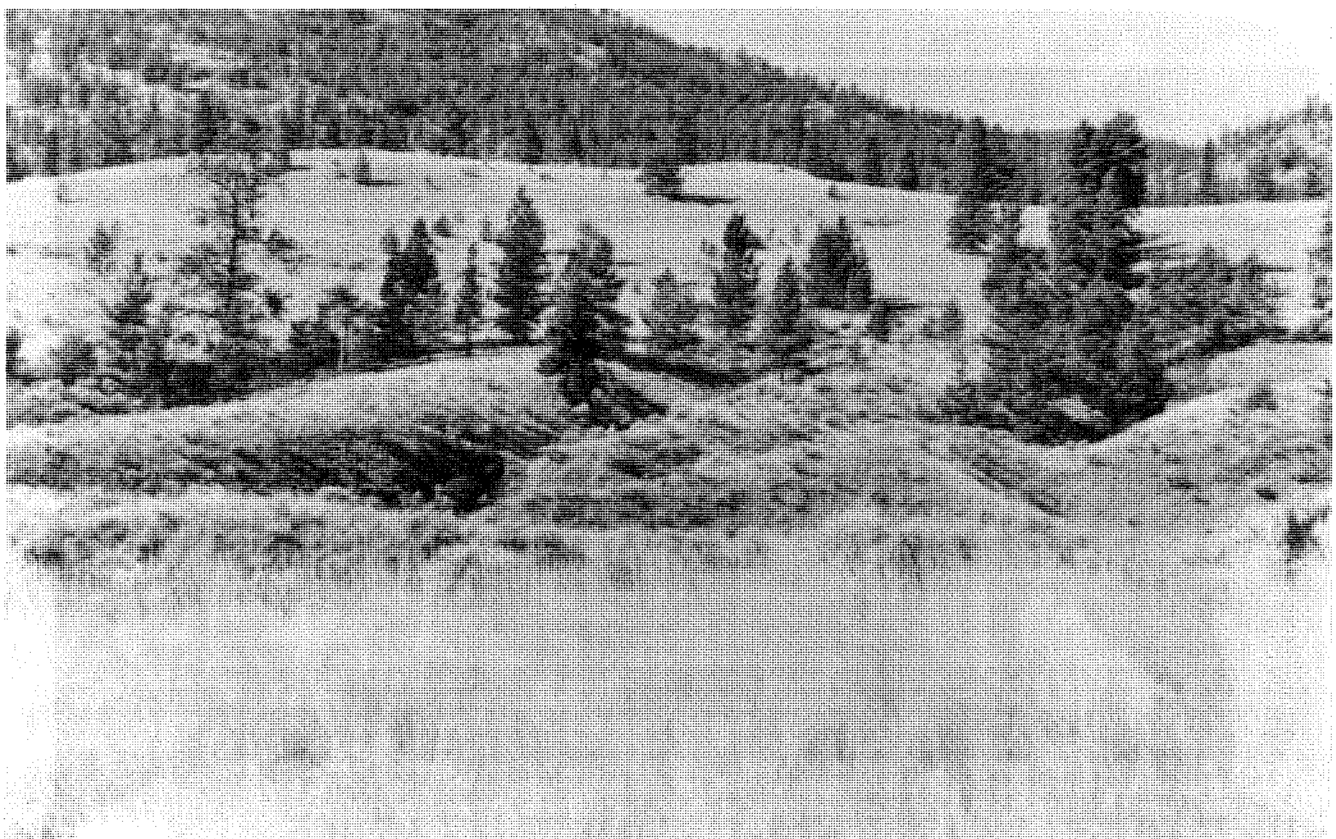
FIG. 46 SURFICIAL DEPOSITS OF SOUTHERN OKANAGAN VALLEY—AREAS 1 AND 2 (AFTER NASMITH 1962)

Courtesy of British Columbia Government

FIG. 47 VINEYARDS ABOVE OSOYOOS LAKE

Courtesy of British Columbia Government

FIG. 48 CALIFORNIA BIGHORN SHEEP



Photograph by J. H. Day

FIG. 49a SUMMERLAND STATION SITE

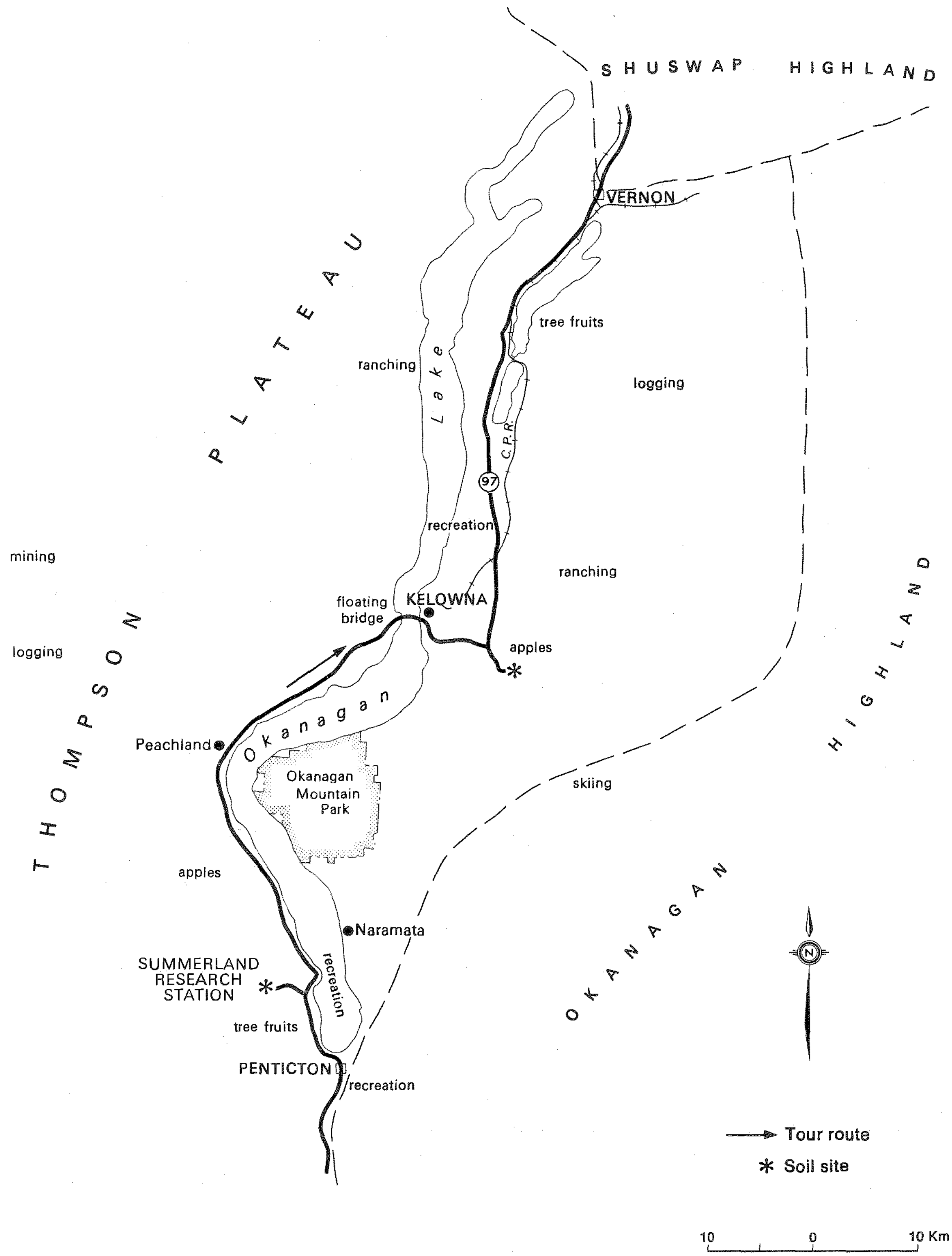


FIG. 49b ROUTE MAP DAY 3

Oliver the route is through alluvial fans, deltas and floodplains, and poorly drained marshlands and wildlife refuge. On the east side of the valley just north of Osoyoos Lake is an area, part of the Great Basin Desert of North America, being considered as an ecological reserve. Horned toads, cacti, rattlesnakes, and several unusual kinds of birds and plants inhabit this small vulnerable desert.

239.7 (148.3) OLIVER (area pop. 5717). Over the next 5 to 6 km the route passes close to the flood control channel, irrigation diversion canal, and supporting works of the Okanagan flood control project, the first such project in British Columbia. On the banks above the north approach to Oliver a silica mine (not operating) may be seen. The area was settled in the 1800's by gold miners. Fruit and vegetable growing began with the opening of the irrigation canal in 1921.

251.4 (156.2) VASEUX LAKE. McIntyre Bluff, a massive cliff of Precambrian mixed-layered gneiss, looms over the southwest end of the lake. An extremely stony fan (Agriculture capability 6P) which originated in the sharp V-cut terrace east of the road is crossed just before reaching the lake. Vaseux Lake is a well known wildlife refuge and bird sanctuary (families of Canada geese are generally visible). California bighorn sheep may often be seen along the rock bluffs east of the lake. (Fig. 48).

260.8 (162.0) OKANAGAN FALLS. Further views of the flood control works and canal may be seen.

266.6 (165.6) JUNCTION Highway 97 and Highway 3A. The community of Kaledon on the shore of Skaha Lake is an irrigation district that has now been almost completely converted to residential housing and small holdings (.5-1 ha). The orchards here are mainly on sandy glaciofluvial deposits (Fig. 46).

268.8 (167.0) GAME FARM. Many types of native and exotic animals are kept in open pens and compounds. Just past this point a good view of the city of Penticton, built on the confluence of two large deltas, is seen across Skaha Lake.

The route follows along the sandy beach of Skaha Lake and through the suburban area.

279.0 (173.4) ARRIVE at motel in Penticton (pop. about 24,000). Thomas Ellis, the first permanent settler, established his cattle ranch headquarters in the heart of the city in 1865. He planted the first fruit trees in 1872 and laid out a townsite in 1892. The name of the city is derived from the Salish Indian name "Pen-Tak-Tin" a "place to stay forever". Although fruit growing is still important, tourism has now more impact on the city.

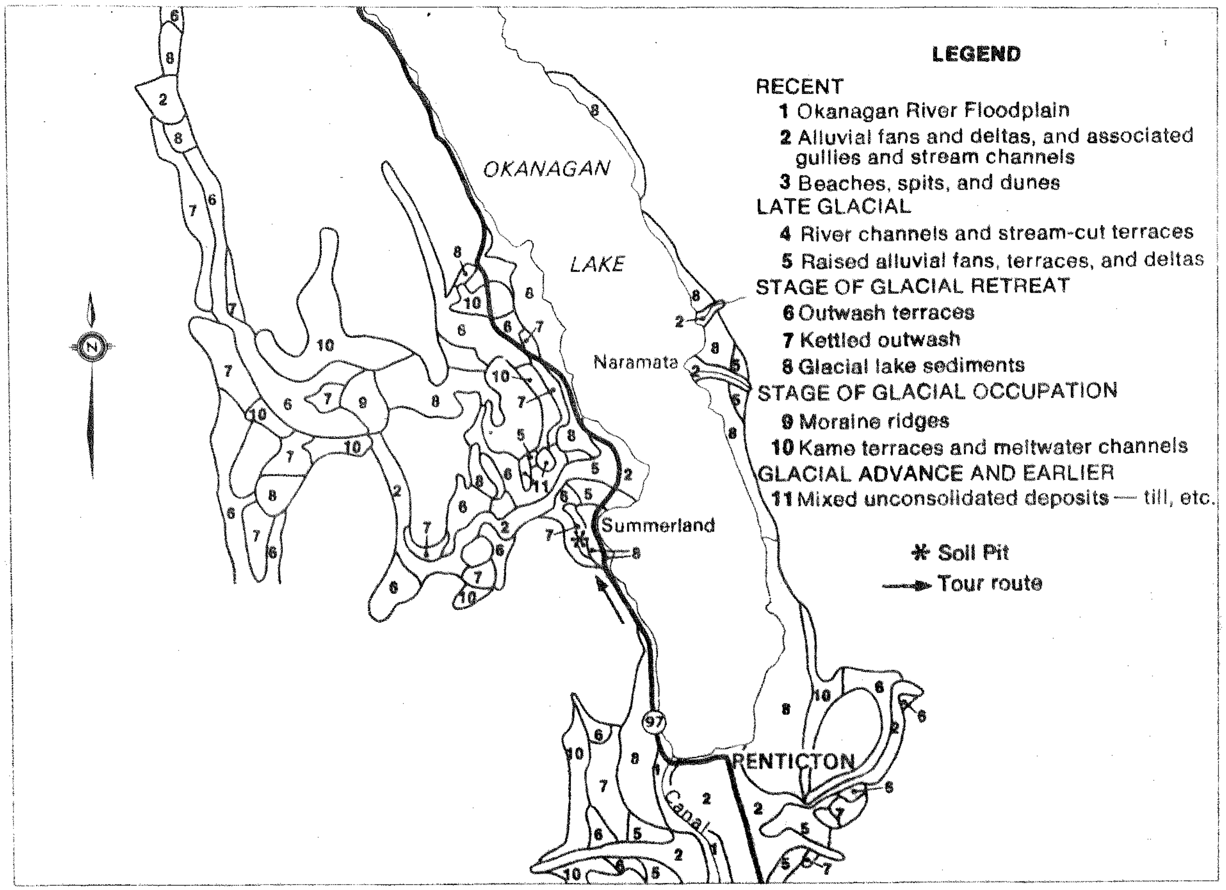


FIG. 50 SURFICIAL DEPOSITS OF SOUTHERN OKANAGAN VALLEY—AREA 3 (AFTER NASMITH 1962)

DAY 3: PENTICTON TO VERNON

The tour follows Highway 97 along the west shore of Okanagan Lake (Figure 49b). The lake is crossed to Kelowna on one of the longest floating bridges in Canada. From Kelowna the route passes through the spectacular scenery of the inter-lake chain to the city of Vernon.

The forenoon will be spent at the Agriculture Canada Research Station, Summerland examining a soil and then touring the station. After lunch the tour travels to Kelowna to observe another soil site before proceeding to Vernon.

Dry open forests and grasslands, characteristic of the drier Eutric Brunisols and Chernozemic soils, occur along the tour route. Tree fruits, grapes, vegetables, and forage crops are grown on irrigated lands dispersed along the valley sides from Penticton to Vernon. Small farms and ranches use the accessible range lands for grazing.

Road Log 3: Penticton to Vernon (136 km)

Km (Mile)

0 (0) LEAVE Penticton for the Agriculture Canada Research Station at Summerland. Glacial lake Penticton silts are exposed along the route. On a clear day these silt benches can be observed on both sides of Okanagan Lake. Piping is visible in some of the almost vertical cliffs.

8.8 (5.5) JUNCTION of Highway 97 and entrance to the Agriculture Research Station (Fig. 49a).

10.9 (6.8) SUMMERLAND STATION SITE: Orthic Brown Chernozemic (see Appendix D)

An Orthic Brown Chernozemic soil on silty glaciolacustrine deposits (Fig. 50) will be examined. The remainder of the morning will be spent touring the Station.

Lunch facilities will be provided at the spacious and well shaded picnic grounds. After lunch the tour continues north along the west shore of Okanagan Lake.

THE SUMMERLAND RESEARCH STATION

The Summerland Research Station was established in 1914. The function of the Station is to solve, through basic and applied research and development, the problems encountered by producers of tree fruits and grapes, and by processors of fruits and vegetables. The objective of the research is to maintain a high level of production and quality of mainly fruit but agriculture generally in the Okanagan Valley and other parts of south-central British Columbia.

Personnel of the station are divided in 6 disciplines according to specialized areas of work, namely Agriculture Engineering, Entomology, Food Processing, Plant Pathology, Pomology, and Soil Science.

Agricultural Engineering: Work of this group includes design, remodelling and testing of low volume spray equipment for pesticides, development of mechanical harvesting aids, and testing trickle irrigation methods.

Entomology: This group studies life cycles and control of problem insects such as orchard mites, codling moth, western cherry fruit fly, pear psylla and other tree fruit and grape insects. Sex attractants (pheromones) are under study and an important part of the program is a sterilized male codling moth method of insect control, now in the commercial orchard stages of investigation. Pesticide chemistry is another part of the program.

Food Processing: This group studies wine quality, recovery of essences, fruit quality of cold and hot packs, convenience desserts, and studies of canned or processed meats. The section services the industry in plant design, processing procedures and so on. Studies now include land disposal of plant processing wastes with the goal of maximum protection of soil and water environment.

Plant Pathology: Investigations include isolation, identification and control measures where possible, of virus, bacterial and fungus diseases of trees fruits and grapes. The most troublesome disease is the little cherry virus of which, even after many years of study, little is known about and for which the only effective control is tree removal. Other diseases under study include apple scab, crown rot, powdery mildew and bacterial fireblight.

Pomology: The Pomology section sustains a broad program of studies of fruit handling from harvest to retail outlets, of the use of growth regulators for stop-drop, coloring and quality of fruit, of effects of weather and sunlight penetration on fruit, of bud cooling for delaying blossom to protect against spring frosts. The program includes breeding and testing, concentrating on cherries and grapes at present, continuing the search for new varieties with high yields and superior quality. Also included are rootstock testing for stronger, smaller trees and the most suitable shapes of trees and vines for both production and easement of hand labor.

Soil Science: The Soil Science section investigates tree fruit nutrition of both major and minor elements, concentrating largely on a problem of calcium deficiency in Spartan apples, a deficiency that leads to breakdown of the fruit in prolonged storage. The second major part of the soils program includes investigations of trickle irrigation, both design and operation of systems, of proper design of sprinkler systems both overtree and solid-set systems. A lysimeter facility that simulates orchard conditions aids the investigations of water use and movement in soils and of the contributions of applied nitrogen to moving groundwaters. The latter is of some concern to residents of the valley from the standpoint of water quality of the lakes and river.

The station has a research complement of about 20 professionals plus support staff, upwards of 100 technicians, laborers, administrative staff, and summer student assistants.

27.0 (17.0) OKANAGAN LAKE CAMPSITE. A large public campsite with adjoining picnic grounds and boat launching facilities.

37.5 (23.3) SQUALLY POINT across the lake which can be very hazardous to boaters during sudden windstorms. On the slopes above is the recently created Okanagan Mountain Park which is used for recreation and wildlife conservation. Ogopogo, an elusive lake monster, often appears near here during the tourist season.

42.6 (26.5) PEACHLAND (pop. 2257); it's economy is based mainly on a large mine, the forest industry, tourism and agriculture.

54.5 (33.8) WESTBANK

61.1 (38.0) LAKEVIEW HEIGHTS Irrigation District for 1.5 km. The arable soils in this area range from glaciolacustrine silts and clays to coarse textured outwash and till. On lacustrine silts and clays, agricultural capabilities are mostly Class 1, 2 and 3 (irrigated) (Fig. 42), on glaciofluvial deposits they range from Class 1 to Class 5 (irrigated) and irrigated and dryland ratings on the till soils are Class 5, 6 and 7. Limiting subclasses are topography, stoniness and soil factors. Table 9 shows the limited amount of good agricultural land in the region.

Table 9. Agriculture land capability classes, Okanagan Agricultural reporting region

	Unimproved		Improved**	
	100 ha	%	100 ha	%
Class 1	13	0.05	116	0.42
2	175	0.64	467	1.69
3	377	1.37	528	1.92
4	768	2.79	1 015	3.68
5	4 074	14.80	3 311	12.04
6	6 419	23.33	6 404	23.28
7	14 697	53.42	14 683	53.37
Water	910	3.31	910	3.31
Other*	79	0.29	79	0.29
Total	27 513	100.00	27 513	100.00

* Other includes unclassified urban areas, national parks and unmapped portions of the district.
**Rating if land unit were irrigated and/or drained.

Low precipitation during the summer severely curtails agriculture production in areas not irrigated, particularly in the Similkameen and Okanagan valleys; however if irrigated, this area is one of the best in Canada, in terms of diversity of crops.

Five broad climatic classes were developed for the Okanagan and Similkameen valleys. The lower Similkameen (Keremeos-Cawston) as well as the South Okanagan north to Summerland are considered 5c (low precipitation). The area from Summerland to Trepanier is considered 4c; from Trepanier to Oyama, 3c; from Oyama to Vernon, 2c; the remainder of the North Okanagan and Shuswap areas are 1c.

Adverse topography, stoniness, and low moisture holding capacity are the major soil limitations in valleys. Soils with topographic and stoniness limitations were somewhat less severely rated in the fruit growing areas since these limitations are less restricting for fruit trees than for crops requiring continual cultivation.

65.6 (40.8) FLOATING BRIDGE across Lake Okanagan was constructed in 1958. Prior to that time motor vehicles and passengers crossed the lake on diesel powered ferries.

67.6 (42.0) CITY OF KELOWNA (pop. 51 356). The name Kelowna is a corruption of the Indian word meaning Grizzly Bear. As far as the white man is concerned, the history of the area dates back to the fur brigades in the early 19th century. Father Pandosy of the Oblate Order established a mission near the city in 1858. The apple trees he planted so thrived that in 1892 the first commercial orchards were planted. Today Kelowna is the focal point of the largest fruit growing district in Canada. The tour passes through Kelowna on Highway 97 and turns southeast to the tree fruit orchards on the benchlands of East Kelowna.

77.7 (48.3) KELOWNA SUBSTATION SITE: Eluviated Eutric Brunisol (See Appendix D)

This site is located at a Substation of Summerland Research Station. An Eluviated Eutric Brunisol on sandy glaciofluvial deposits (Fig. 50) will be examined. The tour then returns to the highway, going north toward Vernon.

95.0 (59.0) AIRPORT serving various centres in British Columbia, Alberta and northern Canada.

95.7 (59.5) RANGER STATION across the highway.

Soil development along this part of the route is similar to the Peachland, Westbank and Kelowna areas. Soils on sandy and gravelly glaciofluvial deposits at the lower elevations, where irrigated, are planted to tree fruits which include apples, pears, cherries and grapes. Only a few orchards of apricots and peaches are grown from Kelowna north. Above the irrigated lands are the open grassland and lightly forested lands which are used for grazing. The more productive forest lands occur above 1200 m.

The effects of glacial ice and meltwater action on the open hillsides on the east side of the valley are very noticeable.

97.3 (60.5) ELLISON LAKE - a shallow lake used for boating and swimming.

102.2 (63.5) WINFIELD - location of a distillery and a pleasure trailer manufacturing plant amidst the fruitlands.

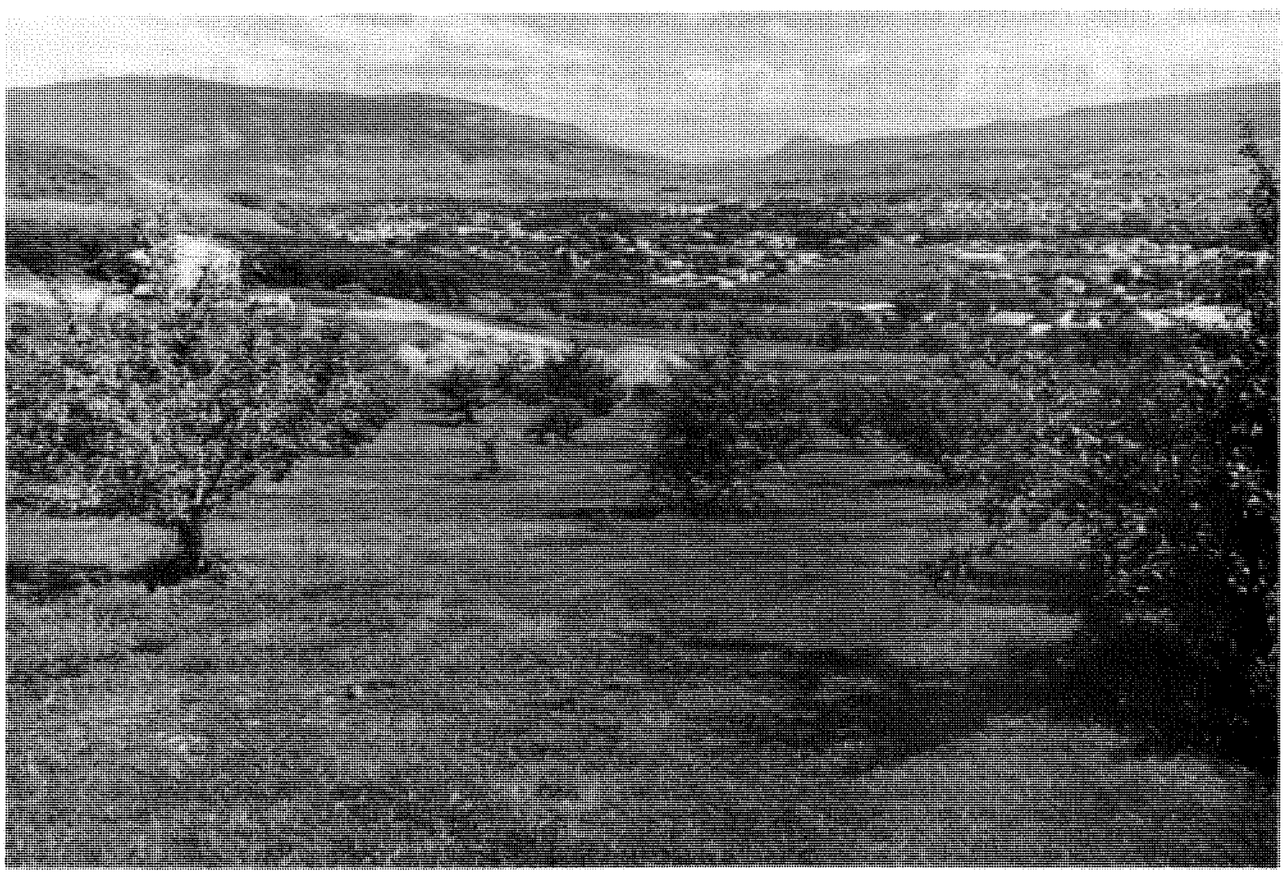
107.0 (66.5) WOOD LAKE - a popular recreation lake.

114.2 (71.0) KALAMALKA LAKE - extends northeastward for 16 km. On a clear sunny day the "colored waters" can be observed where greenish shallow waters near shore are contrasted with the bluish deeper waters of the main part of the lake.

129.0 (80.2) COLDSTREAM VALLEY lookout. Eastward over Kalamalka Lake is the Coldstream Valley which is the physiographic separation between the Shuswap Highland to the north and the Thompson Plateau and the more rugged relief of the Okanagan Highland to the south. Beyond and visible to the east (on a clear day) are the Monashee Mountains, a physiographic division of the Columbia Mountains.

Precipitation increases with an increase in elevation and also eastward towards the Monashee Mountains. As a result, soil development gradually changes from Chernozemic and the drier Eutric Brunisols to the wetter Dystric Brunisolic, Luvisolic and Podzolic soils. The latter soils produce the forests on which the majority of the timber is logged throughout the Interior. Above the lake the Black Chernozemic soils of the grasslands have been used as rangeland and for growing wheat under dry farming methods. Some of this land was formerly a military training ground that is now used for growing forage crops under the Vernon waste water management project.

136.8 (85.0) VERNON CITY (pop. 34 600) for overnight accommodation and meals. (Fig. 51)



Courtesy of British Columbia Government

FIG. 51 NEAR VERNON IN THE NORTH OKANAGAN

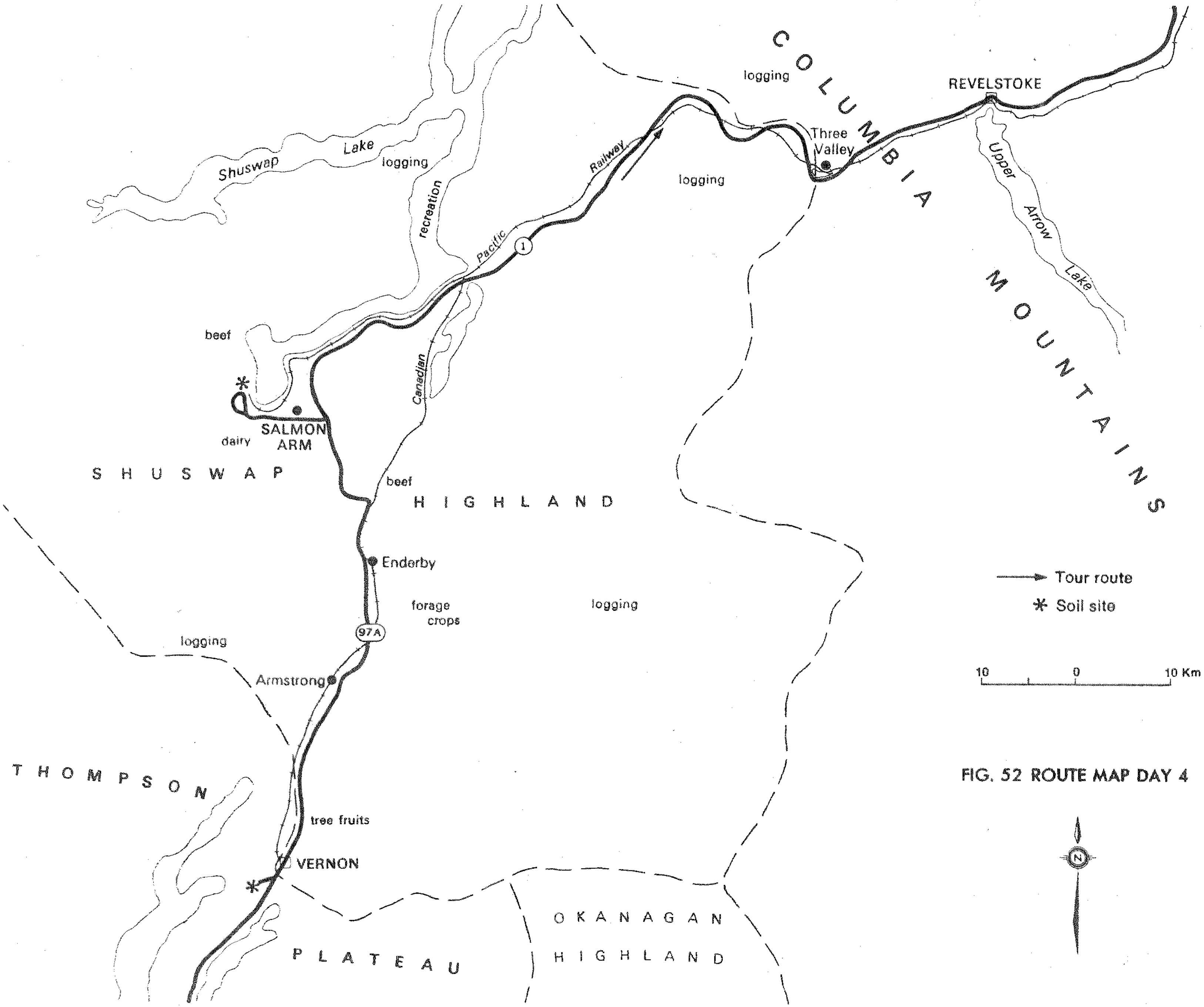


FIG. 52 ROUTE MAP DAY 4

DAY 4: VERNON TO REVELSTOKE

The tour returns a short distance south of Vernon to observe the Waste Water Management Project, examine a soil pit, and view the Vernon area from the Observatory Lookout. Noon lunch will be provided in Vernon. The tour then proceeds north on Highway 97 through the North Okanagan Valley to examine another soil near Salmon Arm on Shuswap Lake (Figure 52). It passes through the Shuswap Highland, ascends into the Monashee Mountains, and terminates at Revelstoke in the Columbia River Valley.

With the gradual disappearance of the dry open forests and range lands north of Vernon and an increase in annual precipitation, the vegetation and soil development change also. The Luvisols and Brunisols of the north Okanagan and Shuswaps give way to Podzols in the mountains.

Road Log 4: Vernon to Revelstoke (197 km)

Km (Miles)

0 (0) LEAVE Vernon for the Vernon Waste Water Management Project.

3.2 (2) WASTE WATER Project - a brief talk will be given by the Project Manager concerning the past development and current expansion of the project for the application of sewage effluent to land by the City of Vernon.

VERNON SITE: Orthic Black Chernozemic (see Appendix D)

The area used for the production of irrigated forage crops is mainly on till and glaciolacustrine materials (Fig. 53). The soil, an Orthic Black Chernozemic on till deposits, will be examined in one of the fields currently being irrigated and producing forage crops. Orthic Black Chernozemic soils occupy an extensive area near Vernon where they occur on till, glaciofluvial and glaciolacustrine deposits.

5.1 (3.2) WEATHER STATION, a short drive to the Upper Air Weather Station operated by the Atmospheric Environment Service for a view and pictures of the Vernon area.

Okanagan Lake is to the west, Kalamalka Lake to the south, Coldstream Valley to the east, Silver Star Mountain (Vernon's ski resort) to the northeast, and the North Okanagan Valley to the north.

The tour will then proceed north through Vernon following Highway 97 and 97B to Salmon Arm. Swan Lake, a small shallow lake, occurs north of Vernon along the highway.

20.8 (12.9) SPALLUMCHEEN LOOKOUT. According to early history much of the area to the northwest received early settlement, mainly due to the abundant grasslands which provided feed for livestock. Silty and clayey glaciolacustrine soils of the Vernon-Armstrong-Enderby area are currently used for dairying, grain and beef production. Soil development varies from Chernozemic to Luvisolic with the latter having developed under forest vegetation.

Soil capability under dryland conditions is Class 2 or Class 3 on glaciolacustrine materials, Class 2, 3, 4 or 5 on the glaciofluvial deposits, and Class 5, 6 and 7 on till. Limiting factors are adverse topography and soil factors on the better classes and topography, stoniness, and low moisture holding capacity on the poorer classes. Under irrigation, capability ratings usually increase one or two classes.

To the northwest, above the general level of the glaciolacustrine deposits, is a large kettled, sandy glacial outwash deposit with Chernozemic soil development. Extensive plantings of asparagus and other vegetables occupy parts of the deposit.

23.8 (14.3) WOOD PROCESSING PLANT. A modern operation that supplements farming in the valley.

31.0 (19.3) ARMSTRONG west of the highway. The city is in the floodplain of a postglacial Shuswap River channel carved through the glaciolacustrine deposits before the drainage reversed and went north to Shuswap Lake via its present drainage channel.

Glaciolacustrine deposits in the Armstrong area vary from heavy clays on the more level topography to medium-textured silts where the deposits have been eroded.

38.5 (24.0) OKANAGAN GREAT DIVIDE road sign. "You are now at the Okanagan Great Divide, height of land between Fraser River and Columbia River drainage basins. All surface water from this point flows north to the Fraser, south to the Columbia". B.C. Dept. of Recreation and Conservation.

43.6 (27.1) ENDERBY. A canal, to be used for irrigation and boating and which would link the Shuswap River with Okanagan Lake, has been contemplated in recent years but has proven to be too costly for the amount of arable land considered suitable for irrigation.

46.8 (29.1) LAVA BLUFFS of basalt and rhyolite of Ologocene or Miocene age can be observed northeast of Enderby.

As the route ascends from the glaciolacustrine and fluvial soils below 550 m a.s.l. in the Shuswap River valley, the soils are developed on sandy glaciofluvial deposits and on till on the mountain slopes. Below this elevation the glaciolacustrine deposits occur again near Salmon Arm.

52.4 (32.6) JUNCTION Highways 97A and 97B. The tour follows Highway 97B to Salmon Arm.

64.5 (40.1) JUNCTION of Highway 97B and Trans-Canada Highway. As the tour progresses westward on Highway 1 the first glimpses of Shuswap Lake can be seen to the north with Salmon Arm located on the south shore.

68.4 (42.5) SALMON ARM (area pop. 10 000). The Salmon River valley, located southwest of Salmon Arm, is used extensively for agriculture: mainly dairying, beef, cereal and forage crops. Other important factors in the local economy are tourism and the lumbering industry. Soil development is Regosolic

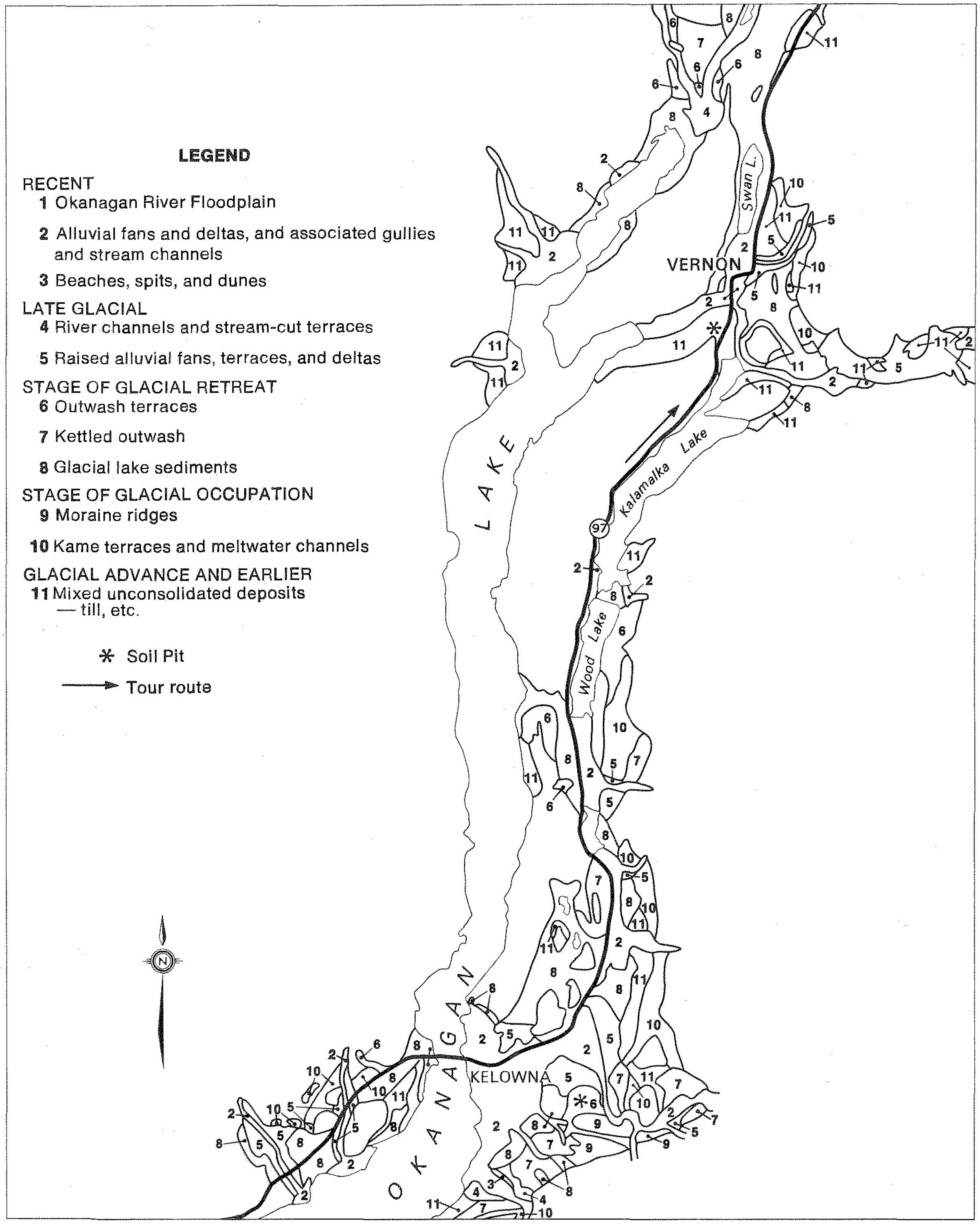
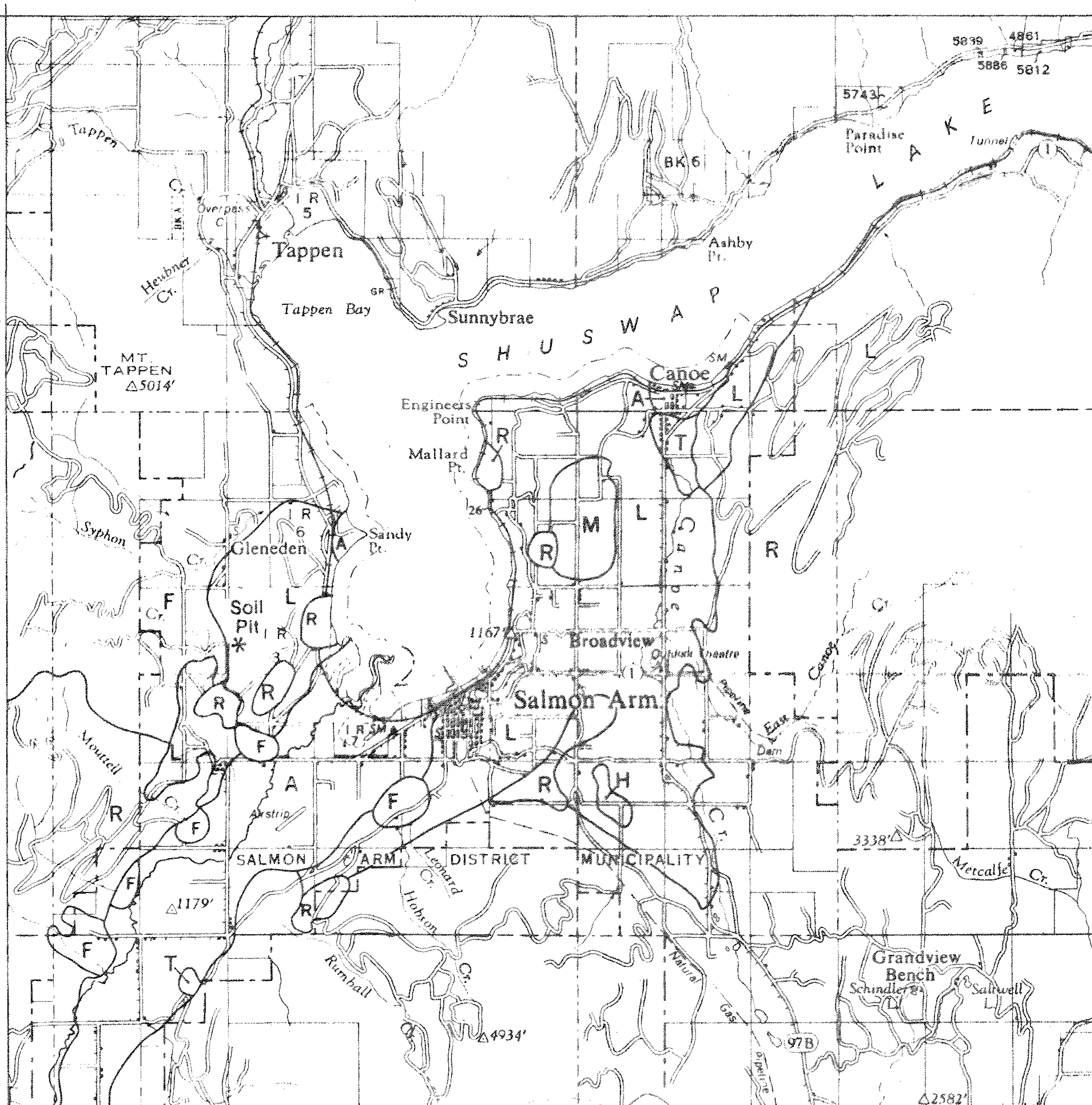


FIG. 53 SURFICIAL DEPOSITS OF NORTHERN OKANAGAN VALLEY (AFTER NASMITH, 1962)



LEGEND

A — Modern alluvium

H — Hummocky gravels

L — Lacustrine deposits undifferentiated

F — Fan deposits

M — Morainal deposits

T — Terraced deposits

R — Rock outcrop and areas of near-surface rock

FIG. 54 SURFICIAL GEOLOGY SHUSWAP LAKE AREA (AFTER R. J. FULTON, 1969) or Gleysolic with inclusions of Organics and Brunisolics. Soil Capability varies from 2X to 4M under dryland conditions with scattered areas of 5^{M}_{P} and 6I.

As the tour leaves the Trans-Canada Highway and the floodplain deposits of the Salmon River (Fig. 54) the soils change to glaciolacustrine deposits with the heavy clays at the lower elevations and the silty soils at between 455 and 550 m a.s.l. The main farming areas on these soils occur to the northwest.

75.8 (47.1) SALMON ARM SITE: Orthic Gray Luvisol (see Appendix D)

This soil is developed on silty glaciolacustrine deposits. Bedrock in the vicinity is variable - limestone occurs to the north and east, granite to the west, and a mixture of granites, metamorphics, and basaltic and rhyolitic flows to the south.

Large gravel pits have been excavated directly west of the soil site in deposits which are a mixture of glacial outwash and colluvial fans.

Soil development on the mountain slopes in the general area of Salmon Arm varies from Luvisolic to Brunisolic with Podzols at the higher elevations above 1200 m a.s.l.

Slash burning on the mountain highland to the west of the soil site resulted in an extensive forest fire in 1973 which terrorized the farming area and the city and caused extensive damage. The burn area was seeded to a mixture of grasses and legumes to provide grazing for cattle and wildlife. After examining the soil pit the tour returns through Salmon Arm and proceeds east and north on Highway 1.

99.3 (61.7) CANOE is the site of a cooperative lumber and plywood mill. This large industry ships lumber to outlets in the 4 western provinces. Mount Bastion, across the lake to the north, is mainly limestone.

112.3 (69.8) SHUSWAP LAKE LOOKOUT road sign. "Lake of the Shuswap. This beautiful lake takes its name from the Shuswap Indians northernmost of the great Salishan family, the largest tribe in interior B.C. Once numbering over 5000, these people were fishermen and hunters; they roamed in bands through a vast land of lakes and forests stretching 150 miles (240 km) to the west, north and east." B.C. Dept. of Recreation and Conservation.

The mountains and slopes adjoining Shuswap Lakes produce good forests for the lumber mills in the Salmon Arm area. A wide variety of conifers make up the forest stands. Distinctive species are Rocky Mountain Douglas Fir, Western Hemlock, Western Red Cedar, Western Larch, and Western White Pine. Ponderosa Pine disappears from the stands under increasing moisture conditions.

120.0 (74.6) SICAMOUS. This small community is often referred to as being the gateway to the Okanagan Valley. Tourist traffic enroute to Vancouver follows either Highway 97 through the Okanagan or remains on Trans-Canada Highway 1 through the Fraser Canyon.

138.8 (86.2) HEMLOCK along the roadside are good indicators of the Interior Western Hemlock zone.

Mara Lake can be seen to the south. Good farming lands are found in the Shuswap River valley between Enderby and the south end of Mara Lake. The valley narrows east of here, greatly restricting any form of agriculture.

145.8 (90.6) CRAIGELLACHIE road sign. "The last spike. A nebulous dream was a reality; an iron ribbon crossed Canada from sea to sea, often following the footsteps of early explorers. Nearly 3000 miles (4800 km) of steel rail pushed across the vast prairies, cleft lofty mountain passes, twisted through canyons, and bridged a thousand streams. Here on Nov. 7, 1885 a plain iron spike welded east to west." B.C. Dept. of Recreation and Conservation.

172.2 (107.0) THREE VALLEY LAKE. Near here the Eagle and Wap rivers to the south form the physiographic boundary between the Shuswap Highland to the west and the Monashee Mountains to the east. Note snowsheds protecting the railway.

176.8 (109.9) EAGLE PASS is the height of land between the Shuswap and Columbia drainages. "In 1865 Walter Moberly, a government engineer was searching for a railway route through these rugged Monashee Mountains. He shot at an eagle's nest and observed the birds fly into a river valley. Following them he discovered this low pass which now carries the main line of the C.P.R." B.C. Dept. of Recreation and Conservation.

191.6 (119.1) COLUMBIA RIVER crossing to Revelstoke. The Columbia is the fourth largest river in North America, exceeded only by the Mississippi, Mackenzie, and St. Lawrence rivers in total flow. Of the total drainage basin of 670 800 km^2, 102 500 km^2 are in Canada. The river flows north from Columbia Lake in the Rocky Mountain Trench, swings around the Big Bend, then continues south through the Arrow Lakes to the International Boundary. It travels some 800 km through Canada and about 1200 km through the United States to the Pacific Ocean.

The 1961 Columbia River Treaty between Canada and the United States provided cooperative arrangements for the construction of three storage dams in British Columbia. These storage projects for power and flood control were completed in 1973. The full potential of the Columbia River and its tributaries is estimated to be about 48 million kW, of which 40 million are in the U.S. and approximately 7.8 million kW are in Canada. Source: B.C. Hydro and Power Authority.

196.9 (122.4) REVELSTOKE (pop. 6500) where overnight accommodation and meals will be provided. This city is named after Lord Revelstoke who was head of the firm which financed the completion of the Canadian Pacific Railway.

In January, 1977 B.C. Hydro awarded the first major construction contract on the Revelstoke Dam. This new hydroelectric project will be sited at Little Dalles Canyon about 5 km upstream of Revelstoke. The dam, which will use water stored in the McNaughton Lake reservoir, is designed to provide for an ultimate generating capacity of 2.7 million kW.

The partial flooding by the proposed reservoir of a large rock mass, the Downie Slide, located some 65 km north of Revelstoke, has been the subject of much controversy. The slide will be stabilized by a drainage system to relieve hydrostatic pressure.

DAY 5: REVELSTOKE TO GOLDEN

After a film presentation on avalanche control, the tour returns to the Trans-Canada Highway to travel eastward into the Selkirk Mountains. The route skirts the southern perimeter of Mount Revelstoke National Park and gradually climbs in elevation to Glacier National Park.

Lunch will be provided at Rogers Pass summit in the park. From the summit the route gradually descends into the Rocky Mountain Trench and the Columbia River Valley. After examining a soil in the Trench the tour leaves for Golden and overnight accommodation.

Road Log Day 5: Revelstoke to Golden (144 km)

Km (Miles)

Following breakfast the senior avalanche forester will give a talk and present a slide show on avalanche control.

0 (0) LEAVE Revelstoke for Golden on Highway #1.

2.4 (1.5) JUNCTION Trans-Canada Highway

4.7 (2.9) REVELSTOKE NATIONAL PARK Junction - a steep winding road ascends into the Park to Mt. Revelstoke Summit (2240 m a.s.l.). The tour continues on highway 1.

12.1 (7.5) WESTERN HEMLOCK and WESTERN RED CEDAR forest - mature stands on Podzolic soils developed on till and colluvium.

20.1 (12.5) ENTER Revelstoke Park. The present park was originated by Revelstoke people and became established in 1914 in the Selkirk Mountains as a prime example of beautiful alpine scenery.

The highway skirts the southern perimeter of the park as it follows the Illecillewaet River valley and the Canadian Pacific Railway line into the mountains.

32.0 (20.2) SNOWSHEDS - Three snowsheds over the next 1½ km were build to deflect avalanches across the highway. Note the abundance of Western White Pine in this area, near the boundary between the Interior Western Hemlock and the Engelmann Spruce-Subalpine Fir zones. Western White Pine is very productive but is highly susceptible to white pine blister rust.

45.0 (28.0) GLACIER NATIONAL PARK west gate. This park was established in 1886 after the railway was built over Rogers Pass.

55.5 (34.5) AVALANCHE slopes. There are about 90 avalanche sites along the highway between the east and west gates of Glacier National Park.

61.0 (37.9) CONNAUGHT TUNNEL west portal. This tunnel, about 8 km long, was opened in 1916 to bypass the steep grade through Rogers Pass.

64.4 (40.0) CEREMONIAL CENTRE at Rogers Pass Summit (1300 m). An active avalanche slope lies directly across the road.

65.6 (40.8) NORTHLANDER HOTEL, built after completion of the highway through

Rogers Pass in 1962. Headquarters for avalanche control and snow removal are located near here. This will be a lunch stop.

69.2 (43.0) SNOWSHEDS for 2 km.

72.4 (45.0) CONNAUGHT TUNNEL east portal. Here the Beaver Valley forms the physiographic boundary between the Purcell and Selkirk mountains.

85.3 (53.0) GLACIER NATIONAL PARK - east gate. Time zone change - watches should be set ahead one hour. Logging occurs on the mountain slopes outside the park boundary. Agriculture is confined to the Rocky Mountain Trench, south to the 49th parallel.

101.4 (63.0) REFORESTATION, a logged area that was replanted in 1973.

106.2 (66.0) ROCKY MOUNTAINS - a good view eastward of the Rockies on the descent into the Rocky Mountain Trench.

116.6 (72.5) COLUMBIA RIVER here flows northward from its source in Columbia Lake.

121.5 (75.5) ROCKY MOUNTAIN TRENCH - a good view of the Trench to the south where the meandering Columbia River has established a floodplain with calcareous Gleysolic and Regosolic soils. Many hanging valleys, indicative of the action of glacial ice and subsequent river erosions, occur in the trench.

133.5 (83.0) JUNCTION of Highway 1 and Hartley Road - the tour route leaves the highway and ascends to the glacial deposits at higher elevations in the Trench.

134.5 (83.6) GOLDEN SITE: Brunisolic Gray Luvisol (Appendix D)

This soil is developed on calcareous till. The depth of leaching is shallow on the parent materials derived from the calcareous bedrock of the Columbia and Rocky Mountain ranges. Soil development in the general area, depending largely on the parent materials, is Brunisolic or Luvisolic. Agricultural capabilities range from Class 3 to 6 in the Trench. Agriculture consists mainly of small mixed farms which produce beef and forage crops.

After the soil profile has been examined the tour proceeds to Golden.

144.8 (90.0) GOLDEN for dinner and overnight accommodation.

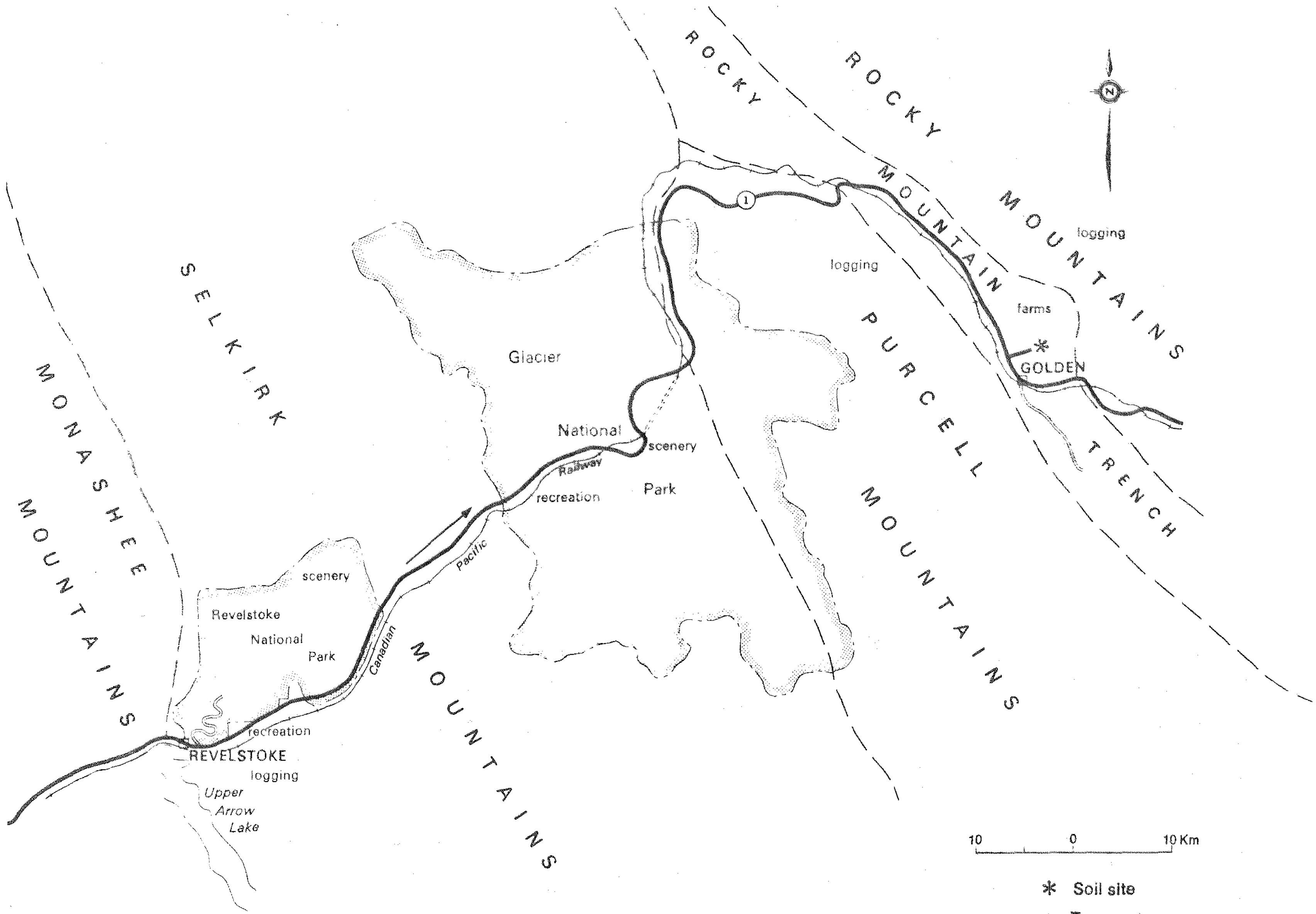


FIG. 55 ROUTE MAP DAY 5

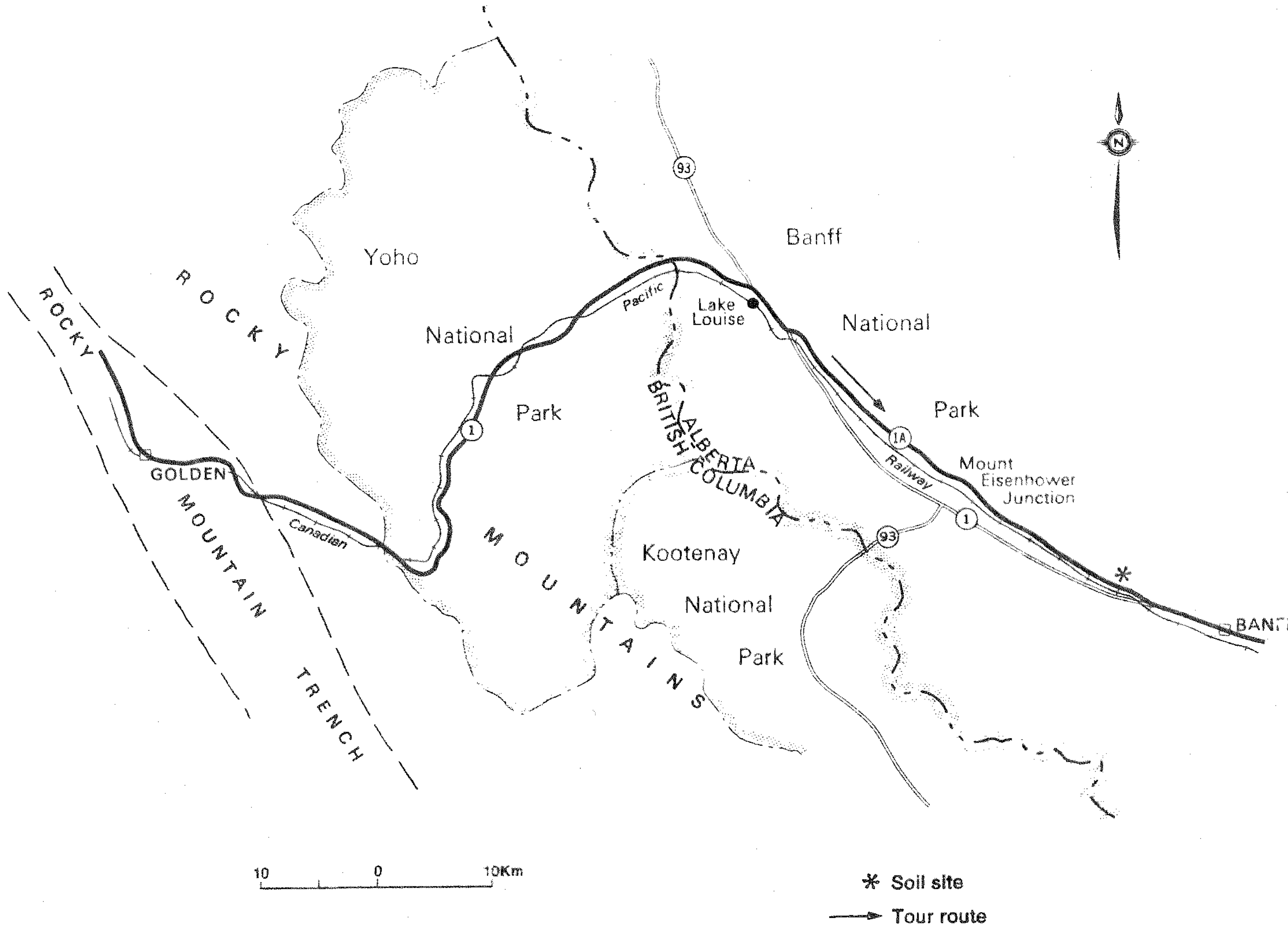


FIG. 56 ROUTE MAP DAY 6

DAY 6: GOLDEN TO BANFF

The tour continues on the Trans-Canada Highway east through Yoho National Park to cross the Continental Divide into Alberta (Figure 56). There will be a lunch stop at Lake Louise. The route then is along Highway 1A to Banff with one soil stop en route. The schedule allows for an early afternoon arrival at Banff to permit sight seeing.

Road Log, Day 6: Golden to Banff (160 km)

Km (Miles)

0 (0) LEAVE Golden to follow the Kicking Horse River eastward on the Trans-Canada Highway. The highly eroded bedrock formations combined with extremely steep valley walls cause many problems in road building and maintenance.

33.8 (21) YOHO NATIONAL PARK entrance. The 1313 km^2 area of the present park is centred on the Kicking Horse Pass. The valley area near the town of Field was used by Indian hunting parties long before the white man sent his surveyors and engineers to lay track for the Canadian Pacific Railway in 1884.

49.9 (31) GENERAL SOILS MAP. Figure 57 shows the soils and bioclimatic zone of the Kicking Horse valley in Yoho National Park.

52.6 (32.7) BRAIDED RIVER viewpoint. "The Kicking Horse River Valley. Here the Kicking Horse River winds over the flat floor of its valley below you. During high water stages it deposits sand and silt over the flooded areas raising the level of the meadows and filling the old abandoned channels". B.C. Dept. of Recreation and Conservation.

59.5 (37.0) MAINTENANCE HEADQUARTERS.

61.8 (38.4) EMERALD LAKE road. The town of Field across the valley is a railway switching yard and divisional point on the Canadian Pacific Railway.

68.2 (42.4) TAKAKKAW FALLS. Time permitting, the tour will take the 25 km round-trip to view the spectacular falls and watch a train go through the spiral tunnel.

72.4 (44.9) SPIRAL TUNNEL. Viewpoint of the lower spiral tunnel.

74.6 (46.4) WAPTA LAKE.

77.9 (48.4) JUNCTION - old highway to Lake Louise.

80.4 (50.0) THE GREAT DIVIDE at Sink Lake (1623 m) "Waters flowing from the west fork of Divide Creek reach the Pacific Ocean via Kicking Horse and Columbia rivers. Waters flowing from the east fork of Divide Creek reach the Atlantic Ocean via the Bow and Saskatchewan rivers, Lake Winnipeg, Nelson River and Hudsons Bay."

87.8 (54.6) JUNCTION highway to Lake Louise.

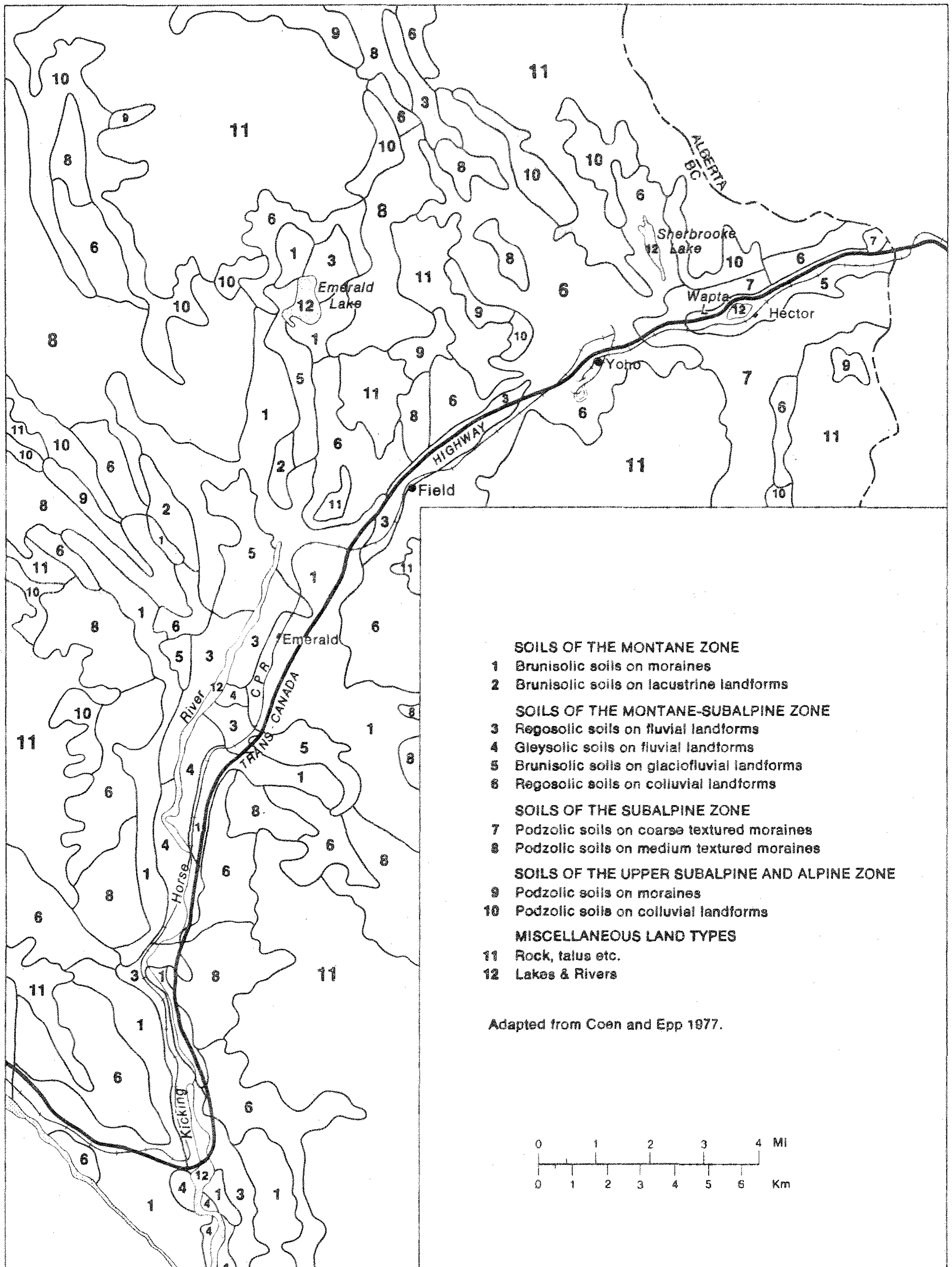


FIG. 57 GENERAL SOILS MAP OF YOHO NATIONAL PARK

88.5 (55.0) LAKE LOUISE. Lunch and sight seeing. The elevation here is 1730 m. Leave Lake Louise and proceed toward Banff.

CROSS Trans-Canada Highway to Highway 1A.

93.8 (58.3) PROTEROZOIC ROCKS exposed here are some of the oldest in the park and were deposited as sediments about 600 million years ago.

94.4 (58.7) CORRAL CREEK fluted moraine area.

103.3 (64.2) TERRACE. For the next few km the tour travels over fluvial terrace materials deposited during the waning of the last glaciation. The weakly developed Brunisolic soils have an intermittent Ae horizon. Well-rounded gravels and cobbles constitute a major portion of the solum.

103.8 (64.5) BAKER CREEK (Fig. 58)

105.2 (65.4) MEADOWS such as this are important habitat for ungulates. From pellet group counts this is one of the most intensely used meadows in the Bow Valley (Courtney, Stelfox and McGillis, 1975).

106.8 (66.4) PROTECTION MOUNTAIN CAMPGROUND. This campground is situated on a large gently sloping calcareous fluvial fan. The central part of this fan is characterized by Regosols and the margins by Brunisols.

From the next 30 km the route will be traversing the lower slopes of the Sawback Range (Fig. 59). For most of the distance the till along the base of these slopes is covered with coalescing fluvial fans of varying steepness. Sediments derived from the limestone and dolomitic rocks of the Sawback Range are very calcareous (often greater than 30% $CaCO_3$ equiv.). High amounts of $CaCO_3$ in both the tills and fluvial sediments retard soil horizon development, and sola are generally less than 50 cm thick. Also, on most of the fans geologic erosion and deposition is sufficiently active to prevent soil horizon development, resulting in soils classified as Regosol.

110.1 (68.4) TILL. On the north an exposure reveals the calcareous stony silt loam nature of the compact tills characteristic of the Bow Valley.

On the south is a panoramic view of the Bow Valley showing the floodplain, terraces, dissected fluted moraines, fluvial fans and inclined moraines.

118.4 (73.6) EISENHOWER JUNCTION. The castellate peaks of Mount Eisenhower (2770 m) can be seen to the north. This mountain was originally named Castle Mountain in 1858 by Dr. James Hector, geologist and physician with the Palliser Expedition. The Castle Mountain syncline is a major structure that extends for 200 km to the northwest.

118.6 (73.7) WARDEN'S CABIN. Park wardens are charged with enforcing park regulations and managing the natural resources. Cabins are distributed throughout the parks, about a day's ride by horseback apart.

119.7 (74.4) SILVER CITY. Between 1883 and 1885 up to 2000 residents lived in a shanty town on this location. They came to get rich, mining copper and lead (mainly in the form of galena) from Copper Mountain on the far side of the valley. Only very limited amounts of ore were found, and the town quickly disappeared.

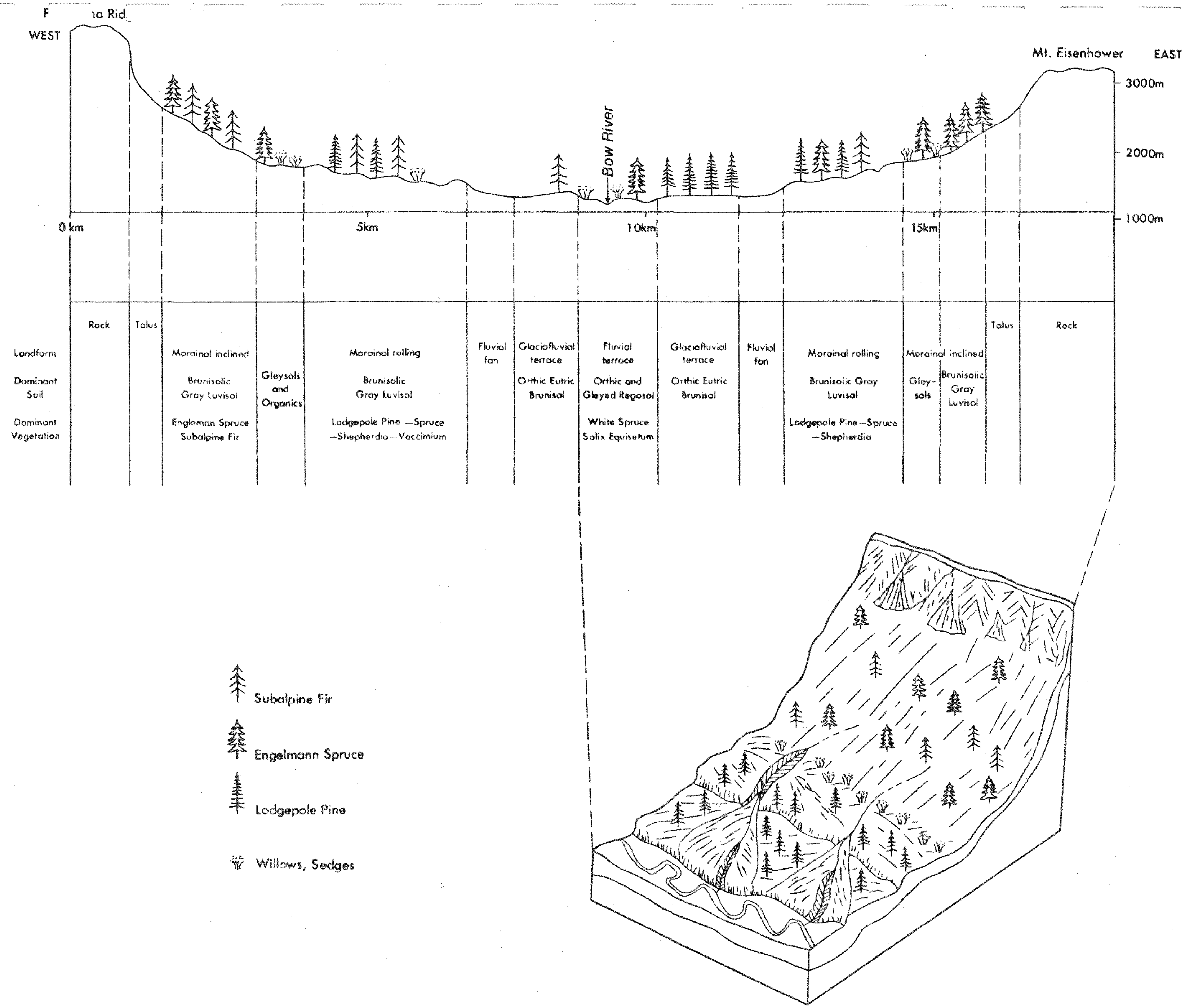


FIG. 58 CONCEPTUAL CROSS-SECTION OF THE GENERALIZED LANDFORMS AND SOILS OF THE BOW VALLEY AT BAKER CREEK.

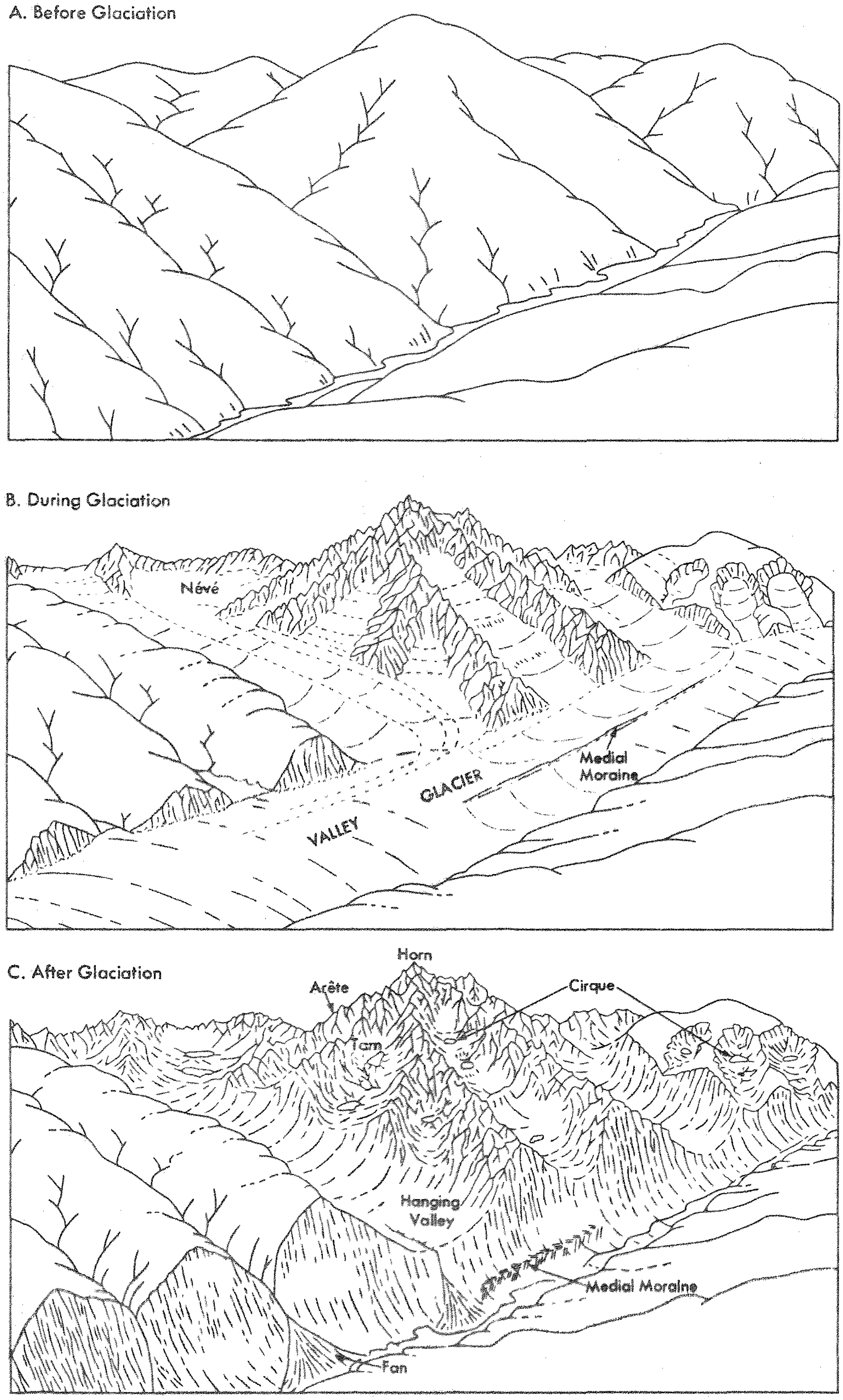


FIG. 59 LANDSCAPE EVOLUTION UNDER ALPINE GLACIATION
(Adapted from Strahler, A.N. (1960) Physical Geography
J. Wiley & Sons, New York)

123.9 (77.0) WILDLIFE EXCLOSURE to the south demonstrates the influence of wildlife on vegetation. The nearly flat area is an example of Gleysolic soils. These soils have the typical mottling associated with a high water table of stagnant water. In mountain terrain many soils are saturated for extended periods but do not exhibit prominent mottling or gleying. These occur in situations where the slopes are steep and water is moving through the soil quickly. It is felt that there are probably high levels of oxygen in the water effectively preventing reducing conditions.

124.9 (77.6) JOHNSTON'S CREEK - Campground and tourist facilities. You will probably note as we travel for the remainder of the day that almost all facilities and developments occur on fluvial fans. This is because the creeks to which the fans owe their origins provide the water required by man and the most level, adequately drained land also occurs here. It may not be as evident that ungulates and other wildlife depend upon the fan habitat for an important portion of their food and shelter. Man and the wildlife he is trying to protect are in direct competition for the same piece of land. The National Parks are currently conducting Natural Resource Inventories, and follow-up studies to arrive at the most acceptable solution to the conflict between man and wildlife.

129.4 (80.4) LANDSLIDE. The hummocky terrain was created by a landslide which probably occurred about 10 000 years ago, at the close of the Wisconsin glacial period. Strong weathering of the materials and a well developed soil profile are evidence that the slump has been stable for an extended period. This is a transition area from Subalpine to Montane vegetation zones. Elevation is about 1410 m. For the next several km we will be passing through stands of Douglas Fir (on dry exposed sites) and Trembling Aspen. Lodgepole Pine is common throughout both zones.

131.0 (81.4) SPRUCE in middle of road. When the road was widened in the 1930's this majestic White Spruce was saved. It provides a convenient example of the kind of vegetation that might flourish if the area was protected from fire for a long period.

131.9 (82.0) WAPITI. The black scars on the trunks of the trees resulted in the early 1940's when wapiti (elk) suffered a food shortage due to over-crowding and resorted to eating aspen bark.

133.5 (83.0) EXPERIMENTAL RANGE PLOT on the west. This exclosure shows the marked increased growth in trees and shrubs when they are protected from browsing ungulates.

135.6 (84.3) FAN. We are now proceeding across the toe of a large gently sloping fluvial fan. Textures on these gently sloping landforms are non-gravelly silt loam and the soils are calcareous to the surface. The dolomitic fine earth materials are often so little weathered that they do not immediately effervesce with cold 10% HCl even though they may have a lime content of 40% $CaCO_3$ equivalent.

To the south is an example of the organic soils associated with the larger mountain valleys. Here also the lower margins of fluvial fans characterize the lower slopes of the valley walls.

137.4 (85.4) MULESHOE SOIL SITE: Eluviated Eutric Brunisol (see Appendix D)

The weakly developed soil is located on a medium-textured fluvial fan derived from highly calcareous bedrock. The stream that periodically provided fresh sediments has not migrated over this section of the fan for an appreciable period, allowing the formation of thin, fairly distinct horizons.

142.1 (88.3) GLEYSOLS. To the west there is an area of wet soils. In the National Parks wet areas of this kind occur mainly along creek and river margins, and thus are of small size and limited areal extent.

142.9 (88.8) JUNCTION with Trans-Canada Highway.

145.1 (90.2) VERMILION LAKES LOOKOUT. To the west on the floodplain of the Bow River, there is an area of Organic soils. In general there are few areas of Organic soils in the front and main ranges of the Rockies, and those areas that do occur are of small areal extent. The example here is one of the largest in Banff Park.

146.4 (91.0) BIGHORN LOOKOUT. There is a restricted watershed area to the north where Banff townsite obtains its domestic water.

In 1976 the speed limit along this section of highway was reduced from 96 km/hr to 65 km/hr, and stopping along the highway was forbidden. When motorists could no longer stop to feed the sheep that habitually begged in this area the sheep soon left. The reduced numbers of bighorn sheep on the highway resulted in fewer road "kills", both animal and human.

148.2 (92.1) JUNCTION of Mt. Norquay and the Trans-Canada Highway. Mt. Norquay is the site of an Olympic-sized ski jump, as well as a popular ski area.

Proceed into the town of Banff.

DAY 7: BANFF TO JASPER

The first 55 km of Day 7 will be along the Trans-Canada Highway from Banff to Lake Louise (Figure 60). West of Lake Louise the route heads north on the Icefields Parkway (Highway 93) through spectacular high mountain scenery to Jasper. Stops will be made to examine a soil pit and eat lunch at Bow Pass; and to visit Athabasca Glacier.

Road Log No. 7: Lake Louise to Jasper (234 km)

Km (Mile)

0 (0) JUNCTION of Trans-Canada Highway (1) and the Icefields Parkway (93) west of Lake Louise. The rock exposed at the roadside was formed over 600 million years ago in Precambrian times.

2.7 (1.7) HERBERT LAKE, a sink lake without a visible outlet.

3.9 (2.4) KICKING HORSE PASS. To the southwest can be seen a break in the mountain chain forming the boundary between Alberta and British Columbia. This notch is the Kicking Horse Pass through which the tour passed on the previous day. The crest of the pass at 1625 m is the highest point on these national transportation links and divides the Pacific watersheds from the waters flowing to Hudson's Bay. The pass was named by geologist Dr. James Hector who was kicked by a pack horse while exploring the area in 1858.

5.0 (3.1) ICE CONTACT STRATIFIED DRIFT can be seen exposed in the road cuts. These glacial materials, deposited from fast running melt water, generally occur in pockets of limited areal extent, along the sides of the valleys and at the confluence of valleys. These deposits generally show deeper soil development than the adjacent till materials.

7.1 (4.4) THE WAPUTIK RANGE to the west forms the boundary between Alberta and British Columbia, dividing westward-flowing waters from eastward-flowing waters. Waputik is the Stony Indian word for white Rocky Mountain Goat.

17.2 (10.7) HECTOR LAKE (1740 m) and Mt. Hector (3400 m) to the east were named after Dr. James Hector, surgeon and geologist to the Palliser Expeditions about 1858. Mt. Hector consists of Proterozoic and Lower Cambrian quartzites and Mid-Cambrian carbonates.

19.2 (12.0) TALUS SLOPES, cirques and hanging valleys can be seen across Hector Lake. The most northerly stands of Alpine Larch found in the Rockies grow near the southern end of the lake. The larches are the only deciduous conifers found in Canada. In autumn, their needles turn a golden color providing an outstanding contrast to the associated Alpine Fir.

23.3 (14.6) NO SEE UM CREEK. A "No See Um" is a small biting black fly.

24.5 (15.3) MOSQUITO CREEK is named after another biting insect.

27.7 (17.3) TRANSITION into the upper portion of the subalpine vegetation zone. Elevation is about 1940 m. Vegetation is characterized by Engelmann Spruce, Alpine Fir and Grouseberry. Fire has resulted in a proliferation of Lodgepole Pine in some areas.

29.1 (18.2) HELEN CREEK.

31.9 (20.0) SEEPAGE. Downslope, to the west, are fairly extensive areas affected by seepage. While large areas of sloping wet soils do not occur frequently in these mountains, when they do occur they greatly influence land use. The horizontal pipes sticking out of the road cuts attest to road construction and stability problems. Trails built on these soils have specific construction requirements. Vegetation and associated wildlife are also affected. Resource inventories underway in the National Parks are attempting to delineate these and other types of areas in order to assist in planning and land management.

32.7 (20.4) IGNEOUS ROCKS. The road cut through the rock on the east has exposed one of the few examples of igneous rocks in the Rockies, and the only known example in Banff National Park. This small dyke of diorite was extruded into the sedimentary layers millions of years ago and has since been uplifted and exposed.

33.6 (21.0) CROWFOOT GLACIER to the west.

34.8 (21.8) BOW LAKE (1980 m). The Bow River drops approximately 500 m to Banff townsite. As the road passes Bow Lake, the headwaters of the Bow River can be seen in the spectacular view of the Bow Glacier.

36.7 (22.9) NUM-TI-JAH LODGE Access Road. The first lodge was built here by the pioneer outfitter and guide, Jimmy Simpson, in the 1920's. Before the construction of the Icefields Parkway (the original road was started in 1931 and completed in 1940) the only access to the lodge was by a twisting horse trail from Lake Louise.

37.8 (23.6) WET MEADOW. To the west is an example of a wet meadow in an upper subalpine environment. The soils in these meadows are saturated to the surface for much of the year. There is little evidence of profile development except for a turfy and organic rich Ah (which may be absent in places) and mottles below. The severity of the micro-climate in these "frost pockets" is thought to prevent forest cover from establishing even though these meadows are below the tree line.

41.4 (25.9) BOW SUMMIT (2070 m, Figure 61)

Bow Pass Site: Orthic Humo-Ferric Podzol (Appendix D)

At this point the tour will take a 1.1 km side trip to Peyto Lookout where there is a spectacular view of Peyto Lake (Figure 61a). If the snow has melted, an opportunity will be provided to examine a Podzolic soil developed on calcareous till at 2130 m. The few trees in the vicinity are mainly Alpine Fir, while the main shrubs are Cream and Red Mountain-heathers.

44.3 (27.7) MISTAYA MOUNTAIN VIEWPOINT (Mistaya is the Cree word for grizzly bear). Excellent examples of well-developed cirques can be seen to the west. These and other features of mountain glaciation abound in this portion of the parks.

48.6 (30.4) SNOWBIRD GLACIER. Note the unvegetated moraines beside and in front of the glacier. These moraines indicate the extent of a previous glacial advance.

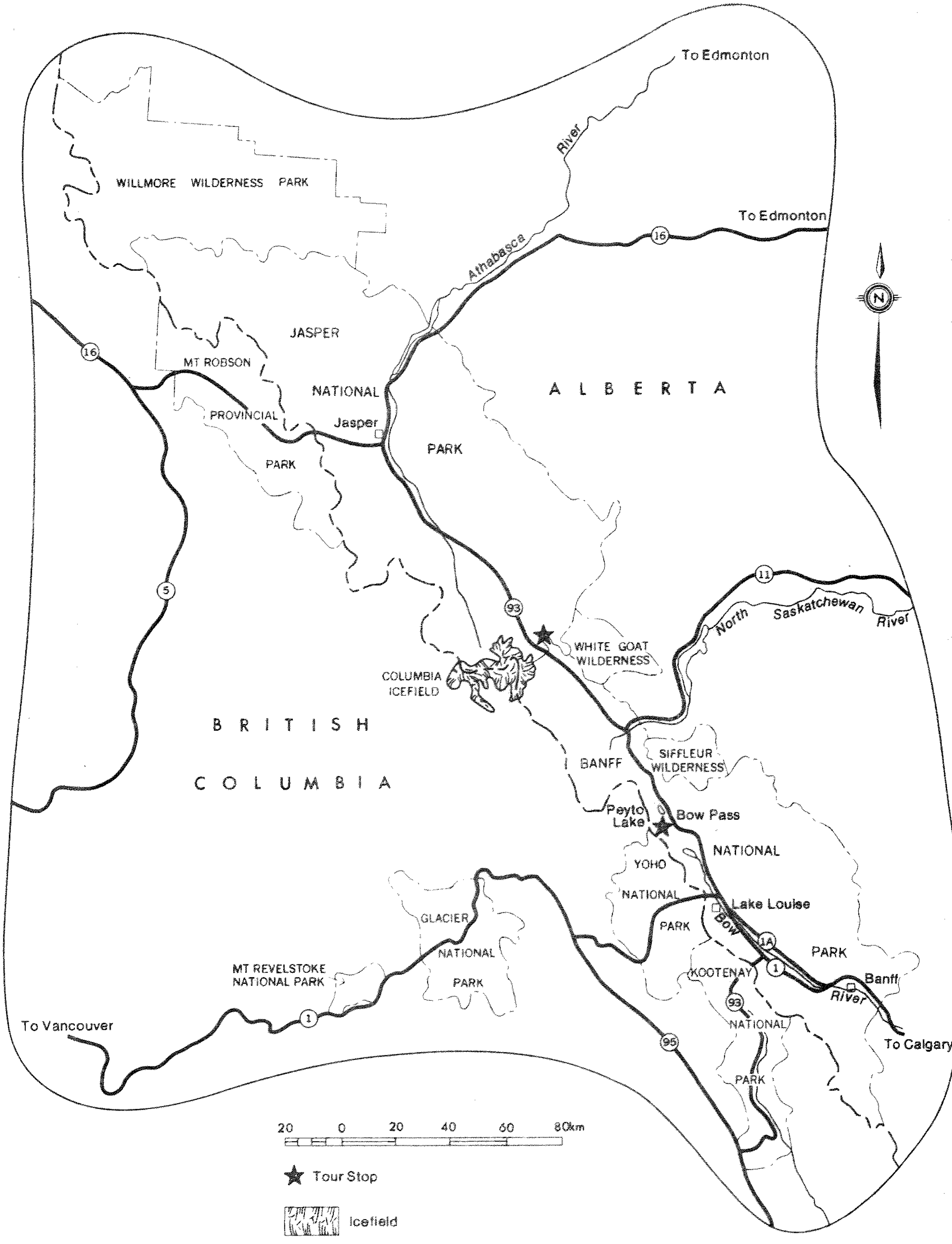


FIG. 60 ROUTE MAP DAY 7

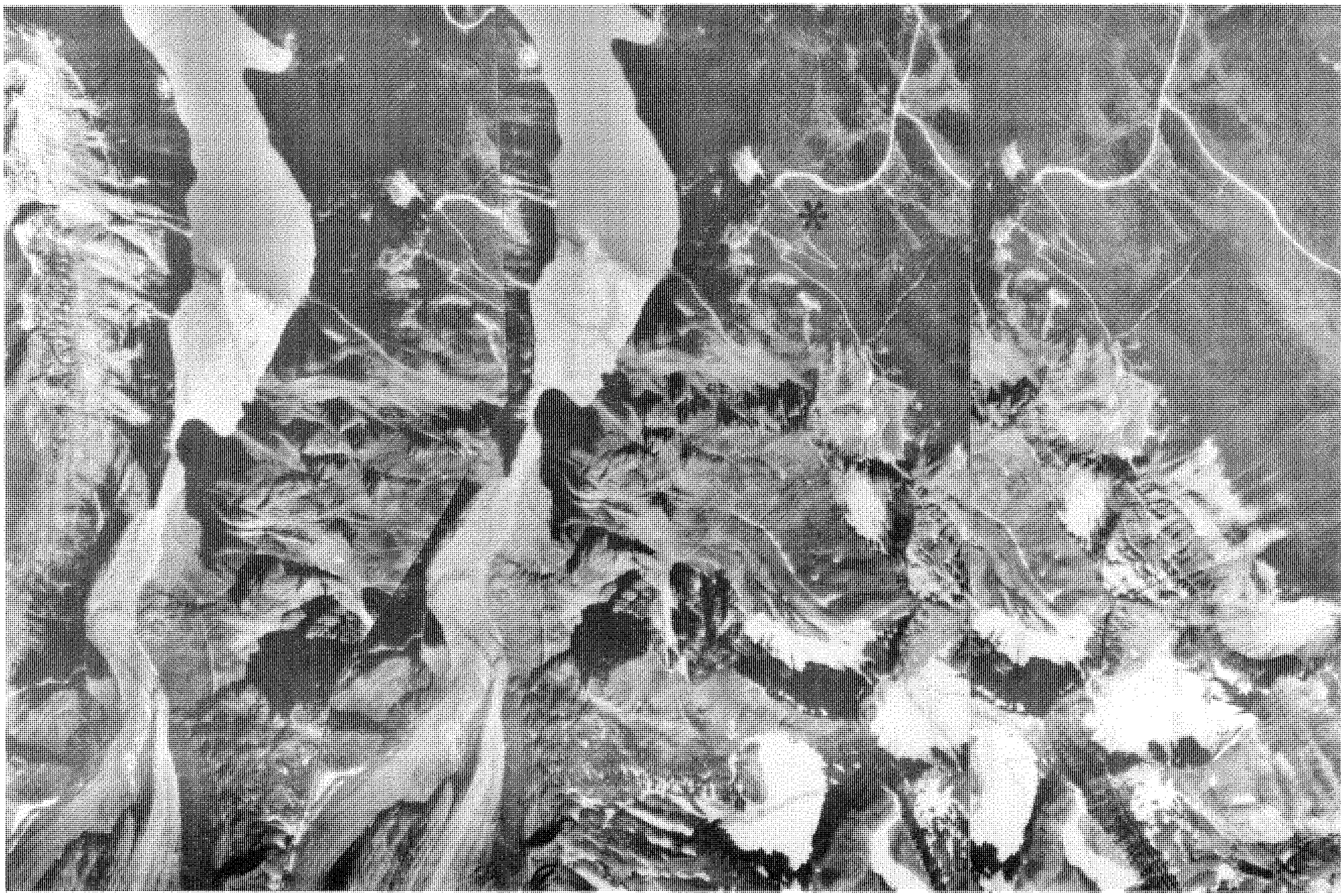
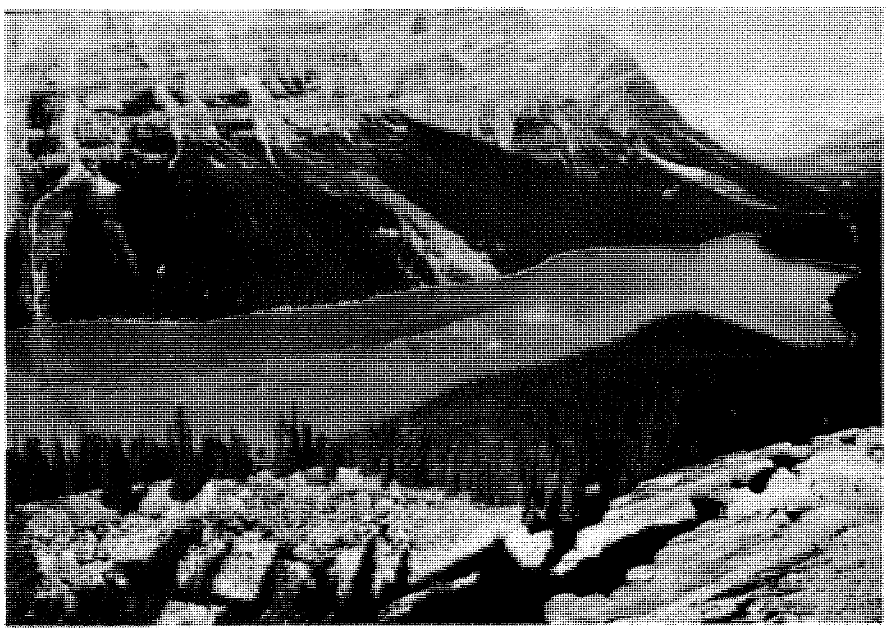


FIG. 61 Stereogram of the Bow Pass area. Soil pit location marked with *. (Alberta Govt. Photos AS162, 165-167)



Photograph by G. Coen

FIG. 61a PEYTO LAKE

52.5 (32.8) SILVERHORN CREEK.

53.1 (33.2) BARBETTE GLACIER to the southwest.

56.8 (35.5) UPPER WATERFOWL LAKE (1650 m). The landscape around this lake is typical habitat for moose. This majestic mammal is found throughout the boreal forests in Canada, especially where marshy and boggy areas are common. A bull moose weighs about 450 kg and will consume approximately 25 kg of aquatic plants and twigs a day.

57.8 (36.2) NORPE CREEK.

58.7 (36.7) LOWER WATERFOWL LAKE. Mount Chephren (3265 m) is the dominant mountain to the west of the lake. The upper half of this mountain is composed primarily of gray Cambrian-aged limestone whereas the lower half is comprised of slightly older quartzites. This valley runs down the axis of what was once a great anticline created when the Rockies were uplifted some 70 million years ago. Since then, the crest of the arch has eroded away leaving only the remnants we see as mountain ranges on either side.

66.8 (41.7) TOTEM CREEK. The Mistaya River runs alongside the highway on the west.

75.8 (47.4) WARDEN STATION and bridge crossing the North Saskatchewan River. Volcanic ash exposed in the river bank has been identified as belonging to three different eruptions (Westgate and Dreimanis 1967). The widespread occurrence of ash mixed with the silty surficial deposits throughout the Rockies appears to strongly influence pedogenesis (Pettapiece and Pawluk 1972). The easily-weathered minerals in the ash release iron and aluminum more readily than the minerals from local sources, thus a change in morphological expression between pedons does not necessarily indicate a change in weathering intensity.

77.7 (48.6) JUNCTION WITH THE DAVID THOMPSON HIGHWAY to Red Deer, a distance of 265 km.

79.0 (49.4) HOWSE PASS lies to the west. In 1807, David Thompson travelled up the North Saskatchewan River from the North West Company outpost of Rocky Mountain House. He was to try to cross the Rockies and establish a trading post on the western slopes for the North West Company. After arriving near the base of this pass in early June, Thompson's writings reveal the feelings of one of the earliest white men in the Rockies: "Here among the stupendous and solitary Wilds covered with eternal Snow, and Mountain connected to Mountain by immense Glaciers, the collection of ages and on which the Beams of the Sun make hardly any impression when aided by the most favorable weather. I staid for 14 days more, impatiently waiting the melting of the Snows on the Height of Land." (as quoted by Patton 1975). Thompson was able to cross the pass and establish a trading post near the present day town of Invermere.

82.9 (51.7) FOREST FIRE. To the west can be seen the scars of a forest fire. When a coniferous forest is burned, the fire releases the Lodgepole Pine seeds and pine dominates the landscape for a considerable period before the spruce and fir forest is able to reestablish itself. Thus, these fire scars can last hundreds of years. In the valley bottoms along the highway, there are very few areas, if any, that do not show evidence of previous fires.

87.1 (54.5) BRAIDED STREAM BED to the west is typical of many glacier-fed streams. These coarse calcareous materials are generally colonized by Yellow Mountain-avens communities. Warm sunny days, perhaps combined with thundershowers on the glaciers, periodically cause abrupt and large changes in the streamflow levels sweeping away the plant communities, only to create another gravelly habitat on the next bend.

Fur Traders in the Rockies

Many of the early white men in the Rockies were fur traders looking for a route across the mountains to the rich fur areas to the West.

In 1800 two North West Company voyageurs, LeBlanc and LaGassi, were probably the first white men to cross the Rockies. It is believed they used Howse Pass. In 1807 David Thompson, a surveyor, mapmaker, and trader with the North West Company, crossed the pass and built forts in the Columbia district. The pass was named after Joseph Howse, a Hudson's Bay Company employee, who first used it in 1810. In the winter of 1810-11 the Piegan indians stopped Thompson from using Howse Pass and trading guns to west coast indians so he detoured to the north and went up the Whirlpool River and over Athabasca Pass. Thompson and his party crossed the pass in mid-winter, and followed the Columbia River to the Pacific Ocean. Although this was a very difficult route it was used for some 15 years.

Jasper Haws (or Hawse) built a small trading post on Brûlé Lake about 1813. "Jasper's House" was used intermittently as a supply post and cache by traders using the Athabasca Trail until 1884. The present name of Jasper National Park immortalizes this Hudson's Bay Company clerk.

90.9 (56.7) RAMPART CREEK. Canadian Youth Hostels such as the one here are situated throughout the Parks, providing accommodation at nominal cost.

92.5 (57.7) BRAIDED STREAM CHANNEL. Glacially-fed streams and rivers such as this one have a strong diurnal change in flow during warm summer days. A hiker may wade across a stream in the early morning and not be able to get back across in the afternoon.

94.6 (59.2) NORMAN CREEK. In the early 1900's, these broad flats opposite the mouth of the Alexandra River were used as a campsite for hunting parties. Animals were often packed to camp, and their bones discarded here, thus the site became known as Graveyard Flats.

100.5 (62.5) AVALANCHE SLOPES, such as the ones on the west wall of the valley, are of common occurrence throughout the Rockies. Only supple shrubs and small plants are able to withstand the crushing force of the moving snow. There is an abrupt change in vegetation and soil in the path of these avalanches. Where considerable mineral debris is carried with the snow, the soils are Regosolic. Where there are abundant willows and deciduous shrubs, and avalanches are frequent enough to prevent Alpine Fir and spruce from regenerating, the soils often have a thick, organic-rich Ah surface horizon. There may or may not be an associated B horizon. Generally above 1800 m, where infrequent avalanching allows the regeneration of Alpine Fir and spruce to at least a krummholz form, the soils are frequently Brunisolic or Podzolic.

102.5 (64.0) COLEMAN CREEK.

107.0 (66.9) WEEPING WALL. In the spring, the flow of water over the sheer limestone cliffs of Cirrus Mountain is almost continuous, staining the gray faces dark. In the winter, the cliff is cloaked in huge sheets and columns of blue ice.

From here, one of the best views of the Castle Mountain Syncline can be seen to the north on the sheer face of Parker's Ridge.

109.0 (68.0) TUMBLE CREEK.

110.9 (69.2) NIGEL CREEK CANYON.

112.8 (70.4) THE BIG HILL. In the next 11 km, the highway climbs 425 m. At the bottom of the hill, the vegetation is typical of the lower subalpine zone. At the top (2000 m) the vegetation is typical of the upper subalpine zone and the alpine zone can be seen on Parker's Ridge to the west.

120.0 (75.0) PARKER'S RIDGE. From here, an easy climb for about 2.5 km takes hikers into an alpine meadow. The profusion of colour provided by the many flowering plants in mid-summer tends to mask the tenuous hold these plants have on life. Frosts and drying winds can occur any day of the year, and plants often have less than 2 to 3 weeks to complete their annual cycle.

In this area, mountain goats can often be seen and an excellent view of the Saskatchewan Glacier in itself makes the climb worthwhile. Snow remains late in the spring and the youth hostel nearby is frequented by skiers throughout the ski season.

124.1 (77.6) SUNWAPTA PASS (2030 m), and the boundary between Banff and Jasper National Parks. Waters flowing south into the North Saskatchewan drainage system end up in Hudson Bay, and waters flowing north into the Athabasca-Mackenzie drainage system eventually reach the Arctic Ocean.

125.7 (78.5) WILCOX CREEK. Constant maintenance is required to prevent these aggrading streams from clogging their passage-ways under the highways and then damaging the road bed.

128.9 (80.4) COLUMBIA ICEFIELD CHALET. Built in 1938 (prior to completion of the Icefields Parkway) by Jack Brewster to provide an opportunity for visitors to stop and see an active glacier (Figure 64).

129.1 (80.5) COLUMBIA ICEFIELD INFORMATION CENTRE. The tour will stop and visit the Athabasca Glacier.

Columbia Icefield and Athabasca Glacier

The Columbia Icefield (Figure 62) which straddles the continental divide, has an average elevation of about 3000 m a.s.l. and covers an area, including outlet glaciers of approximately 325 km^2. Although ice thickness has not been measured, estimates based upon measurements of surface slope suggest that it

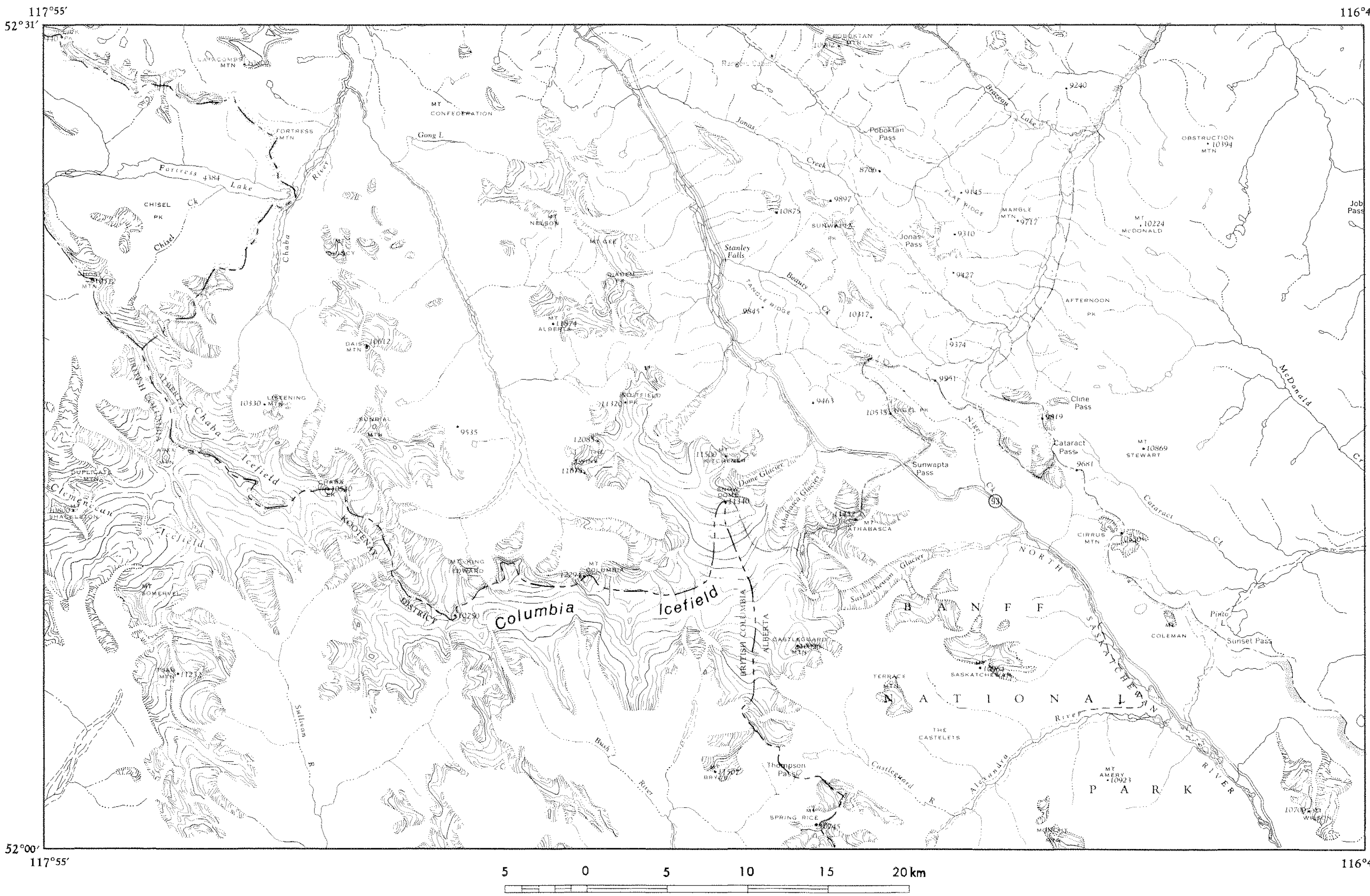


FIG. 62 The Columbia Icefield situated along the Continental Divide is a large snow and ice field with several outlet glaciers. There are several other icefields in the area

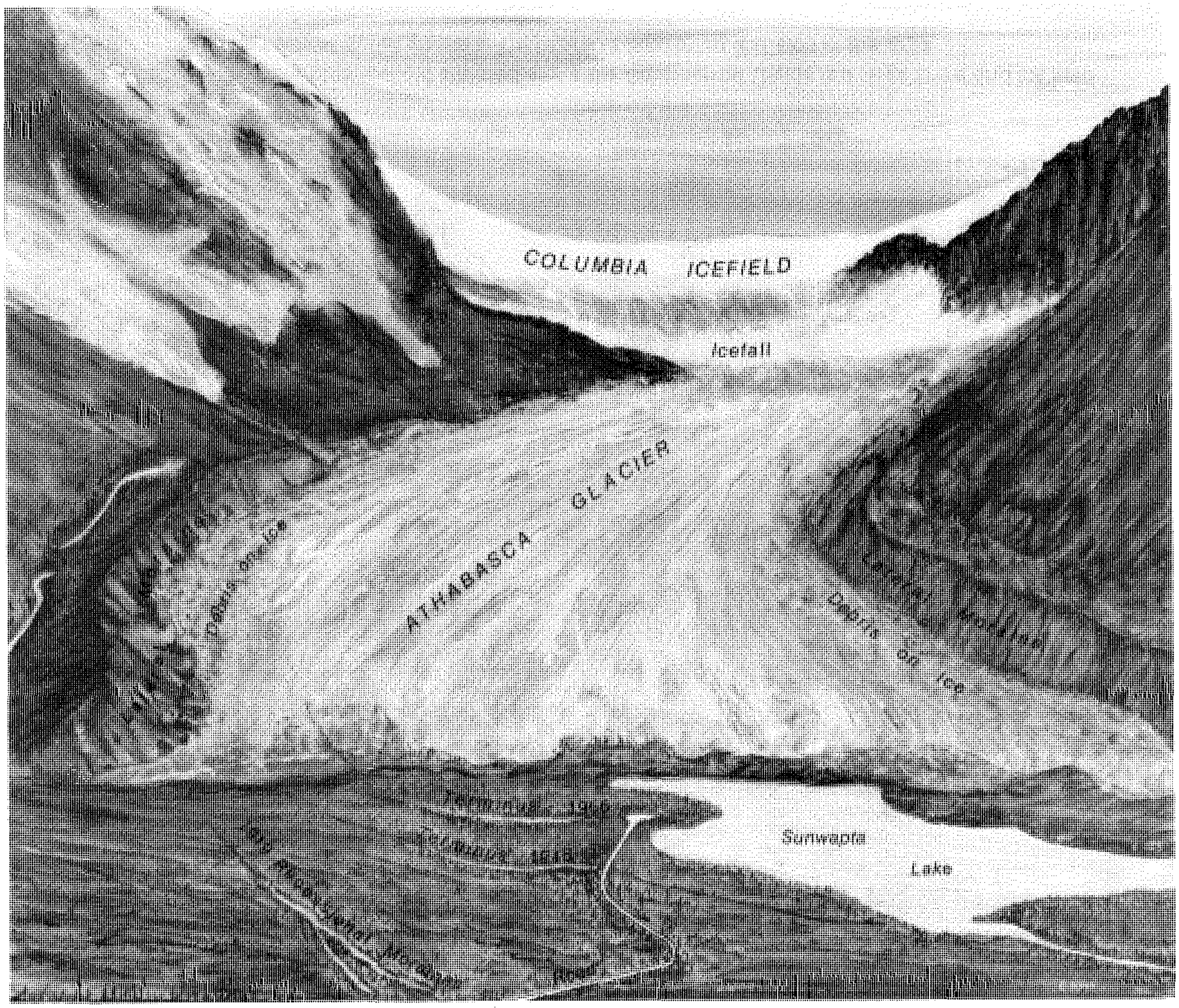


FIG. 63 Athabasca Glacier, located beside the Banff-Jasper highway, drops approximately 670m over its 7.3km length. The glacier front has a net retreat of 13m per year

averages no more than 100 m. As viewed from the highway, the Icefield appears as the skyline at the head of Athabasca Glacier and as the ice cliffs on Snow Dome, Mt. Kitchener, and Mt. Stutfield (Figure 62).

The Athabasca Glacier, as a major outlet glacier from the Columbia Icefield, encompasses an area of about 18.5 km^2, a length of 7.3 km, and a width of 1.2 km. It descends over three bedrock steps marked by ice-falls where transverse crevasses occur. The boundary between accumulation and ablation zones usually is positioned in the highest icefall at about 2600 m a.s.l. Most of the glacier is parabolic in cross-section, except for two bedrock shelves inclining upwards towards the terminus in the last 0.7 km. Ice thickness on the centerline ranges between 250 and 325 metres. Below the bedrock shelves the ice thins rapidly towards the terminus. Ice velocity along the centerline is approximately 130 m/yr over the lowest icefall and decreases from 70 m/yr just below the falls to a mere 5 to 10 m/yr at the terminus. Meltwaters from Athabasca Glacier, and from small glaciers on its southeast side, drain to Sunwapta Lake (1920 m a.s.l.) and eventually through the Mackenzie River system to the Arctic Ocean.

Fluctuations in the ice front have been recorded since 1897; studies of moraines and tree rings (dendrochronology) provide information prior to that. An ice advance ended about 1715 which was further forward then at any time for at least 350 years previously, a position corresponding approximately to the highway (Figure 63). A readvance reached another maximum about 1840 followed by a recession underway by 1870 which has continued with minor interruptions. Recession since 1870 totals 1.4 km or about 13 m/yr. Recessional rates during the period 1960 to 1970 averaged 3.5 m/yr. An average of 3.8 m of ice melts annually from the glacier surface between the lowest icefall and the terminus. An estimate of the amount of thinning during the last 100 years is indicated by the crest of the lateral moraine being 250 m higher than the present terminus. However the thinning is considerably less further up the glacier.

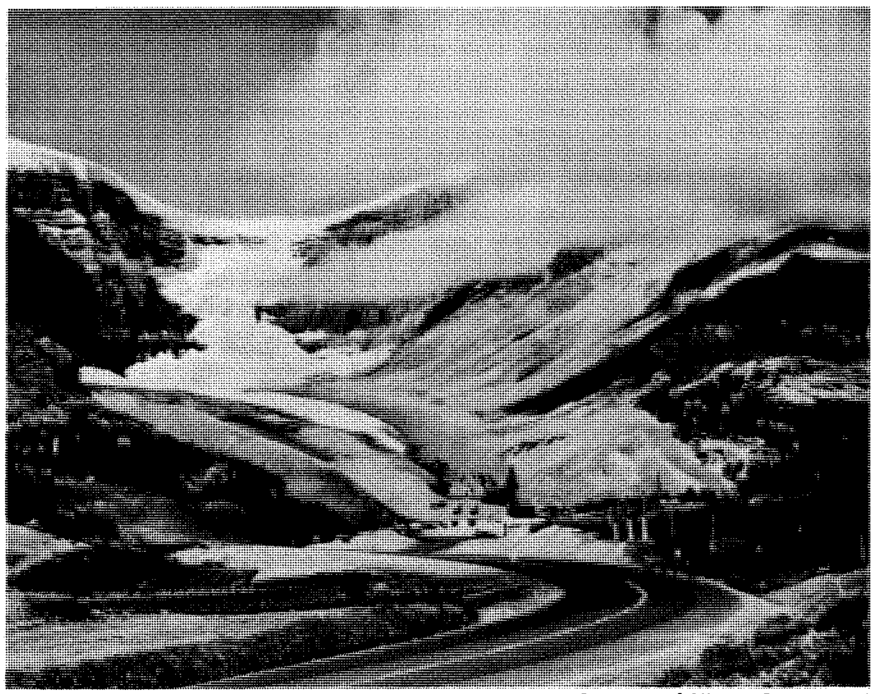
Numerous recessional moraines are crossed by the road leading to the glacier terminus. These arcuate steep-sided ridges of unsorted rock debris are 3 to 6 m high, and the most recent ones represent winter ice front advances of 7 to 10 m. The glacier front retreats 15 to 27 m during the summer.

Further details on glaciology, geomorphology, and chronology for the Athabasca Glacier and its environs are presented and appropriately illustrated in the bulletin "Probing the Athabasca Glacier" by Richard C. Kucera. The bulletin is available upon request from D.J. Pluth, Dept. of Soil Science, University of Alberta, Edmonton.

138.4 (86.5) STUTFIELD GLACIER VIEWPOINT. Note the fluvial fan resulting when the gradient of the stream is decreased causing the stream to deposit its sediment load in this typical form.

148.7 (92.8) SUNWAPTA RIVER to the west. (Sunwapta is the Stony Indian word for "turbulent river"). The asymmetric chain of mountains east of the highway is known as the Endless Chain Ridge. These mountains are the east limb of the Castle Mountain Syncline.

156.4 (97.8) JONAS CREEK.



Courtesy of Alberta Government

FIG. 64 ATHABASCA GLACIER AND THE ICEFIELDS CHALET

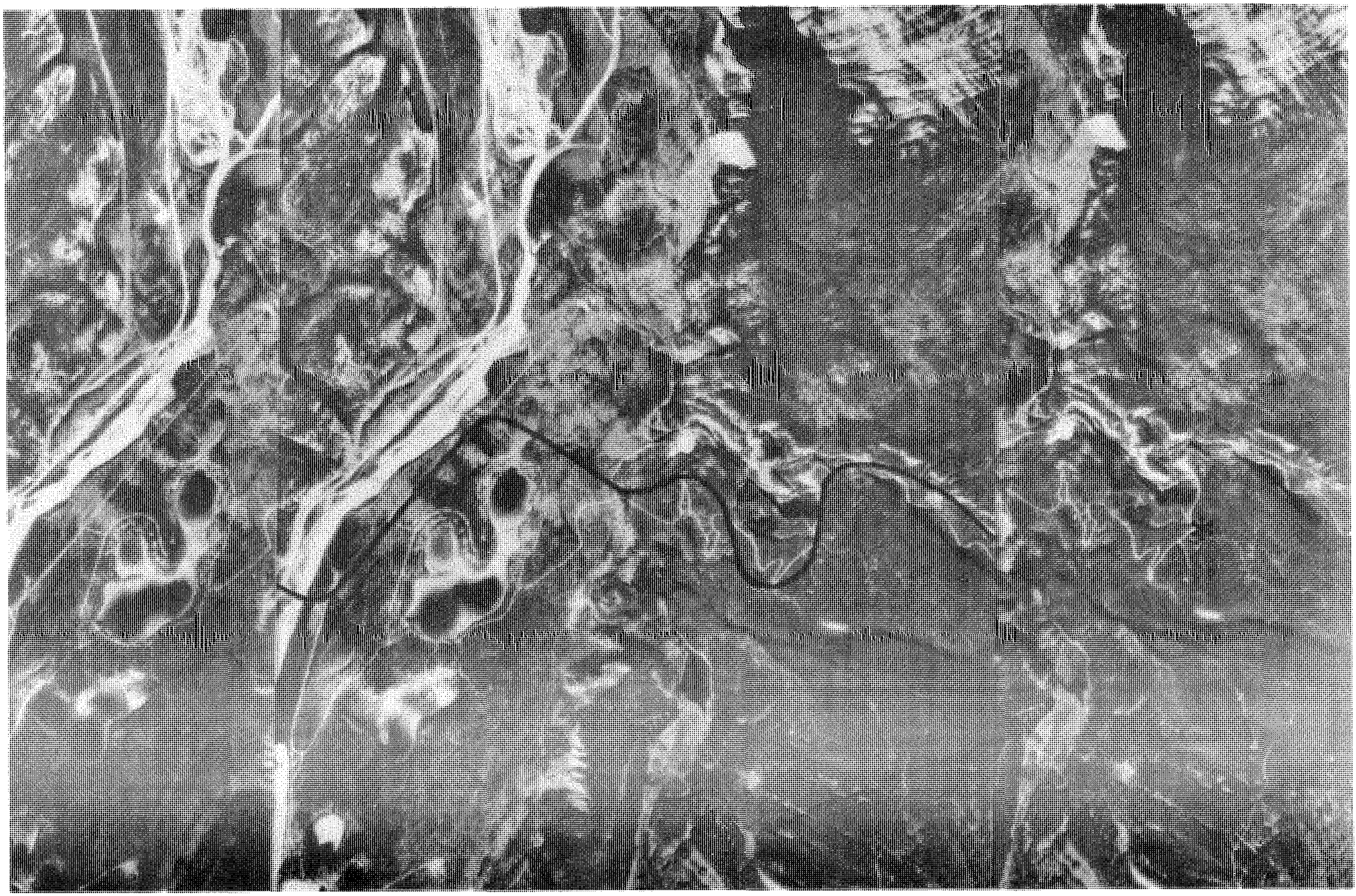


FIG. 65 Stereogram of the Signal Mountain area. Soil pit location marked with *. (Alberta Govt. Photos AS145, 51-53)

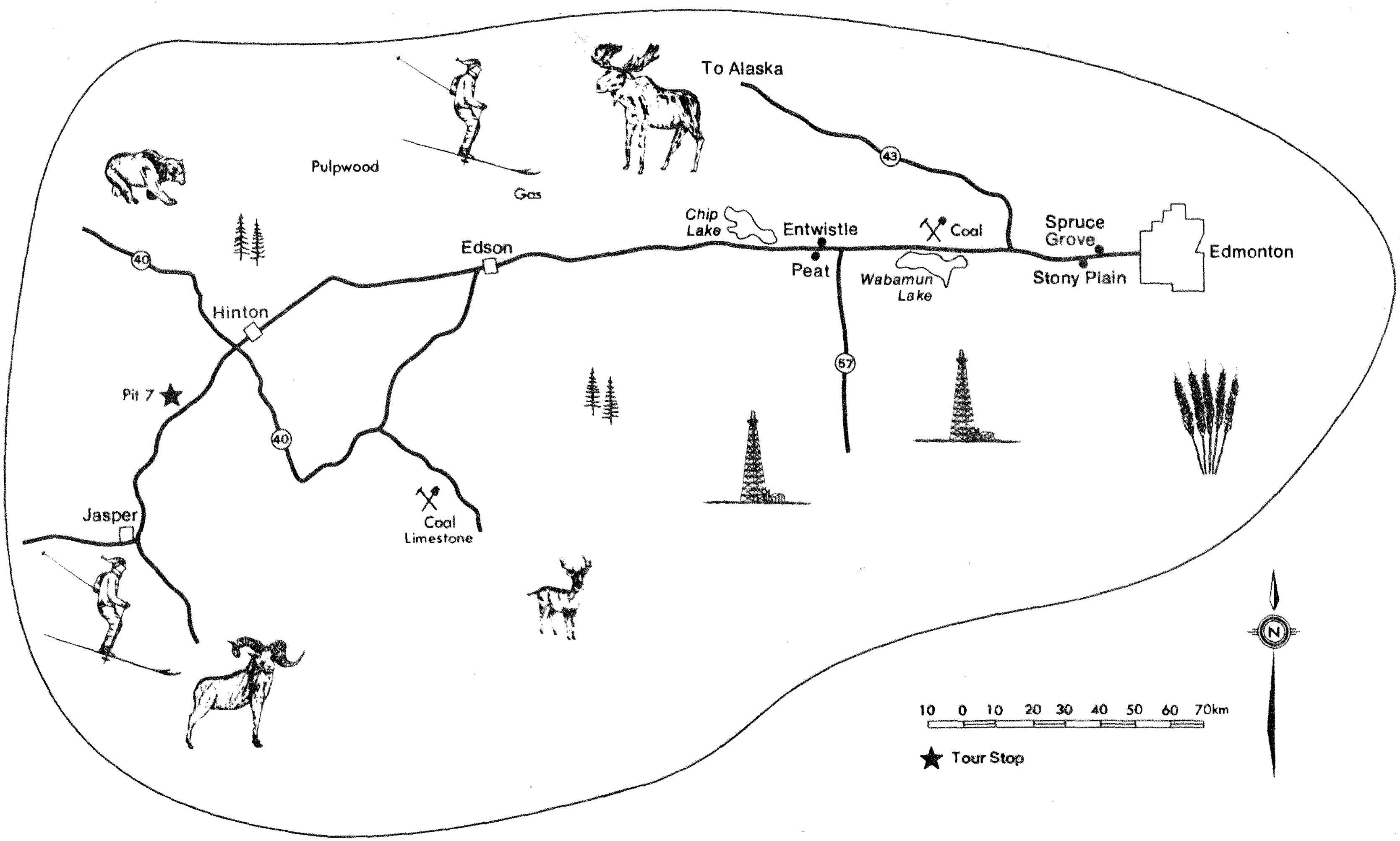


FIG. 66 ROUTE MAP DAY 8

161.7 (101.0) POBOKTAN CREEK. (Poboktan is the Stony Indian word for owl). For the next 14 km the landforms to the east will be coalescing fluvial aprons and fans. The parent materials are derived from the Cambrian quartzites of the Endless Chain Ridge. The soils have strongly developed Brunisolic profiles.

173.0 (108.0) BUBBLING SPRINGS Picnic Area.

175.7 (110.0) SUNWAPTA FALLS JUNCTION (side road to the falls 0.6 km distant). The Sunwapta River joins the Athabasca River about 3 km from the falls. For the next 40 km, the soils are developed mainly on slightly stratified calcareous till with some glaciofluvial materials - both associated with rolling topography. Luvisolic and Brunisolic soils with lime at about 45 to 60 cm characterize the area.

181.4 (113.2) BUCK LAKE Road. There are several small kettle lakes in this rolling land form.

182.5 (114.0) HONEYMOON LAKE Road.

183.3 (114.5) ATHABASCA VALLEY VIEWPOINT. On the east-facing aspects across the Athabasca Valley is a till-mantled slope which shows a gullied surface typical of many slopes in the larger mountain valleys of the Main Ranges. These forested gullies are often 50 to 150 m deep and may be up to 1 km in length. They are oriented directly up-slope. Soil development on these slopes varies little from adjacent "non-gullied" slopes indicating they are no longer in the process of formation.

187.6 (117.2) TREMBLING ASPEN stand to the east is often a good indicator of fluvial fan or apron landforms and associated Regosolic soils.

196.1 (122.7) GLACIOLACUSTRINE SILTS. Associated with the slightly stratified tills in this part of the valley are occasional small deposits of glaciolacustrine silts. The road cut along the east side of the highway exposes these materials for a short distance. As construction materials the silts respond differently than adjacent till materials. Where the silt deposits are exposed, as on the river bank hidden from view to the west, mountain goats frequently congregate to lick the soil, and reputedly, replenish body minerals lost during their spring molt.

198.8 (124.2) MT. KERKESLIN CAMPGROUND. Mount Kerkeslin is the prominent synclinal mountain to the northeast. The Castle Mountain syncline extends from south of Lake Louise to Mt. Kerkeslin.

201.7 (126.0) WARDEN STATION.

202.1 (126.4) JUNCTION with Highway 93A leading to Athabasca Falls and to Jasper.

214.8 (134.2) GLACIOFLUVIAL GRAVELS. From approximately this point to Jasper townsite, the road traverses fluvial and glaciofluvial gravels and cobbles. This is also where the subalpine meets the montane vegetative zone. The Brunisolic and Luvisolic soils are mainly shallow (20 cm to Ck).

220.5 (138.0) MARMOT MOUNTAIN. To the northwest can be seen the ski slopes of Marmot Mountain and farther north the Sky Tram to the top of Whistlers Mountain.

226.0 (141.0) ATHABASCA RIVER.

227.7 (142) JUNCTION with Highway 93A.

231.7 (145) WHISTLERS ROAD to Sky Tram and Youth Hostel.

233.0 (146) MIETTE RIVER.

233.8 (146.5) JUNCTION with Highway 16. Cross Highway 16 and proceed to Jasper townsite.

Jasper National Park

Jasper National Park was established by the Federal Government on September 14, 1907. Establishment of the present townsite of Jasper did not occur until 1911 with the arrival of the Grand Trunk Pacific Railway. A second railway, the Canadian Northern, was completed in 1915 paralleling the Grand Trunk through Jasper and over Yellowhead Pass. These two railways eventually consolidated into the Canadian National Railways. Over the intervening period Jasper has become a popular resort area and today the townsite contains a resident population of 3000.

The elevation of Jasper townsite is about 1000 m and the summit of Yellowhead pass to the west is 1130 m, one of the lowest passes along the Continental Divide. The Athabasca Valley is one of the driest areas in the Canadian Rockies. The average precipitation at Jasper townsite is less than 400 mm (less than Edmonton) and portions of the valley to the east are probably drier. Annual precipitation in the Snake Indian Valley to the east is likely less than 200 mm. Much of the lower Athabasca Valley is frequently snowfree during the winter. Due to low snowfall, redistribution and sublimation, moisture from snow provides a small amount of the total moisture available for plant growth.

The climate of the Jasper area is reflected in the occurrence of open forests and grassy dryland meadows. Rocky Mountain Douglas Fir dominates climax stands in the Montane zone in the valley bottom. Lodgepole Pine stands cover much of the area, representing seral communities following forest fires.

Soil genesis reflects the influence of the climate and vegetation as well as the calcareous parent materials. Shallow Brunisolic and Luvisolic soils characterize this area. A typical example of a mountain landscape is shown in Figure 65.

DAY 8: JASPER TO EDMONTON

The route follows Highway 16 east from Jasper to near the park gates where a Brunisol soil on loess will be examined. The tour will continue eastward across the foothills and western plains to return to Edmonton (Figure 66).

From the park gates to Hinton the Brunisolic soils on loess are the dominant soils in the Athabasca Valley (Figure 67). Luvisolic soils on till, and organic (bog) soils are most common from east of Hinton to Wabamun Lake. The soils then grade quite rapidly from Orthic Gray Luvisol to Dark Gray Luvisol to Dark Gray Chernozemic, and finally to Black Chernozemic at Stony Plain.

Road Log No. 8: Jasper to Edmonton (365 km)

Km (Mile)

0 (0) JUNCTION of Highway 16 and Jasper townsite east exit.

1.0 (0.6) JUNCTION with Maligne Lake Road.

6.7 (4.2) THE PALISADE. The long, steadily rising cliff to the northwest is known as the Palisade. This cliff marks the beginning of the Front Ranges of the Rocky Mountains. The Pyramid thrust fault separates the Palisades from Pyramid Mountain (to the west with the telecommunication tower on top). The reddish-orange quartzites of Cambrian age (600 million years age) identify Pyramid Mountain as belonging to the Main Ranges west of the thrust fault.

8.5 (5.3) JUNCTION with the road leading to the Palisades Warden Training Centre. The former Swift homestead has a long and interesting history, but not as park property. It was the only piece of land to which private title was held when Jasper Park was established. Negotiations for the purchase of this troublesome island of property were only completed in 1962.

11.2 (7.0) MONTANE ZONE. The open canopied and grassland areas in this part of the Athabasca Valley are characterized by Brunisolic and Regosolic soils developed on sandy loam to silt loam textured fluvial materials. The frequent deposition of windblown calcareous dust interrupts the development of a thick Ah horizon, preventing the formation of a diagnostic "chernozemic Ah".

11.7 (7.3) JASPER AIRFIELD. Elevation 1020 m.

14.1 (8.8) LOESS. The overhanging calcareous loess "cap" on the north provides evidence that considerable calcareous dust is deposited adjacent to Jasper and Brûlé Lake in the Athabasca Valley. The Overlander soil pit will demonstrate the influence of this wind blown material on soil development.

14.2 (8.9) SNARING RIVER. The river is named after a small tribe of Indians which used to frequent the area, snaring small animals for food.

18.0 (11.2) ATHABASCA RIVER. Note the glacially polished rock face south of the highway on the east side of the bridge.

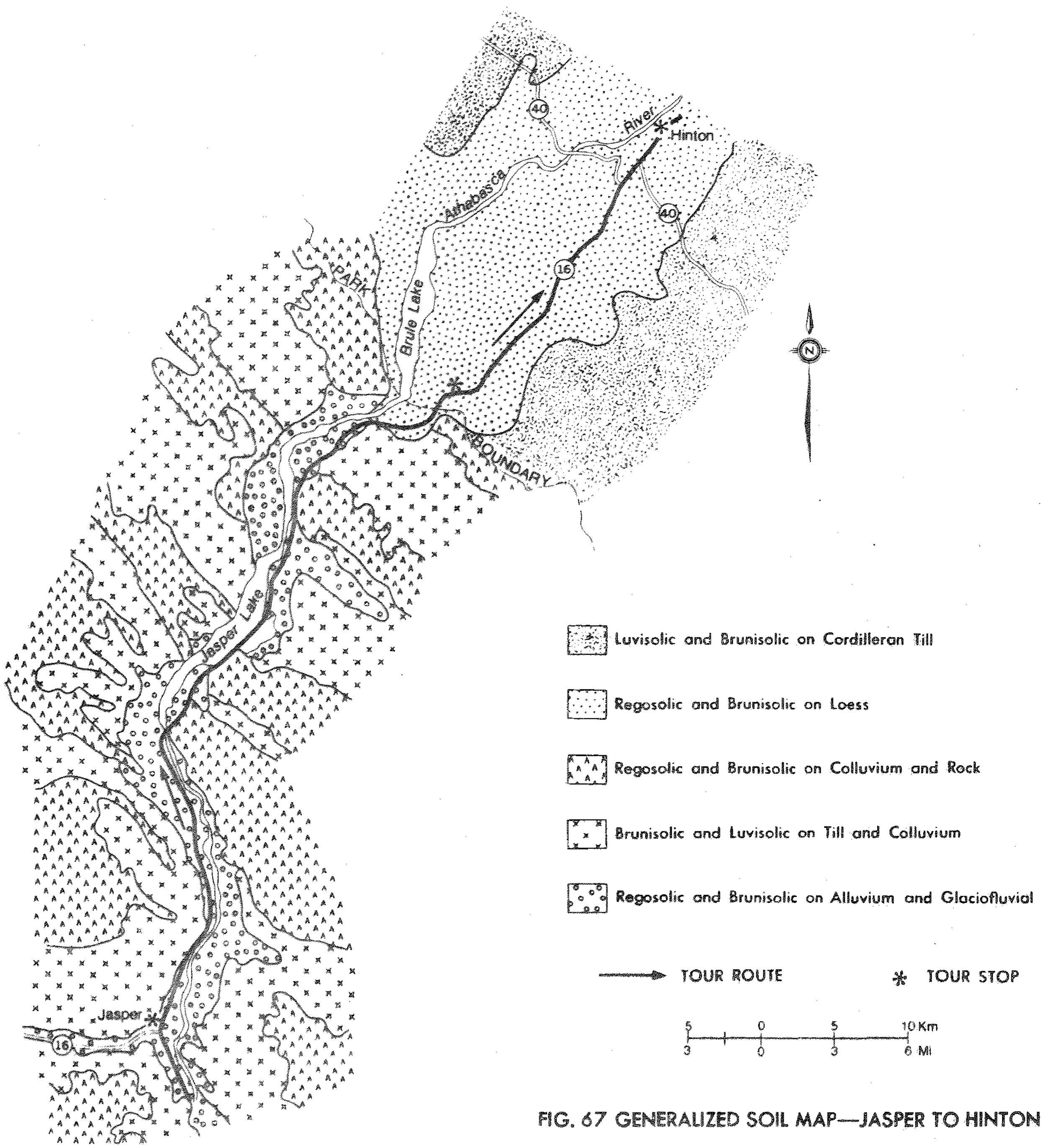


FIG. 67 GENERALIZED SOIL MAP—JASPER TO HINTON

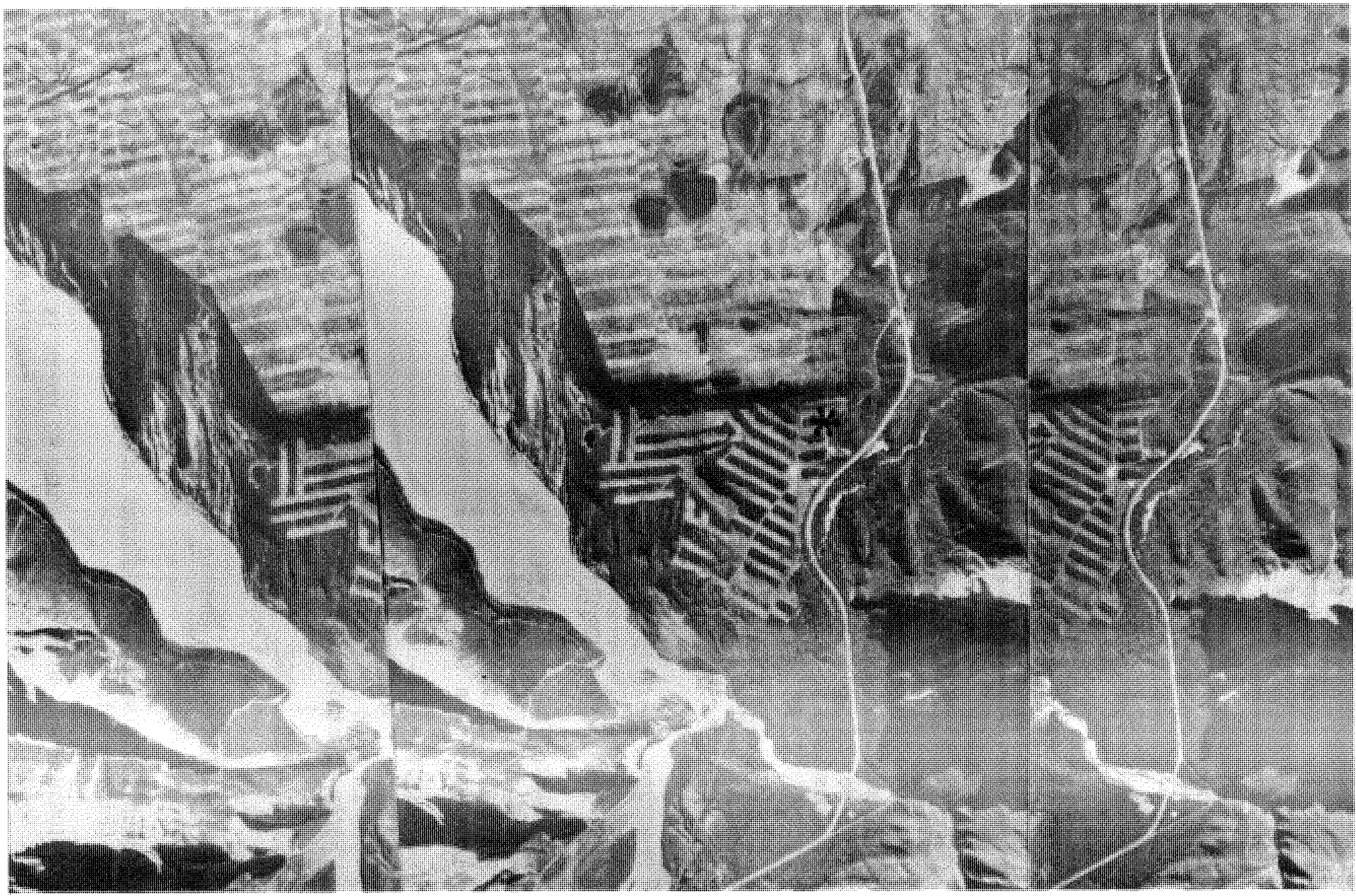


Fig. 68 Stereogram of the Brûlé Lake area. Overlander site is marked with *. (Alberta Govt. Photos AS2872, 9-11)

18.6 (11.6) COLD SULPHUR SPRING. Water from rain and snow flows through Devonian-aged limestones and shales dissolving minerals, some of which are high in sulphur. The strong hydrogen sulfide smell is indicative of microbial conversion of the mineral forms of sulphur to H_2S.

23.1 (14.5) JASPER LAKE. In the fall, when the water level of the lake is low, considerable unvegetated shoreline is exposed, and the loose sand and silt becomes the source for replenishing the many dunes in the area.

26.3 (16.4) DUNES. These sand dunes are partially stabilized by grasses and some spruce. Regosolic soils characterize the area.

28.0 (17.5) TALBOT LAKE. To the southeast across Talbot Lake, the profile of a fluvial fan can be seen outlined by the light green of Trembling Aspen against the darker green of the conifers. Rapidly aggrading fluvial fans, as indicated by Regosolic soils, often have Trembling Aspen as a pioneer species. This "clue" is a useful mapping tool.

31.8 (19.9) JASPER HOUSE historic point of interest. One of the earliest outposts of the mountain fur trade, was named for Jasper Hawes who first set up the North West Company Post in 1812 about 25 km downstream at Brûlé Lake. About 1820, the post was taken over by the Hudson's Bay Company and rebuilt at this point.

32.6 (20.4) ROCKY RIVER.

36.5 (22.8) ANIMAL LICK. Bighorn sheep often come to lick the mineral-rich soil.

41.3 (25.8) JUNCTION. Road to Miette Hot Springs. Located about 17 km from Highway 16. These springs are the warmest (54 C) in the Canadian Rockies. A pool and bathing facilities are maintained for the use of visitors.

The settlement of Pocahontas, founded at this junction about 1911, was named after a Virginia (USA) coal field in hopes that the coal mine established here would be as productive. Poor quality coal caused the mine to close after 10 years of operation when the railway was moved to the other side of the river.

47.1 (29.5) FIDDLE RIVER.

48.6 (30.4) JASPER PARK EAST GATE. This is the approximate boundary between the Rocky Mountains and the Rocky Mountain Foothills.

51.6 (32.3) OVERLANDER LODGE.

OVERLANDER SITE: Orthic Melanic Brunisol (see Appendix D)

This cumulic Brunisolic soil is developed in the calcareous loess that blankets the landscape (Figure 68).

70 (44) JUNCTION Highway 40 north. Highway 40 north is a segment of the Forestry Trunk Road leading to the city of Grande Prairie and the town of Grande Cache. Grande Cache is about 145 km north of the junction in a coal mining area. McIntyre Mines Ltd., which operates both underground and surface mines, produced

1.7 million tonnes of clean coking coal for markets in Japan in 1975. The Alberta Resources Railway links the agricultural area surrounding Grande Prairie and the mining area of Grande Cache with the Canadian National main line near Brûlé Lake. Construction of this railroad was completed in 1969.

72 (45) JUNCTION-Highway 40 south to the "Coal Branch" area which is about 65 km to the southeast. This region was initially developed because of the need for coal for the railways. Commercial production of coal began in about 1911, with peak production reached during the Second World War, when about 1.5 to 2 million tonnes per year were produced. Deterioration of the coal industry came after World War II when diesel oil became the source of power for the railway. "Ghost" towns with their slag piles became the only reminder of the once prosperous mining communities. However, in the late 1960's a strip mine operation began at Luscar to extract coking coal for export to Japan. Other mining companies are expected to further develop the coal resources in the area.

74 (46) HINTON corporate limits. Population 6000. Hinton originated as a small hamlet associated with the coal industry. In 1957, North Western Pulp and Power Ltd. went into production bringing an economic boom to the area. The mill directly employs a large number of people and a considerable number are also employed by suppliers of contracted services to the mill. The pulpwood lease surrounding Hinton is about 1.7 million ha in size. A stud mill also capable of producing railroad ties went into production in the mid 1970's. A further economic boom occurred in the late 1960's when the coal industry was reactivated. Hinton was established as the hub of the service industries supplying the mining operations at Luscar and Grande Cache. With its ideal location on the Yellowhead Highway adjacent to Jasper National Park, Hinton derives considerable revenue from tourism and long distance heavy transport. In addition, a forestry training school is located here.

80 (50) JUNCTION with Forestry Trunk road leading south along the eastern edge of the mountains.

92 (57) MORAINAL UPLAND. This point on the highway is approximately the eastern extremity of the loessal soils. Over the next 50 km three major associations of soils occur. One association is comprised of a collection of Gray Luvisols developed on medium-to coarse-textured calcareous till; the same material underlying the loess soils to the west (Figure 69). Another association consists of a collection of Luvisolic and Brunisolic soils that are distinguished from soils of the former association by the presence of a thin deposit of fluvial and/or eolian sand over the till. Numerous areas of Organic and Gleysolic soils are also recognized (Dumanski _et al_. 1973). The landform is primarily a rolling morainal upland. Agricultural capability classes 5 and 6. Forest capability classes 4 and 5.

115 (72) OBED. Elevation of 1086 m is the highest point on the Canadian National Railways mainline.

119 (74) BLANKET BOG area with inclusions of better drained mineral soils.

124 (77) MORAINAL PLAIN. These medium- to coarse-textured Luvisolic and Brunisolic soils developed on an undulating to gently rolling morainal plain are rated as agricultural capability classes 5 and 6; and Forest capability classes 4 and 5.

126 (79) MEDICINE LODGE. The flowing well that is located here is a popular stopping point for travellers. There is a minimum security detention centre on the hill. Inmates from this institution work nearby cleaning and thinning forested areas, collecting seed cones, etc. East of Medicine Lodge the highway parallels the north bank of the McLeod River. The McLeod flows into the Athabasca about 70 km north of the tour route.

141 (88) FLUVIAL SANDS. These coarse-textured Luvisolic and Brunisolic soils have developed on a gently rolling fluvial blanket. The parent material is an olive brown to grayish brown sand containing occasional orthoquartzite and metaquartzite pebbles up to 5 cm in diameter. The sandy materials in this area represent deposition from meltwater flowing from the Marlboro Glacier into a glacial lake in the Edson Lowland (surrounding the town of Edson east of here) during initial stages of glacier retreat (Roed 1968). Agricultural capability class 6, Forest capability class 5.

142 (88.5) MARLBORO. The hamlet of Marlboro is underlain by a deposit of marl. In 1912, the Marlboro Cement Company established a cement plant to utilize local marl deposits. These proved unsatisfactory and by 1917 the cement plant was receiving limestone from a quarry near Jasper. One of the stacks from the cement plant still stands at the edge of the community.

The marl is about 1.5 m thick and can be seen to the east of the hamlet where it is overlain by organic material and underlain by sand and gravel of the Marlboro delta. It is very fossiliferous containing gastropods, pelecypods, and ostrapods. The marl has been dated by radiocarbon method at 1830 ± 150 years B.P. A chemical analysis of the marl indicated 92.24% calcium carbonate equivalent. The low calcium carbonate content is probably the main reason this marl deposit was not developed further for the manufacture of cement (Roed 1968).

146 (91.3) SUNDANCE CREEK. About 1 km north of the highway a rather spectacular meltwater channel is located along the course of Sundance Creek. This meltwater channel was formed at the eastern edge of the Marlboro glacier and was eventually eroded 120 m into the bedrock in places. Some of the sandy material deposited in the resulting delta was redistributed by winds to form the dune field south and east of the delta. The dune field is comprised of U-shaped dunes consisting dominantly of very fine to fine-grained sand and Organic soils in the inter-dune areas. Some shallow blow-outs and small sand shadows are also present (Roed 1968). Brunisolic soils occur on the dunes which are relatively stable at present because of a heavy vegetative cover.

153 (95.7) FORAGE CROPS. Climate is the major limitation to agricultural production in this area limiting crops mainly to forages.

155 (97) ROLLING MORAINAL UPLAND. Medium- to fine-textured Luvisolic soils have developed on till of Cordilleran origin. Agricultural capability class 5, Forest capability class 4.

158 (98.8) JUNCTION Highway 47 to Robb and the Coal Branch area.

161 (100) ROLLING MORAINAL UPLAND. Medium- to fine-textured Luvisolic soils have developed on till of Continental (provenance in Canadian Shield area) origin. This till is dense, plastic, and brown to yellowish brown in color. Agricultural capability classes 5 and 6. Forest capability class 4.

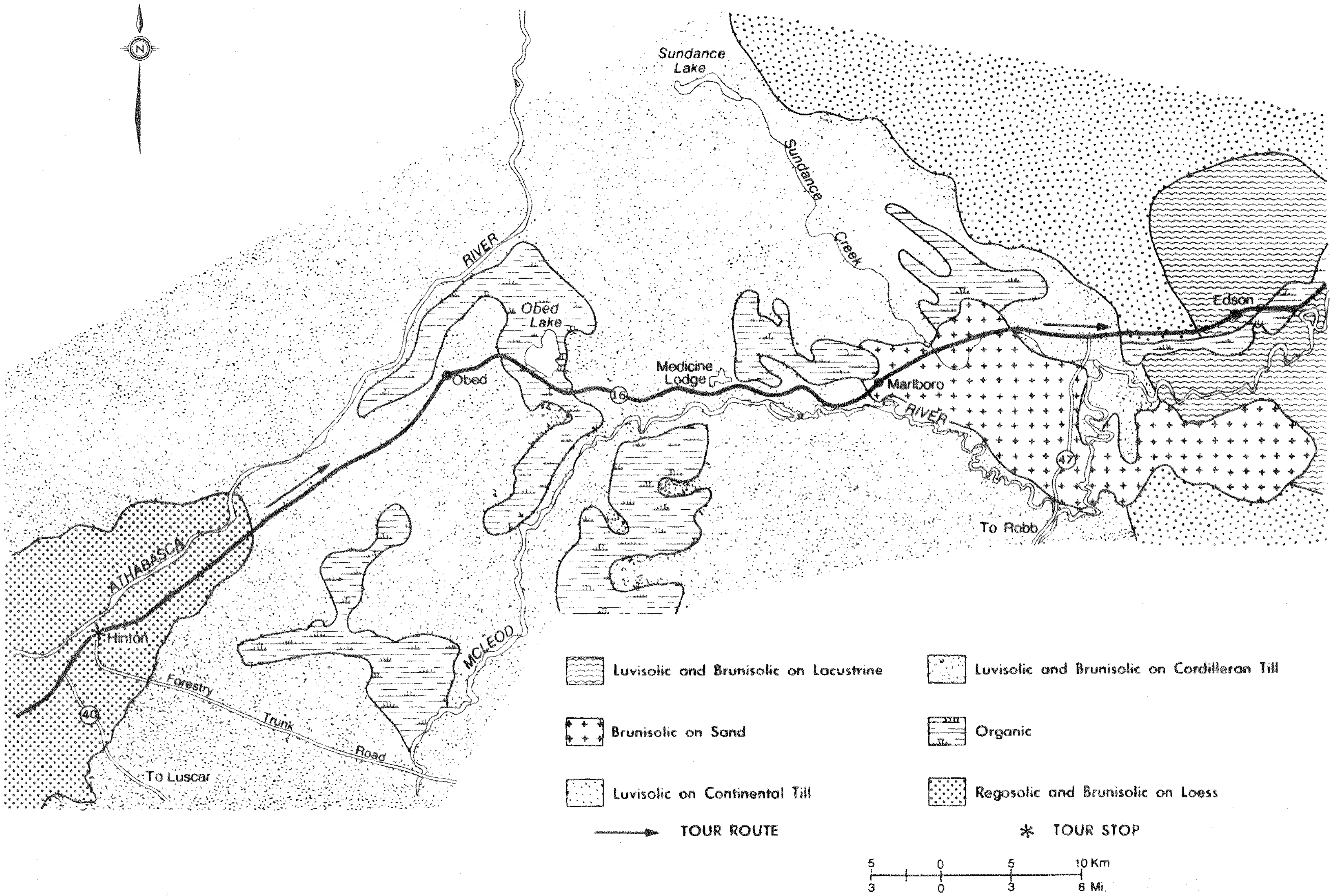


FIG. 69 GENERALIZED SOIL MAP— HINTON TO McLEOD RIVER

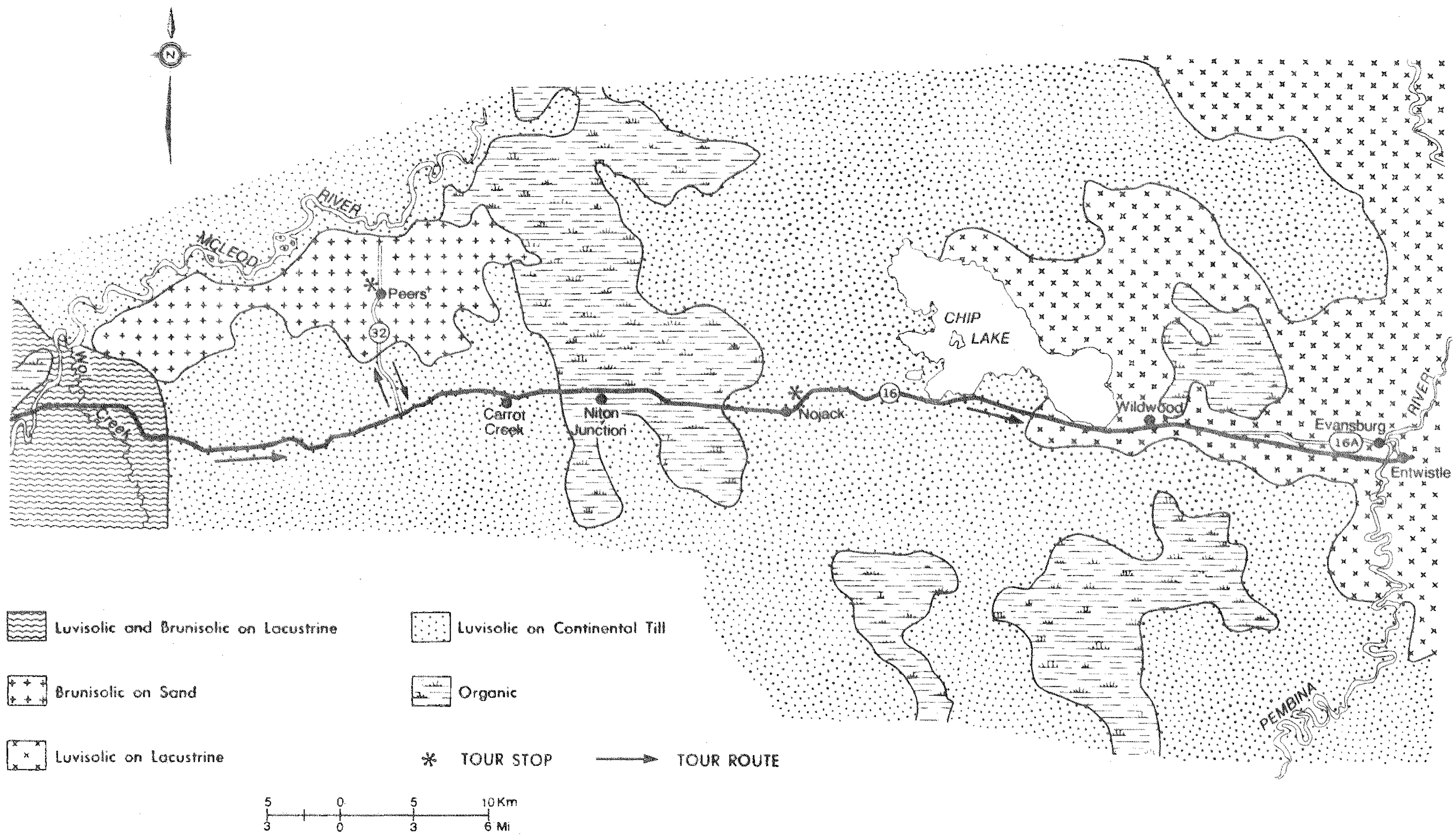


FIG. 70 GENERALIZED SOIL MAP—PEMBINA RIVER TO McLEOD RIVER

163 (102) LACUSTRINE DEPOSITS. Medium to fine-textured Luvisolic soils have developed on a level to undulating lacustrine blanket. The parent materials of the soils are olive brown to dark yellowish brown silts and clays that are moderately to strongly calcareous. The glacial lake in which the lacustrine clays and silts were deposited probably was transgressive in nature (Roed 1968). Initially water was trapped between the Keewatin and Cordilleran ice sheets. Retreat of the Cordilleran ice sheet allowed a progressive lowering of the lake level. The final lake position was in the Alberta Plains Region to the north and south of Edson. Deposits collected in lakes of this type are generally heterogeneous. The lacustrine materials found in the central portions of the lacustrine basin are thicker, of finer texture, and more calcareous than those found along the edges.

Extensive areas of Organic soils are found in association with the mineral soils. The mineral soils are rated agricultural capability classes 4 and 5.

164 (102.5) POINT OF INTEREST SIGN. "The Edson-Grande Prairie Trail". The old trail between Edson and the Peace River country came into use when Edson became the end of steel on the Grand Trunk Pacific Railway in 1910. The trail was cut through timber and over muskegs, 320 km to Sturgeon Lake and then west, leading the hardy settlers to "The Grande Prairie", where they dispersed and took up their homesteads. The tortuous, mud-choked trail was used until the railway reached Grande Prairie in 1916.

166 (104) EDSON corporate limits. Population 3500. Edson, originally established as Heatherwood, was incorporated as a town in 1911. Soon after, it became a jumping-off point to the north as mail and settlers travelled along the Edson-Grande Prairie trail by stagecoach and horseback. Present day Edson is supported by a number of industries. The oil and gas industry and the forest products industry (including pulp and paper, fence posts, and railroad ties) are important to the economy of the area. Regional government offices and maintenance shops of the Alberta Forest Service, Alberta Government Telephones, and Alberta Highways and Transportation are located in Edson. A significant amount of revenue comes from the tourist industry as Highway 16 passes through the town. Edson also serves a modest farming population which is located primarily northeast of town.

172 (107) ORGANIC SOIL area. Depth of peat varies from 1 to 3 m.

178 (111) MCLEOD RIVER.

181 (113) WOLF CREEK.

185 (116) UNDULATING morainal plain composed of medium- to fine-textured Luvisolic soils. The till is of Continental origin. Agricultural capability classes 4 and 5. Extensive Gleysolic and Organic soils also occur in this area (Figure 70).

203 (127) JUNCTION with Highway 32. This area is characterized by sand dunes and muskeg (Organic soils). Rapidly drained Brunisolic soils have developed on the coarse-textured, stone-free, eolian materials (Twardy and Lindsay 1971). The dunes, which are U-shaped or longitudinal, are well stabilized by tree cover and are rated agricultural capability class 6. Organic soils are common in the inter-dune areas.

211 (132) CARROT CREEK.

213 (133) ORGANIC SOILS with lesser amounts of Gleysolic and Luvisolic mineral soils.

220 (137.5) FARMSTEAD located in area of Organic and Gleysolic soils. Depth of peat varies from 15 cm to 1.5 m. The land is used for grazing and hay production.

222 (139) UNDULATING MORAINE. Medium- to fine-textured Luvisolic and Gleysolic soils developed on an undulating ground moraine.

234 (146) CHIP LAKE. The southwest tip of Chip Lake is visible north of the highway. The shallow lake covers an area of 70 km^2. At present there is no recreational development on the lakeshore.

241 (150.5) LACUSTRINE PLAIN. This is an area of very fine textured Gray Luvisol soils developed on a level to undulating lacustrine plain. Forages comprise the major crop grown in the area. Agricultural capability class 4.

249 (155) WILDWOOD. Population 300. The transition between Agro-Climatic areas 3H and 2H occurs in this vicinity.

258 (161) PEAT. Two peat moss processing plants are located on opposite sides of the highway. Peat is harvested from bogs in the vicinity and processed primarily for use as a soil amendment for nurseries and home gardens. Much of the product is sold in California.

264 (165) PEMBINA RIVER.

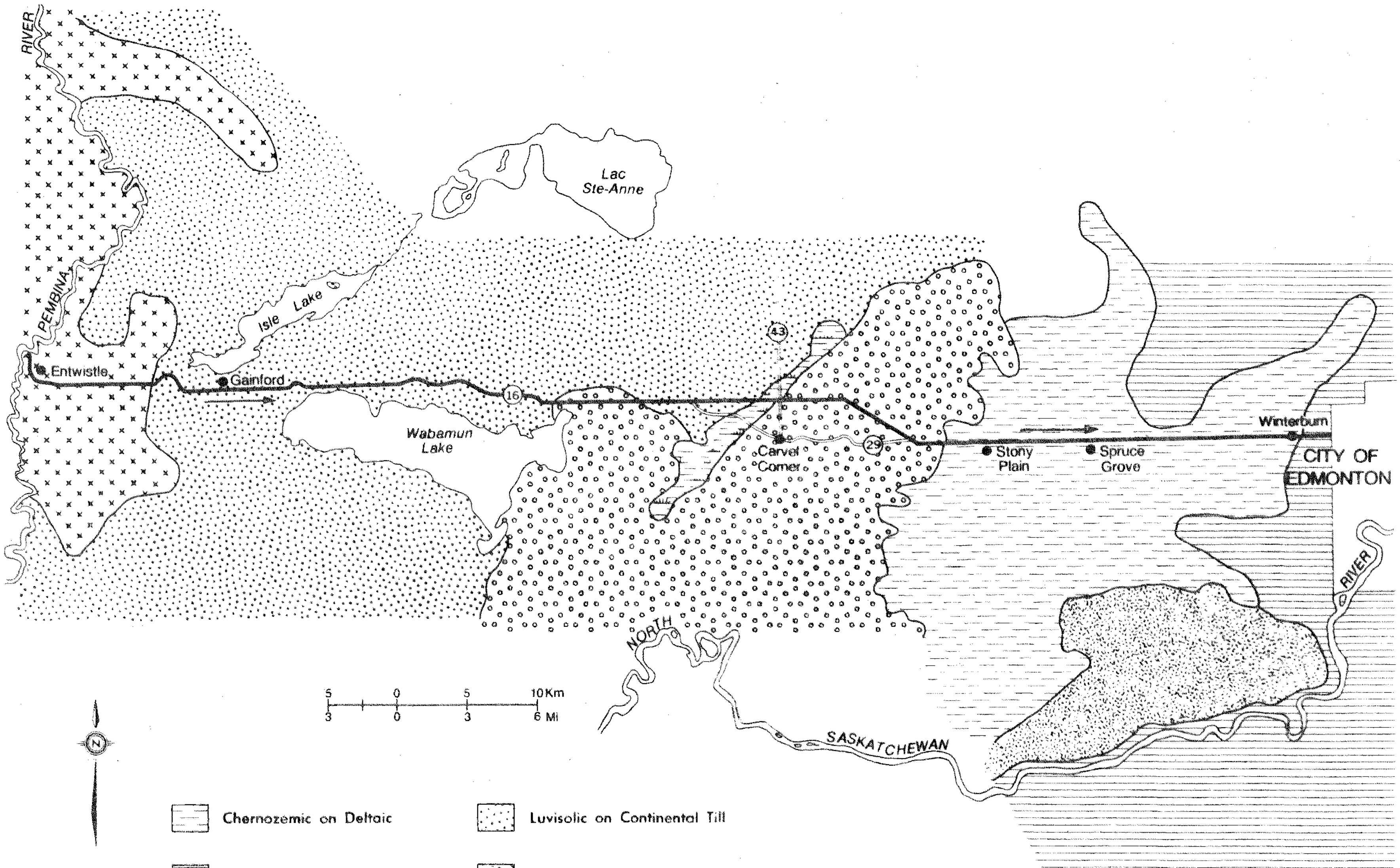
265 (166) ENTWISTLE.

267 (167) MORAINAL PLAIN. This is an area of medium- to fine-textured Luvisolic soils developed in a lacustrine veneer and blanket overlying an undulating and rolling morainal plain (Figure 71; Lindsay et al. 1968). Agricultural capability classes 4 and 5.

275 (172) MORAINAL PLAIN. This is an area of medium- to fine-textured Luvisolic soils developed on a gently rolling to rolling morainal plain. Agricultural capability classes 3 and 4. The transition from Agro-Climatic area 3H to 2H occurs in this vicinity.

280 (175) GAINFORD.

300 (187) WABAMUN LAKE to the south side of highway. Proximity to large population centres has resulted in extensive recreation development around this lake for both summer and winter activities. Large coal deposits and an ample water supply for cooling the steam condensers make Lake Wabamun an ideal location for thermal power generation. The Wabamun thermal plant, situated on the north shore of the lake, has a capacity of 582 000 kw. On the north side of the highway, four draglines work at the Whitewood Mine where more than two million tonnes of coal are mined per year for use in the thermal plant. The Sundance steam plant is located across the lake from the Wabamun plant. Presently the capacity is about 1 350 000 kw with further expansion expected. The Wabamun and Sundance plants are operated by Calgary Power Ltd.



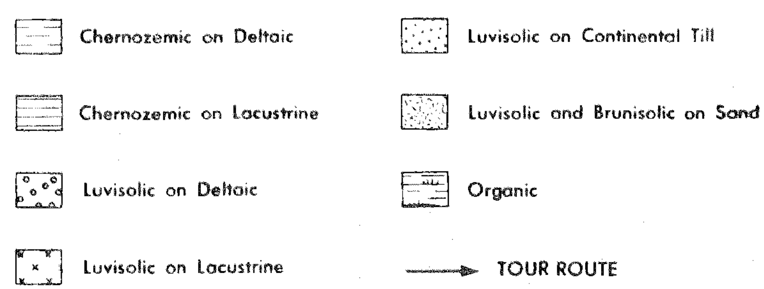


FIG. 71 GENERALIZED SOIL MAP—PEMBINA RIVER TO EDMONTON

320 (200) JUNCTION Highway 43 (the Alaska Highway). This is an area of coarse- to medium-textured Luvisolic soils developed on a pitted glaciofluvial deposit commonly referred to as a pitted delta. Pitted deltas are composite deltas of many streams that flowed on the surface of the glacier ice and terminated in a lake. The pitted delta in this area was deposited partly over ice and partly around large ice blocks standing in the water of Lake Edmonton. As the front of the glacier receded, deltas were formed at different localities close to the ice edge. The melting of ice blocks that were covered or surrounded by sediments produced the characteristic pits and kettles. Although the deltas have a rough topography resembling that of a hummocky dead-ice moraine in general appearance, the materials differ markedly from till. The pitted deltas are composed mainly of fine sands and silts with clayey beds. The sands and silts are well bedded with cross-bedding developed in coarser materials. In some places the pitted deltas contain many pebbles and cobbles that have been either ice rafted into place, or have come from ice blocks.

The soils developed on these deltaic materials frequently have bands in the lower sola which have presented difficulties in classification (Coen, Pawluk and Odynsky 1966). These bands contain more organic matter, free iron and clay than the interbands. This results in a darker, redder color and finer texture. These bands are often coincidental with stratified layers, but their occasional transgression across geologic stratification and their development in profiles without stratification suggest a pedogenic origin. Soils with thick, well-developed bands are most prevalent in deep, generally coarse-textured parent materials. The upper band generally occurs at depths varying from 50 to 112 cm below the soil surface. Band thickness varies from a fraction of 1 cm to about 20 cm, and bands generally conform to the contour of the soil surface. Agricultural capability classes 4 and 5.

337 (210) CHERNOZEMIC SOILS. These are coarse- to medium-textured Chernozemic soils developed on a pitted glaciofluvial landform. Agricultural capability classes 1 and 2.

340 (212) STONY PLAIN. Population 2500. This community lies in Agro-Climatic area 1.

347 (217) SPRUCE GROVE. Population 5500. The size and population of centres such as Spruce Grove and Stony Plain along with others near Edmonton have increased dramatically in the past ten years. The expansion of urban environments has been at the expense of prime agricultural land.

363 (227) WINTERBURN. Population 100. The soils are medium- to fine-textured Chernozemic and Gleysolic soils developed on a level to gently undulating lacustrine plain. This large area of lacustrine deposits represent the former glacial lake Edmonton. This lake, which covered most of the Edmonton district, bordered against the ice in many places and its level was rapidly lowered in response to new outlet levels and to the melting rate of the glacier. Lacustrine conditions persisted longest in the center of the basin and the thickest Lake Edmonton sediments are generally found there. Because of the rapid lowering of the lake level no beaches are found on Lake Edmonton. The development of Lake Edmonton could have been caused by 1) blockage of normal drainage to the east by an ice advance in that area; 2) tilting of the land due to the removal of the ice load or orogenic readjustment of the Canadian Rocky Mountains. In mechanical composition the Lake Edmonton sediments range from

sand to clay. In thickness they range from about 30 m to less than 1 m. Till underlies most of the Lake Edmonton deposits except in very small areas where it was eroded before deposition of lake sediments. Ice rafted till and pebbles found in the sediments suggest that the lake was in contact with the retreating glacier for the greater part of its existence (Bayrock and Hughes 1962). Agricultural capability classes 1 and 2.

365 (228) CITY OF EDMONTON corporate limits. Proceed to University of Alberta and Congress headquarters.

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APPENDIX A: THE CANADIAN SYSTEM OF SOIL CLASSIFICATION

Soils are classified in Canada according to a hierarchical system developed by the Canada Soil Survey Committee. Classes in all of the five categories: order, great group, subgroup, family and series, are based upon observable or measurable soil properties. Diagnostic properties at high categorical levels reflect soil genesis and hence the environmental factors that influence soil genesis. The nine soil orders, arranged alphabetically, are defined in brief, general terms and the great groups are listed.

Brunisolic order.

Soils having genetic horizons but lacking the horizons diagnostic of other orders. They occur dominantly in subhumid to humid forested regions and they usually have brown B horizons. Great groups are: Melanic Brunisol - has a mineral-organic surface horizon (Ah) and is not strongly acid; Eutric Brunisol - lacks a well developed Ah and is not strongly acid; Sombric Brunisol - has an Ah and is strongly acid; Dystric Brunisol - lacks a well-developed Ah and is strongly acid.

Chernozemic order.

Soils of the grasslands; they have a well-developed base-rich, mineral-organic surface horizon (Ah). The four great groups are based upon color of the surface horizon which reflects soil climate: Brown, Dark Brown, Black and Dark Gray.

Cryosolic order.

Soils of the permafrost zone that includes about one third of Canada; they may be composed of either mineral or organic material having permafrost near the surface (1 to 2 m). There are three great groups: Turbic Cryosol - strongly cryoturbated mineral soils as indicated by microrelief or by mixed horizons; Static Cryosol - mineral soils that are not strongly cryoturbated; Organic Cryosol - organic material having permafrost within 1 m.

Gleysolic order.

Soils having drab colors, prominent mottling or other features resulting from periodic or permanent high water table and reduction. They occur commonly in depressions and level areas that either receive runoff water or are groundwater discharge areas. There are three great groups: Humic Gleysol - well-developed mineral-organic surface horizon (Ah); Gleysol - lacks a well-developed Ah; Luvic Gleysol - has a B horizon (Btg) of significant clay accumulation.

Luvisolic order.

Soils, usually in forested regions, in which leaching has resulted in significant translocation of clay from the A to the B horizon (Bt). Usually they have a light gray eluvial horizon (Ae). The great groups are: Gray Brown Luvisol - mild soil climate and forest mull Ah; Gray Luvisol - cold to cool soil climate with usually less than 5 cm Ah.

Organic order.

Soils composed dominantly of organic materials (more than 17% organic carbon) of the required thickness (usually 60 cm for fibric materials and 40 cm for others). Great groups are: Fibrisol - mainly fibres that are not decomposed; Mesisol - more decomposed than Fibrisol; Humisol - highly decomposed, few fibres; Folisol - composed mainly of thick leaf litter over rock.

Podzolic order.

Acid soils developed under forest and heath; they have a B horizon enriched in humified organic matter and Al and Fe weathering products, usually underlying a light gray, weathered Ae horizon. Great groups are: Humic Podzol - B depleted of Fe; Ferro-Humic Podzol - B rich in organic matter combined with Al and Fe; Humo-Ferric Podzol - B contains less organic matter than Ferro-Humic Podzol.

Regosolic order.

Development of genetic horizons is absent or very weakly expressed. Great groups are: Humic Regosol - has a dark, mineral-organic surface horizon (Ah); Regosol - either lacks or has a thin Ah.

Solonetzic order.

Soils associated with saline materials and having prismatic or columnar structured, Na-rich, B horizons that are hard when dry and nearly impermeable when wet. They occur mainly in the grasslands associated with Chernozemic soils. Great groups are: Solonetz - lacks a well-developed eluvial Ae; Solodized-Solonetz - has a well-developed Ae; Solod - has an Ae and an AB in which the structure of the former B has disintegrated.

Subgroups are formed by subdivisions of great groups according to kind and arrangement of horizons indicating conformity to the central concept of the great group, intergrading to other orders, or additional special horizons. Families are differentiated from subgroups on the basis of parent material characteristics, soil climate factors and soil reaction. Series are differentiated from families on the basis of detailed soil features.

Classification Correlation

Canadian	USA	FAO
Brunisolic	Inceptisol	Cambisol
Chernozemic	Mollisol	Kastanozem, Chernozem, Rendzina
Cryosolic	Pergelic subgroups	Gelic subgroups
Gleysolic	Aquic suborders	Gleysol, Planosol
Luvisolic	Alfisol	Luvisol
Podzolic	Spodosol	Podzol
Organic	Histosol	Histosol
Solonetzic	Natric great groups	Solonetz

APPENDIX B: METHODS OF ANALYSIS

Soil descriptions - follow the standard conventions outlined in the Canadian System of Soil Classification (Canada Soil Survey Committee, 1978).

Analytical methods - are described in the Manual on Soil Sampling and Methods of Analysis (Canada Soil Survey Committee, 1976).

General procedures are as follows:

pH: saturated paste (H_2O) and neutral salt (0.01 M $CaCl_2$)
Total C: induction furnace method
$CaCO_3$ equiv: calcimeter method
Total N: semi-micro Kjeldahl
Exchangeable cations:
- a. neutral salt - extracting with 2N NaCl
- b. pH 7 - buffered ammonium acetate

Iron and aluminum:
- a. dithionite - citrate - bicarbonate
- b. acid ammonium oxalate (pH 3)
- c. sodium pyrophosphate (0.1M)

Water soluble salts: ions were determined on saturated extracts.
Available nutrients:
- a. N - modified P1 Bray (NH4F-H_2SO_4) extract
- b. P - modified P1 Bray (NH4F-H_2SO_4) extract
- c. K - ammonium acetate (1N)
- d. S - 0.1 M $CaCl_2$

Organic matter: classical NaOH/$Na_4P_2O_7$ extractions
Mineralogy: x-ray diffraction of the <2 µm soil fraction
Fibre content: syringe method for fibres retained on 100 mesh seive
Bulk density: saran-coated clod method, coarse fragments included
Water holding capacity: pressure plate method
Atterberg limits: standard procedure

APPENDIX C FORMAT FOR MICROMORPHOLOGICAL DESCRIPTIONS

The descriptions of soil micromorphology begin with a brief paragraph summarizing the main features of the microfabric in general terms. The relative frequencies, sizes or areal extent of features such as voids and nodules are indicated in brackets following the feature described. The technical name of the fabric in (1) Brewer's (1964) and (2) Brewer's and Pawluk's (1975) terminology is given following the general paragraph. On some occasions only the terminology that is best suited or most descriptive is used.

Illumination In these descriptions the following abbreviations are used to correct the illumination used

plane light - light vibrating in one direction
X polarizers - with crossed polarizers
partly X - with partly crossed polarizers

Magnifications used for descriptions

a) 25x - for colour, and arrangement of large peds and/or aggregates
b) 63X - for arrangement of smaller units and more detailed description
c) 125X - for examination of specific features.

Guide to relative frequencies of pedological features - after Stace *et al* (1968)

a) cutans more frequent (F) >5% of the area
common (C) 5-2%
occasional (O) 2-0.5%
rare (R) rare but easily located and identified
very rare (VR) section must be searched to positively identify them.

b) nodules (F) >20% of the area
(C) 10-20%
(O) 5-10%
(R) 2-5%
(VR) <2%

Description of overall porosity

Using only those voids greater than 25μm in diameter
<5% - very dense
5-10% - dense
10-25% - moderately porous or moderately packed
25-40% - highly porous or loosely packed
>40% - extremely porous or very loosely packed

Note: a horizon that consists of well packed fine sand and silt at low magnification is silasepic porphyroskelic while at higher magnification it is granular. On some occasions, both fabrics will be stated along with the applicable magnification.

Types of banded fabrics - after Dumanski and St. Arnaud (1966)

1. isoband
2. banded fabric type A
3. banded fabric type B
4. banded fabric type C

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APPENDIX D SITE, PEDON AND MICROMORPHOLOGICAL DESCRIPTIONS AND ANALYTICAL DATA

Soil descriptions follow standard methods as presented in the Canadian System of Soil Classification.

Parent materials at soil sites in British Columbia were described by J.M. Ryder, Geology Section, Resource Inventory Division, B.C. Ministry of Environment, Victoria. The descriptions relate, in general, to material below the base of the B horizon. Terminology is after Wentworth; "pebble" and "cobble" terms have no shape or roundness connotation.

Description of a Duric Ferro-Humic Podzol at the Mount Seymour Site

Classification:	Canada - Duric Ferro-Humic Podzol, coarse loamy, mixed, acid, cool humid family U.S.A. - Orthic Haplohumod, coarse loamy, mixed, frigid family F.A.O. - Orthic Podzol
Location:	North Vancouver District Municipality on side road near television transmission tower, Mt. Seymour, 49°21'12"N 122°20'28"W. (Mount Seymour Provincial Park)
Elevation:	870 m a.s.l.
Climate:	Maritime with high precipitation (3000-4500 mm <), mild winters and cool summers.
Vegetation:	Tsuga heterophylla, T. mertensiana, Abies amabilis, Thuja plicata, Alnus rubra, Vaccinium parvifolium, V. ovalifolium, Rubus spectabilis.
Landform:	Severely hummocky, sloping morainal blanket.
Parent Material:	Coarse skeletal morainal (till)
Slope:	Complex, upper slope, 18%, aspect 205°
Drainage:	Moderately well drained, moderately permeable, slow runoff; seepage present.
Land Use:	Water supply area, recreation

Horizon	Depth (cm)	Description
L	38-36.5	Fresh needles and leaves
F1	36.5-17	Abundant, medium and fine roots, randomly oriented; extremely acid; clear wavy boundary to -
F2	17-6	Dusky red (10R 3/4, m) and red (10R 4/6, d) and very dusky red (10R 2/2, d); organic litter; strong, medium granular; abundant, coarse, and medium exped roots, randomly oriented; extremely acid; clear, wavy boundary to -
H	6-0	Red (7.5R 2/2, m and d); well decomposed organic litter; strong, fine to medium granular; abundant, medium and fine exped roots, randomly oriented; extremely acid; clear, wavy to -
Ae	0-4	Brown (10YR 5/3, m) and light gray (10YR 7/1, d) fine sandy loam; moderate, medium and coarse, subangular blocky breaking to strong, medium granular; nonsticky, friable, hard, slightly plastic; continuous, weak cementation; plentiful, fine, inped roots, vertically oriented; abundant, very fine pores, randomly oriented; 3% gravels; extremely acid; abrupt, irregular, broken boundary to -
Bf	4-12	Very dusky red and dark reddish brown (2.5YR 2/2 & 3/4, m) and reddish brown (5YR 4/3, d) and very pale brown (10YR 7/4, d); sandy loam; moderate to strong, medium, subangular blocky breaking to strong, fine and medium granular; nonsticky friable slightly hard, nonplastic; continuous, weak cementation; plentiful, medium, inped roots, vertically oriented; spherical concretions are common, fine and scattered throughout the matrix (yellowish brown and brown); 5% gravels; extremely acid; clear, irregular boundary to -
Bhf1	12-27	Black (7.5YR 2/0, m and d) sandy loam; moderate to strong, medium, subangular blocky breaking to moderate, fine granular; nonsticky, friable, soft, nonplastic; plentiful, fine and medium inped roots, vertically oriented; plentiful micro, inped pores randomly oriented; few, very thin clay films on ped surfaces; spherical concretions are common, fine, and scattered throughout the matrix (yellowish brown and brown); 5% gravels, extremely acid; clear, irregular boundary to -
Bhf2	27-42	Dark reddish brown (2.5YR 2/4, m) and dark reddish brown (5YR 3/4, m) and reddish yellow and dark brown (7.5YR 6/6, & 4/4, d); sandy loam; moderate to strong, medium subangular blocky breaking to strong, fine, granular; nonsticky, friable, soft, nonplastic; plentiful, fine and medium inped roots, vertically oriented; plentiful, fine inped pores, randomly oriented; few, very thin clay films in channels or pores only; spherical concretions are common, fine and scattered throughout the matrix (yellowish brown and brown); 5% cobbles, 5% gravels; extremely acid; clear, irregular boundary to -

Bfgj	42-59	Dark brown (10YR 4/3, m) and brown and dark brown (10YR 5/3 & 4/2, d); sandy loam; moderate to strong, medium subangular blocky breaking to strong, fine granular; nonsticky, friable, soft, slightly plastic; few, fine, prominent mottles (dark reddish brown); plentiful, fine and medium inped roots, vertically oriented; plentiful, fine, inped pores, randomly oriented; few, very thin clay films in channels and pores only; 5% cobbles, 5% gravels; extremely acid; clear, irregular boundary to -
Bcgj	59-80	Grayish brown to light olive brown (2.5Y 5/2 to 5/4, m) and light yellowish brown and light olive brown (2.5Y 6/4 and 5/4, d); sandy loam; moderate and strong, medium and coarse platy; nonsticky, friable, very hard, slightly plastic; continuous, strong cementation; very few, fine, exped roots; obliquely oriented; plentiful, micro, inped pores, randomly oriented; common, very thin clay films as bridges between sand grains; many, coarse, prominent mottles (dark reddish brown); 10% cobbles, 15% gravels; very strongly acid; clear, irregular boundary to -
C	80-95	Dark yellowish brown (10YR 4/4, m) and light brownish gray and light yellowish brown (2.5Y 6/2 & 6/4, d); sandy loam; massive breaking to strong, medium, angular blocky; slightly sticky, friable, very hard, plastic; many, fine, distinct mottles (dark brown); very few, fine, exped roots, obliquely oriented; few, micro, inped pores, randomly oriented; common, thin clay films on ped faces; 5% gravels; very strongly acid; clear, wavy boundary to -
Cgj1	95-131	Olive brown (2.5Y 4/4, m) and light gray and white (2.5Y 7/2 & 8/4, d); sandy loam; massive breaking to medium and coarse angular blocky; nonsticky, friable,hard, plastic; common, medium and fine, distinct mottles (brown); roots absent; plentiful, medium, inped pores, randomly oriented; few very thin clay films in channels and pores only; 10% stones, 20% cobbles; 20% gravels; very strongly acid; gradual, wavy boundary to -
Cgj2	131+	Olive brown (2.5Y 4/4, m) and light gray (2.5Y 7/2 & 8/4, d); cobbly, gravelly sandy loam; massive breaking to strong, medium and coarse, angular blocky; nonsticky, friable, hard, plastic; many, coarse, distinct mottles (brown); roots absent; plentiful, medium, inped pores, randomly oriented; few, very thin clay films in channels and pores only; 10% stones, 20% cobbles, 25% gravels; very strongly acid.

Described by A.J. Green, September 27, 1976.

PARENT MATERIAL DESCRIPTION

The parent material is a compact, partially indurated till. It is roughly one m thick at the site, but locally varies in thickness from zero to several m. The local bedrock is granite of the Coast Plutonics complex, (Roddick, 1965).

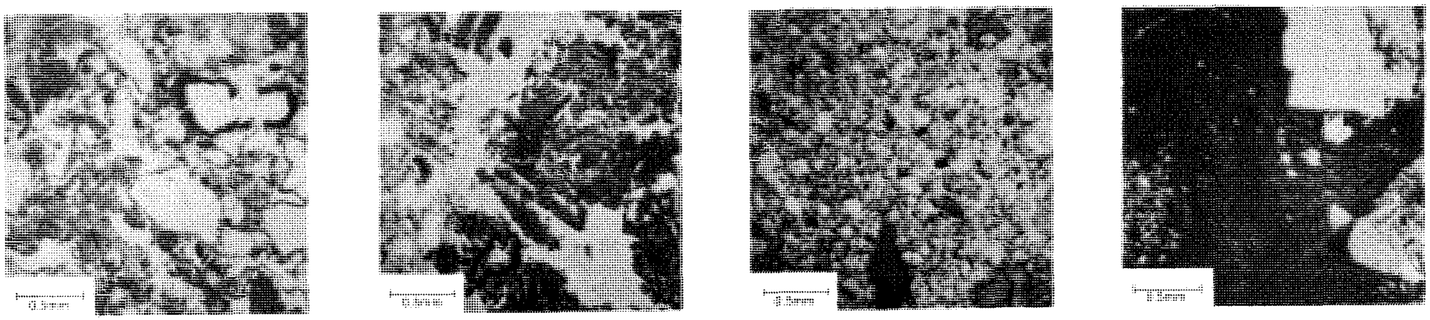
The matrix of the till is not homogeneous, but consists of irregular zones and lenses that vary in texture from gritty sandy silt to gritty sand. The general colour of the matrix is grayish brown to light olive brown, but this is modified in many places by patches of rusty colouration that result from oxidation. Clasts are distributed irregularly throughout the till, so that although the overall proportion of clasts is relatively low (estimated at 1% of total volume), there are places where stones in clusters constitute as much as 25% of the till material. The clasts range in size from pebbles to large boulders; most are subangular and blocky in shape. They consist predominantly of locally occurring plutonic rocks such as granite, granodiorite and quartz diorite, and andesite is also present. Granitic clasts are commonly weathered and disintegrate when disturbed into a gritty sand. In general, the characteristics of this till reflect its derivation from the underlying and adjacent bedrock types.

TABLE 10. ANALYTICAL DATA FOR A DURIC FERRO-HUMIC PODZOL AT THE MOUNT SEYMOUR SITE
DONNEES ANALYTIQUES DU PODZOL FERRO-HUMIQUE DURIQUE A STATION MOUNT SEYMOUR

Horizon	pH H_2O	pH $CaCl_2$	C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de bases	Exchangeable Cations / Cations échangeables Ca	Mg	K	Na
			%	%		me/100g	%	me/100g	me/100g	me/100g	me/100g
L											
F1	3.89	3.26	22.64	0.591	38.31	76.01	2.01	0.75	0.28	0.38	0.12
F2	3.43	2.89	41.22	0.852	48.38	125.05	10.07	9.81	2.08	0.45	0.25
H	3.20	2.72	54.02	1.540	35.08	117.50	9.86	13.11	3.62	0.33	0.44
Ae	3.34	2.84	5.63	0.185	30.43	18.49	3.62	0.44	0.10	0.07	0.06
Bf	3.96	3.44	6.95	0.318	21.86	34.93	1.49	0.28	0.11	0.08	0.05
Bhf1	4.76	4.04	7.87	0.227	34.67	67.68	0.46	0.23	0.03	0.02	0.03
Bhf2	4.97	4.30	5.51	0.165	33.39	40.65	0.71	0.18	0.02	0.06	0.03
Bfgj	5.09	4.53	3.64	0.092	39.57	25.26	0.87	0.13	0.02	0.05	0.02
Bcgj	5.32	4.73	0.61	0.023	26.52	8.70	1.84	0.01	0.01	0.02	0.02
C	5.45	4.90	0.45	0.014	32.14	6.02	3.49	0.14	0.01	0.03	0.03
Cgj1	5.76	4.85	0.19	0.009	21.11	7.70	4.42	0.24	0.01	0.05	0.04
Cgj2	5.66	4.62	0.11	0.007	15.71	7.27	25.17	1.58	0.01	0.07	0.07

Horizon	Part. Size Dist. (<2mm) anal. gran. Sand/Sable	Silt/Limon	Clay/Argile	F-Clay/Argile-F	P Bray 1	P Bray 2	Pyrophos. Fe	Pyrophos. Al	Oxalate Fe	Oxalate Al	Bulk D. Densité apparente	Hygro. Moisture Humidite Hygro.
					ppm	ppm	%	%	%	%		%
L												
F1					5.1	9.5	0.82	0.97	0.96	1.11		8.19
F2					4.2	7.9	0.27	0.32	0.30	0.44		12.39
H					5.4	8.2	0.03	0.18	0.07	0.17		13.56
Ae	55.51	39.15	5.74	0.62	1.3	3.0	0.20	0.07	0.56	0.11	1.19	1.56
Ae-Bhf					5.2	8.1	0.87	0.47	0.98	0.52	1.06	3.19
Bf	66.70	29.14	4.16	0.00	8.4	8.8	0.75	2.18	0.96	3.73	1.07	8.93
Bhf2	62.12	35.08	2.79	0.00	5.8	10.5	0.56	1.43	0.83	2.89	1.32	5.97
Bfgj	70.70	27.11	2.19	0.31	10.6	24.1	0.23	0.84	0.48	2.02	1.31	4.57
Bcgj	64.26	33.32	2.42	0.10	20.2	48.3	0.07	0.32	0.38	0.79	1.80	1.74
C	55.00	45.29	2.41	0.19	45.0	91.0	0.02	0.20	0.13	0.57	1.84	1.10
Cgj1	69.96	26.83	3.21	0.68	67.5	119.5	0.02	0.20	0.13	0.55	1.90	1.29
Cgj2	70.65	25.47	3.88	0.67	46.8	72.7	0.02	0.14	0.18	0.26		0.98

Figure 72. Micromorphology of the Duric Ferro-Humic Podzol at the Mount Seymour site



a. plane light b. partly X c. plane light d. plane light

Ae The horizon is moderately porous with skeleton grains of sand (F) and some igneous and metamorphic rock fragments (0) set in an open brown matrix of clay and silt (Fig. a). Dark brown cross sections of well decomposed plant remains occur particularly in voids, but some are in the matrix material. There are small broken organic fibres throughout the matrix and around grains.
-1- agglomeroplasmic

Bf The moderately porous fabric consists of rock fragments up to 3mm in size of igneous and metamorphic origin (0), sand grains and silt grains of quartz, felspar, quartzite (C), amphiboles and pyroxenes (0) embedded in highly ferruginous aggregates of clay and fine silt. Voids are lined with thick isotropic ferrans which sometimes form zones of complete aggregates (Fig. b). Organic matter remnants (0) occur in voids and some are incorporated in the matrix. Matrans are (0) around skeleton grains.
-1- asepic to isotic agglomeroplasmic

Bcgj The dense fabric consists of rock fragments up to 4mm in size (0), sand grains (F-C) of quartz, quartzite, and feldspar, and silt sized grains of quartz, mica and feldspar embedded in a compact matrix of fine silt and some clay (Fig. c). Thin isotropic ferrans and anisotropic argillans occur around some grains and in small voids.
-1- silasepic porphyroskelic

C The dense fabric is slightly bedded with some compact layers of fine silt and clay, and other layers with sand and rock fragments up to 4mm embedded in fine silt (Fig. d). The rock fragments are igneous and metamorphic. The sand grains are quartz, feldspar, quartzite and some hornblende (C). The silt grains (F-C) are mica, quartz and feldspar. Ferriginous deposits (0-C) are scattered throughout the fabric. They vary in size from 100-300μm. Bands of clay occur in the finer layers of the fabric.
-1- silasepic porphyroskelic

Photograph by D. Moon

FIG. 73 COASTAL MOUNTAIN HEMLOCK ZONE TYPICAL OF VEGETATION AT THE MOUNT SEYMOUR SITE

Description of a Sombric Humo-Ferric Podzol at the Abbotsford substation site.

Classification:	Canada - Sombric Humo-Ferric Podzol, coarse loamy over sandy skeletal, mixed, acid, mild subhumid family
	U.S.A. - Typic Haplorthod, coarse loamy over sandy skeletal, mixed, mesic family
	F.A.O. - Dystric Cambisol
Location:	Agriculture Canada small fruit substation, NW 1/4 Sec 5 Tp 16 Matsqui Municipality 49°01'20"N 122°20'28"W
Elevation:	60 m a.s.l.
Climate:	ref. Abbotsford airport
Vegetation:	cropland
Landform:	glaciofluvial plain
Parent Material:	silty loess over gravel
Slope:	midslope, 1-2%
Drainage:	well drained, moderately permeable, very slow runoff
Land Use:	mixed farming

Horizon	Depth (cm)	Description
Ap	0-9	Dark brown (7.5YR 3/2, m) and dark brown (10YR 3/3, d); silt loam; moderate, medium subangular blocky and granular; slightly sticky, very friable, soft, slightly plastic; abundant, very fine inped roots, randomly oriented; few, fine, spherical concretions throughout matrix; occasional round gravel; strongly acid; some fragments of charcoal and wood; clear, wavy boundary to -
Bf1	9-17	Dark reddish brown (5YR 3/3, m) and dark brown (7.5YR 4/4, d); silt loam; moderate, medium and fine subangular blocky; slightly sticky, friable, slightly hard, slightly plastic; abundant, very fine inped roots, randomly oriented; few to common, fine and medium spherical concretions throughout matrix; occasional round gravel; very strongly acid; gradual wavy boundary to -
Bf2	17-29	Dark brown (7.5YR 4/4, m) and yellowish brown (10YR 5/4, d); silt loam; moderate, medium, subangular blocky; slightly sticky, friable, slightly hard, slightly plastic; abundant, very fine inped roots, randomly oriented; few to common, fine and medium spherical concretions throughout matrix; occasional round gravel; very strongly acid; distinct, smooth boundary to -
Bm1	29-46	Dark brown (7.5YR 4/4, m) and yellowish brown (10YR 5/4, d); silt loam; moderate, medium and coarse, subangular blocky; slightly sticky, friable, slightly hard, slightly plastic; plentiful, very fine inped roots, randomly oriented; few to common, fine and medium spherical concretions throughout matrix; occasional round gravel; strongly acid; gradual wavy boundary to -
Bm2	46-63	Strong brown (7.5YR 4.5/4, m) and yellowish brown to light yellowish brown (10YR 5/4-6/4, d); silt loam; weak to moderate, medium and coarse, subangular blocky; slightly sticky, friable, slightly hard, slightly plastic; abundant, very fine inped roots, randomly oriented; few, fine and medium spherical concretions throughout matrix; occasional round gravel; very strongly acid; gradual, wavy boundary to -

Bm3	63-73	Dark yellowish brown (10YR 3/6, m) and light yellowish brown (10YR 6/4, d); silt loam; weak to moderate, medium and coarse, subangular blocky; slightly sticky, friable, slightly hard, slightly plastic; abundant, very fine inped roots, randomly oriented; few, fine and medium spherical concretions throughout matrix; occasional round gravel; very strongly acid; gradual, smooth boundary to -
IICB	73-90	Dark yellowish brown (10YR 4/4, m) and brown to pale brown (10YR 5/3-6/3, d); gravelly sand; structureless; nonsticky, loose, nonplastic; few, very fine roots; randomly oriented; 5% cobbles, 35% gravels; strongly acid; gradual, smooth boundary to -
IIC1	90-124	Variegated colours; gravelly sand; structureless; single grain; nonsticky, loose, nonplastic; few, very fine roots, randomly oriented; 5% cobbles, 35% gravels; strongly acid; gradual, smooth boundary to -
IIC2	124-145	Variegated colours; gravelly sand; structureless; single grain; nonsticky, loose, nonplastic; very few roots, randomly oriented; 5% cobbles; 35% gravels; strongly acid; gradual, smooth boundary.

Profile described by H. Luttmerding, 1976.

CLAY MINERALOGY

A large amount of X-ray amorphous material is present in all horizons. Traces of vermiculite and chlorite are present in the C horizon, as well as at the surface, and contribute to vermiculitized chlorite. Mica is absent, quartz and feldspar are present, throughout the profile.

PARENT MATERIAL DESCRIPTION

The parent material consists of non-compact silt overlying pebbly sand. In test pits, the thickness of the silt varied between 10 and 35 cms; the base of the sand was not reached. No bedding was visible in either unit. The contact between the two units is gradational; the pebbly sand grades upwards into silty sand which in turn grades upwards into sandy silt with granules.

The silt unit consists of dark yellowish brown medium to coarse silt. It contains scattered granules and small pebbles that together constitute less than 1% of the material. These are mostly subangular and many of them display some sharp edges and fresh faces which have resulted from breakage et al. The pebbles consist of various volcanic rock types and a wide range of other lithologies.

The underlying pebbly sand is slightly oxidized and its colour is dark yellowish brown. It is poorly sorted and consists of a mixture of particle sizes ranging from fine sand to granules and pebbles. The pebbles constitute less than 10% of the total deposit. The sand consists chiefly of quartz grains, and includes minor amounts of dark (ferromagnesian) minerals and lithic fragments. The larger sand grains are subangular and subrounded.

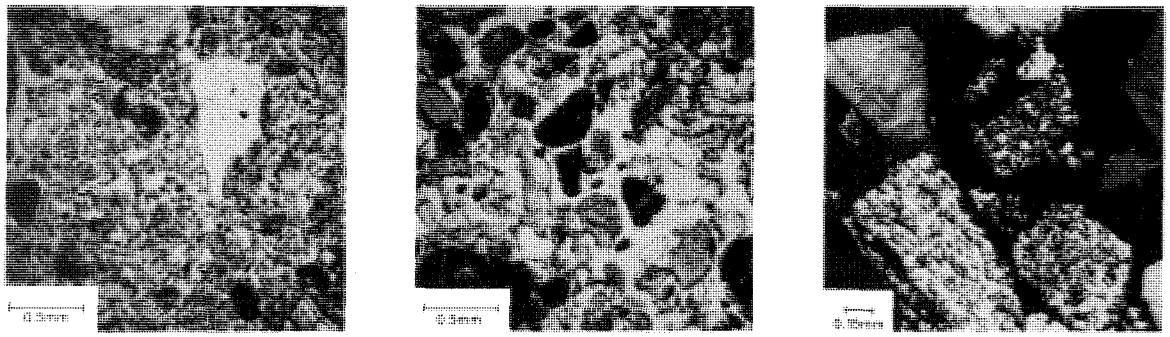
According to Armstrong (1960), this site lies within an extensive area of late-glacial sand and gravel deposits which he termed "Abbotsford Outwash". These sediments are over 30 m thick in places. The characteristics of the pebbly sand described above are in accord with this mode of origin. The overlying stoney silt probably accumulated in shallow temporary lakes that occupied abandoned channels or other depressions on the old outwash surface. Alternatively, the silt may be partially of eolian origin. The stones may have been incorporated into the silt veneer by frost heave or biological disturbance.

TABLE 11. ANALYTICAL DATA FOR THE SOMBRIC HUMO-FERRIC PODZOL AT ABBOTSFORD SUBSTATION SITE
DONNEES ANALYTIQUES DU PODZOL HUMO-FERRIQUE SOMBRIQUE A STATION ABBOTSFORD

Horizon	pH		C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de bases	Exchangeable Cations Cations échangeables			
	H_2O	$CaCl_2$						Ca	Mg	K	Na
			%	%		me/100g	%	me/100g			
Ap	5.38	5.32	12.75	0.875	14.57	51.32	56.80	25.05	3.23	0.81	0.06
Bf1	4.07	4.69	4.06	0.209	19.52	28.07	18.85	4.13	0.79	0.34	0.03
Bf2	5.14	4.80	2.87	0.159	18.05	22.88	13.94	2.25	0.58	0.34	0.02
Bm1	5.51	5.16	1.23	0.072	17.08	12.67	17.13	1.28	0.46	0.41	0.02
Bm2	5.76	5.06	0.98	0.055	17.82	10.78	13.08	0.50	0.11	0.78	0.02
Bm3	5.84	5.12	0.75	0.038	19.74	9.09	15.51	0.38	0.07	0.94	0.02
IICB	5.61	5.12	0.42	0.021	20.00	6.01	15.31	0.19	0.03	0.68	0.02
IIC1	6.15	5.31	0.20	0.010	20.00	3.87	9.56	0.14	0.02	0.19	0.02
IIC2	6.27	5.40	0.12	0.007	17.14	2.26	16.37	0.16	0.04	0.16	0.01

Horizon	Part. Size Dist. (<2mm) anal. gran.				P		Pyrophos.		Oxalate		Hygro. Moisture Humidite Hygro.
	Sand Sable	Silt Limon	Clay Argile	F-Clay Argile-F	Bray 1	Bray 2	Fe	Al	Fe	Al	
					ppm	ppm	%	%	%	%	%
Ap	22.04	67.24	10.72	1.42	382.1	1342.4	0.45	0.51	0.78	0.94	5.72
Bf1	27.75	66.84	5.41	0.00	140.4	232.7	0.49	0.65	0.87	1.40	3.44
Bf2	30.83	65.77	3.40	0.00	49.2	90.9	0.34	0.61	0.86	1.28	3.29
Bm1	36.29	60.42	3.29	0.00	20.3	43.4	0.08	0.31	0.27	0.78	2.16
Bm2	46.73	49.91	3.36	0.00	14.2	40.7	0.07	0.30	0.54	0.71	1.74
Bm3	63.35	34.21	2.44	0.00	20.8	55.9	0.05	0.21	0.43	0.94	1.60
IICB	81.24	17.05	1.71	0.00	52.9	124.7	0.03	0.15	0.29	0.43	0.98
IIC1	96.18	2.42	1.40	0.00	84.5	110.7	0.01	0.14	0.15	0.33	0.57
IIC2	96.52	2.74	0.74	0.00	53.3	77.2	0.01	0.07	0.13	0.23	0.33

Figure 74. Micromorphology of the Sombric Humic-Ferric Podzol at the Abbotsford Substation Site



a. plane light b. plane light c. partly X

Bfl The moderately dense brown fabric (Fig. 74a) consists of sand sized quartz, quartzite and feldspar skeleton grains (C) in a matrix of fine aggregates of clay and silt. The aggregates are joined together. Organic matter remnants occur in the voids and in the matrix. Matrans (C) and thin weakly oriented ferriargillans (O) exist round sand grains. Ferruginous concentrations (up to 300μm, O) occur in the aggregates.
-1- silasepic agglomeroplasmic
-2- silasepic matrigranoidic

Bm2 The porous fabric consists of rock fragments (O) of metamorphic and igneous origin and sand grains (C) of quartz, feldspar, amphiboles and pyroxenes with coatings, bridges and aggregates of dull brown matrix material of clay and silt (Fig. 74b). Many rock fragments are highly weathered. There are ferruginous nodules (O). Matrans (R) up to 300μm thick surround some sand grains.
-1- silasepic intertextic
-2- matriplectic

IIC2 The highly porous fabric consists of rock fragments of igneous and metamorphic origin, up to 5mm in size (O) and sand (C) and silt grains (C) of quartz, feldspar, pyroxenes and amphiboles (Fig. 74c). There is no matrix material. Thin weakly oriented ferriargillans coat some grains.
-1- granular
-2- orthogranic

Courtesy of British Columbia Government

FIG. 75 FARMLAND NEAR THE ABBOTSFORD SUBSTATION SITE

Description of an Orthic Gray Luvisol at the Similkameen Mine Site

Classification:	Canada - Orthic Gray Luvisol, loamy skeletal, mixed, alkaline, weakly calcareous, cool subhumid family U.S.A. - Typic Cryoboralf, loamy skeletal, mixed family F.A.O. - Albic Luvisol
Location:	About 16 km SW of Princeton on old Highway over Kennedy Mtn. 49°19'20"N 120°34'15"W.
Elevation:	1160 m a.s.l.
Climate:	Continental with long cold winters and short warm summers; annual precipitation is 360 mm.
Vegetation:	Typical species include Lodgepole Pine, Rocky Mountain Douglas Fir and Pinegrass.
Landform:	morainal blanket
Parent Material:	fine loamy morainal
Slope:	complex, midslope, 15%; aspect 135°
Drainage:	well drained, slowly pervious, moderate runoff
Land Use:	productive forest; forest grazing

Horizon	Depth (cm)	Description
F-H	1-0	Dark reddish brown (5YR 3/2, m) and gray (10YR 5.5/1, d); thin mesic fibrimor; abrupt, broken boundary to -
Ah	0-2	Very dark gray (10YR 3/1, m); loam; weak, fine granular; nonsticky, friable, soft, nonplastic; plentiful, fine, exped roots, vertically oriented; many, fine, inped and exped pores; medium acid; abrupt, broken boundary to -
Ae1	2-15	Brown (10YR 5/3, m) and light brownish gray (10YR 6/2, d); stony, cobbly, gravelly loam; weak, fine granular; nonsticky, very friable, soft, nonplastic; plentiful, fine, inped and exped roots; many, fine, inped and exped pores; strongly acid; clear, wavy boundary to -
Ae2	15-24	Brown (10YR 5/3, m) and pale brown (10YR 6/3, d); stony, cobbly, gravelly loam; moderate, fine and medium subangular blocky; nonsticky, friable, soft, nonplastic; plentiful, fine and medium inped and exped roots, horizontally oriented; many, fine inped and exped pores; strongly acid; clear, wavy boundary to -
AB	24-34	Brown (10YR 5/3, m) and pale brown (10YR 6.5/3, d); stony, cobbly, gravelly loam; moderate, medium subangular blocky breaking to moderate, fine angular blocky; sticky, firm, slightly hard, plastic; plentiful, fine inped roots, vertically oriented; many, fine inped and exped pores; strongly acid; clear, wavy boundary to -
Bt	34-83	Dark yellowish brown (10YR 4.5/3, m) and very pale brown (10YR 7/4, d); stony, cobbly, gravelly clay loam; weak to moderate, fine and medium angular blocky; sticky, firm, hard, plastic; plentiful, fine, inped roots, vertically oriented; common, fine, exped pores; common, thin clay films in voids and channels; strongly acid; gradual, wavy boundary to -
BC	83-109	Brown (10YR 4.5/3, m) and very pale brown (10YR 7/3, d); stony cobbly, gravelly loam; very weak, medium, subangular blocky; sticky, friable, hard, plastic; few, fine, inped roots vertically oriented; few, fine, inped pores; slightly acid; abrupt, broken boundary to -
Ck	109-220	Brown (10YR 5/3, m) and very pale brown (10YR 7/3, d); stony, cobbly, gravelly loam; structureless, massive; sticky, firm, hard, plastic; few, fine inped roots, horizontally oriented; very few, very fine pores; moderate effervescence; secondary carbonate as few, medium horizontal streaks and oblong spots that are friable and soft; mildly alkaline.

Described by J.H. Day, 1975.

PARENT MATERIAL DESCRIPTION

The parent material is a compact, massive till that locally is at least 6 m in thickness.

The till matrix is a sandy silt that also contains a small amount of clay. Its colour is light olive brown. Clasts constitute 20 to 25% of the till and consist of angular and subangular pebbles and cobbles, and occasional boulders. Angular clasts consist of rock types that occur locally as bedrock, chiefly lavas and argillite of the Nicola Group, (Rice, 1960). Many different lithologies are represented in the relatively rounded erratics; andesite, basalt, tuff, syenite and granite are most common.

CLAY MINERALOGY

Abundant smectite, minor chlorite and traces of vermiculite are present in the parent material and decrease upward through the profile. Vermiculite is chloritized in the B horizon and in the surface horizons where X-ray amorphous material is abundant. Quartz and feldspar are weak but constant in amount throughout the profile.

TABLE 12. ANALYTICAL DATA FOR AN ORTHIC GRAY LUVISOL AT THE SIMILKAMEEN MINE SITE
DONNEES ANALYTIQUES DU LUVISOL GRIS ORTHIQUE A STATION SIMILKAMEEN MINE

Horizon	pH H_2O	pH $CaCl_2$	C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de bases	Exchangeable Cations / Cations échangeables Ca	Mg	K	Na
			%	%		me/100g	%	me/100g			
F-H				0.686		33.51	79.1	21.32	3.05	2.15	Tr
Ah	6.1	5.7	7.69	0.419	18.4	32.70	85.7	23.25	2.84	1.90	0.04
Ae1	5.9	5.3	1.44	0.089	16.2	12.52	78.2	8.05	0.96	0.77	0.01
Ae2	6.0	5.1	0.63	0.039	16.2	9.76	86.1	6.78	1.16	0.38	0.03
AB	6.1	5.3	0.70	0.041	17.1	14.68	84.0	10.07	1.76	0.46	0.04
Bt	5.8	5.3	0.54	0.039	13.9	18.32	86.7	12.25	2.94	0.61	0.08
BC	7.0	6.3	0.30	0.028	10.7	13.61	99.9	10.70	2.49	0.35	0.07
Ck	8.2	7.3	0.27	0.021							

Horizon	Part. Size Dist. (<2mm) anal. gran. Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile-F	P Bray 1	P Bray 2	$CaCO_3$ Equiv.
					ppm	ppm	%
F-H							
Ah							
Ae1	40.15	41.54	18.31	9.53	60.6		
Ae2	45.98	36.62	17.40	11.69	75.4		
AB	41.21	35.10	23.69	12.74	95.4		
Bt	37.98	32.04	29.98	19.82	83.0		
BC	42.99	33.77	23.24	13.34	21.7		
Ck	40.68	36.48	22.84	12.99	1.5		4.87

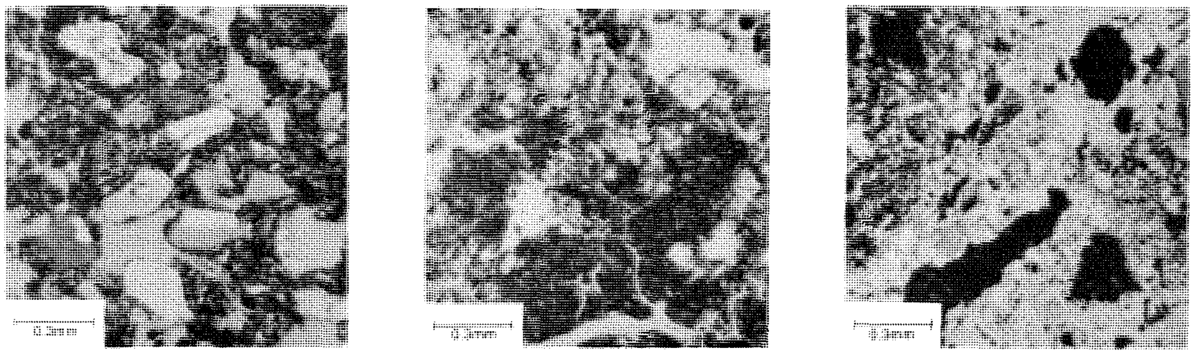
Table 13. Vegetation Structure at the Similkameen Mine Site.

Layer	Species	Cover Class*
Tree Layer: A		
A1	*Pinus contorta*	*1*
A2	*Pinus contorta*	*4*
	Pseudotsuga menziesii	*2*
Shrub Layer: B		
B1	*Pseudotsuga menziesii*	*2*
	Salix scouleriana	*2*
	Pinus contorta	*1*
B2	*Pseudotsuga menziesii*	*1*
	Rosa gymnocarpa	*1*
	Spiraea betulifolia	*1*
	Salix scouleriana	*1*
	Paxistima myrsinites	+
	Shepherdia canadensis	+
	Populus tremuloides	+
Herb Layer: C		
	Calamagrostic rubescens	*4*
	Astragalus miser	*2*
	Lupinus polyphyllus	*2*
	Arctostaphylos uva-ursi	+
	Lilium columbianum	+
	Aster conspicuus	+
	Linnaea borealis	+
	Carex concinnoides	+
	Orthilia secunda	+
	Castilleja miniata	*r*
Moss and Lichen Layer: D		
	Pleurozium schreberi	*2*

*Cover according to Braun Blanquet's system as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%
1 - numerous or scattered with cover up to 5%
+ - few, with small cover, r - solitary, with small cover

(Recorded for British Columbia Ministry of Environment, Resource Analysis Branch by T. Lea)

Figure 76. Micromorphology of the Orthic Gray Luvisol at the Similkameen Mine Site



a. partly X b. plane light c. X polarizers

Ae The fabric consists of irregularly shaped poorly formed aggregates 50μm to 1mm size, rock fragments up to 8mm in size (C), sand and silt grains (C) and organic fragments (R). Matrans (O) occur on the upper surfaces of rock fragments. Portions of the aggregates and some shards are isotropic giving evidence of volcanic ash.

-1- Silasepic agglomeroplasmic

-2- Phyto-ortho-matrigranic/matrigranoidic (Fig. a)

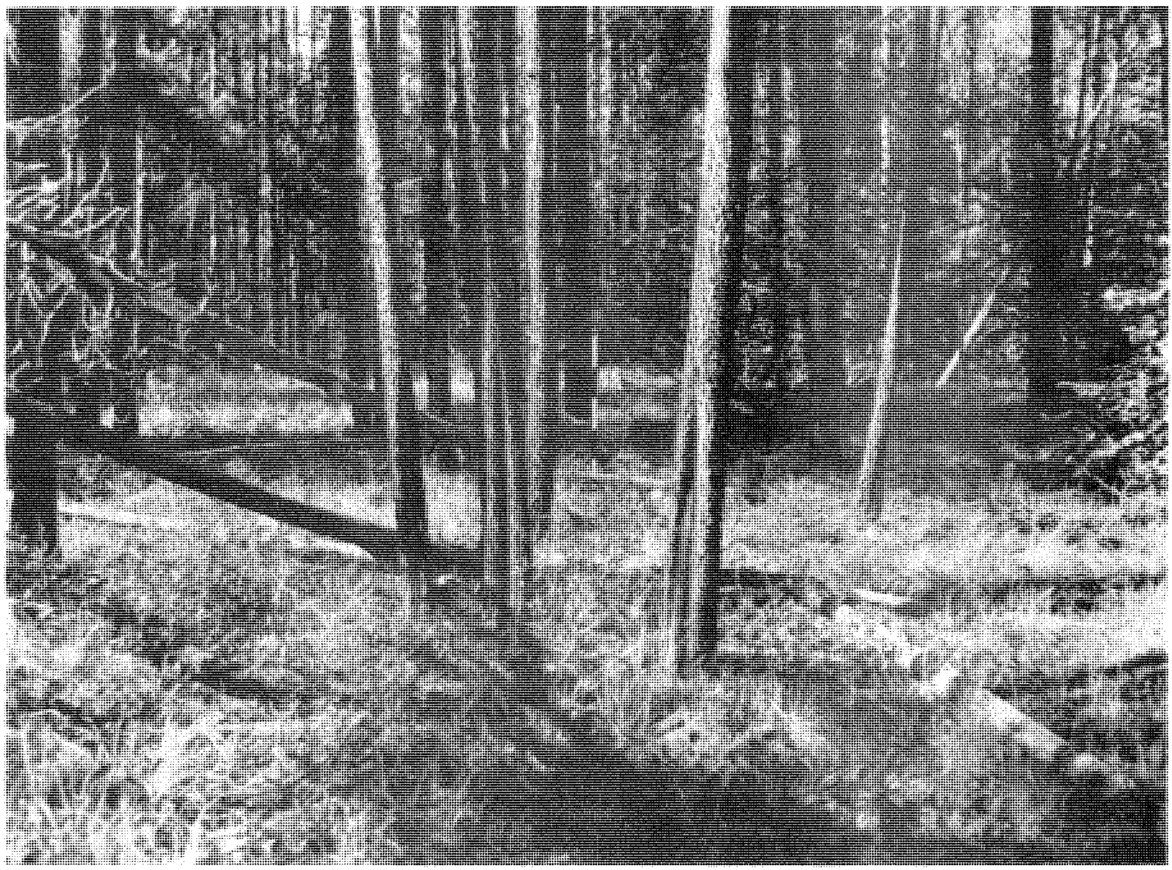
Bt The fabric consists of matrix material of silt and clay with sand grains (C) and rock fragments (F). Thin (5-10μm) moderately oriented argillans (O) coat some peds and vughs. Weakly oriented bodies of clay (R) (Fig. b) and brown ferruginous deposits (R) occur in the matrix. Moderately porous with skew planes and vughs.

-1- Silasepic to argillasepic porphyroskelic

Ck The fabric consists of a matrix material (occasionally separated into aggregates) of silt and clay with sand grains (O) and rock fragments (F). Calcitans (50-100μm thick, C) and calcareous aggregates (C) (Fig. c) with silt inclusions line the walls of vughs and chambers. Ferruginous nodules (R) occur in the matrix. The fabric is moderately porous.

-1- Silasepic porphyroskelic to agglomeroplasmic

-2- Matrigranoidic porphyroskelic



Photograph by A. McLean

FIG. 77 LODGEPOLE PINE ON AN ORTHIC GRAY LUVISOL, PRINCETON AREA

Description of an Orthic Sombric Brunisol at the Mount Kobau site.

Classification:	Canada - Orthic Sombric Brunisol, coarse loamy, mixed, acid, cool subhumid family U.S.A. - Umbric Dystrocrept, coarse loamy, mixed, frigid family F.A.O. - Dystric Cambisol
Location:	Roadcut near summit of Mt. Kobau
Elevation:	1990 m a.s.l.
Climate:	Continental with cold winters and hot summers
Vegetation:	The site is dominated by Big Basin Sagebrush with solitary stunted Alpine Fir
Landform:	sloping morainal blanket
Parent Material:	coarse loamy and coarse silty morainal and colluvial materials
Slope:	simple, lower slope, 15%; 270^{o} aspect
Drainage:	well drained, moderately pervious, slow runoff
Land Use:	grazing

Horizon	Depth (cm)	Description
Ah1	0-7	Black (10YR 2/1.5 m, crushed) and very dark gray (10YR 3/1.5 d, crushed); gravelly silt loam; weak, fine granular; nonsticky, very friable, soft, nonplastic; plentiful, fine exped roots, vertically oriented; many medium pores; very strongly acid; diffuse wavy boundary to -
Ah2	7-100	Very dark brown (10YR 2/2 m, crushed) and very dark grayish brown (10YR 3/2 d, crushed); gravelly silt loam; weak, fine granular; nonsticky, very friable, soft, nonplastic; plentiful, fine, exped roots, vertically oriented; many medium pores; very strongly acid; diffuse, wavy boundary to -
Bm1	100-110	Dark yellowish brown (10YR 3/4 m, crushed) and dark brown (10YR 4.5/3 d, crushed); cobbly, gravelly silt loam; weak, fine, subangular blocky; nonsticky, friable, slightly hard, nonplastic; very few, very fine, exped roots, vertically oriented; common, medium pores; very strongly acid; gradual, wavy boundary to -
Bm2	110-129	Dark brown (10YR 3/3 m, crushed) and brown to yellowish brown (10YR 5.5/3.5 d, crushed); cobbly, gravelly silt loam; weak to moderate, fine to medium subangular blocky; slightly sticky, friable, slightly hard, slightly plastic; very few, very fine, inped roots, vertically oriented; common, medium pores; extremely acid; gradual boundary to -
Bm3	129-161	Dark grayish brown (2.5Y 4/2 m, crushed) and brown (10YR 5/3 d, crushed); cobbly, gravelly silt loam; moderate, medium subangular blocky; sticky, friable, slightly hard, plastic; very few, very fine exped roots; vertically oriented; common, medium pores; common, thin clay skins in voids and channels; extremely acid; diffuse, smooth boundary to -

BC	161-180	Dark grayish brown (2.5Y 4/2 m, crushed) and pale brown (10YR 6/3 d, crushed); cobbly, gravelly silt loam; moderate, medium subangular blocky; slightly sticky, friable, slightly hard, slightly plastic; no roots present; common, medium pores; few, thin clay skins in voids and channels; very strongly acid.

Described by H.A. Luttmerding and J.H. Day, 1975. The Ah2 horizon was subsampled as follows: Ah2 7 to 27 cm, Ah3 27 to 47 cm, Ah4 47 to 67 cm, Ah5 67 to 84 cm, and Ah6 84 to 100 cm.

CLAY MINERALOGY

Abundant chlorite, a trace of mica, amphibole, talc and smectite are present in the parent material, and persist upward throughout the profile due to weak weathering.

PARENT MATERIAL DESCRIPTION

The soil parent material is tentatively identified as slopewash and rubbly moraine.

The slopewash constitutes the upper part (25 to 45 cm thick) of the material exposed in the roadcut section. It consists of massive silty sand containing scattered small clasts. The clasts consist of angular and subangular pebbles and granules of local bedrock types. The rubbly moraine consists of boulders and cobbles in the lower part of the section. The interstices between these clasts are filled with the relatively fine-textured slopewash material. 80% of the clasts consist of local bedrock types (schist and quartzite), whereas erratics of granite, diorite, syenite, gabbro and other plutonic lithologies constitute the remainder.

The surficial material appears to be infilling shallow depressions between bedrock outcrops, and is probably not more than 2 m in total thickness. Local bedrock consists of green schist and red quartzite of the Palaeozoic Kobau Group, (Bostock, 1939).

Glacial grooves and striae on the summit ridge of Mount Kobau indicate that this area was overridden by ice during the last glaciation (Bostock, 1939; Geol. Assoc. Can., 1958). Upon deglaciation, an undulating rock surface, partially covered by glacial-dumped rubble, was exposed. Throughout postglacial time, the effects of weathering, along with soil creep, slopewash and other processes of mass wasting have induced downslope movement of fine-textured surface material. This has been washed into and over the rubbly moraine lying in depressions and concavities.

TABLE 14. ANALYTICAL DATA FOR AN ORTHIC SOMBRIC BRUNISOL AT THE MOUNT KOBAU SITE
DONNEES ANALYTIQUES DU BRUNISOL SOMBRIQUE ORTHIQUE A STATION MOUNT KOBAU

Horizon	pH H_2O	pH $CaCl_2$	C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de Bases	Exchangeable Cations Cations échangeables Ca	Mg	K	Na
			%	%		me/100g	%	me/100g			
Ah1	5.1	5.0	6.80	0.572	11.7	27.31	69.8	14.28	3.63	1.14	0.01
Ah2	5.1	4.6	3.93	0.340	11.6	19.14	49.2	7.38	1.58	0.45	0.01
Ah3	5.2	4.6	3.37	0.325	10.4	17.36	43.7	5.96	1.25	0.35	0.02
Ah4	5.1	4.5	3.10	0.263	11.8	17.55	38.3	5.41	1.02	0.22	0.07
Ah5	5.1	4.4	2.82	0.241	11.7	15.94	36.1	4.81	0.70	0.20	0.04
Ah6	5.3	4.5	2.47	0.224	11.0	14.16	33.9	4.03	0.57	0.15	0.05
Bm1	5.4	4.6	0.63	0.079	8.0	9.12	43.1	3.25	0.52	0.13	0.03
Bm2	5.5	4.5	0.48	0.042	11.4	9.52	44.9	3.36	0.70	0.19	0.02
Bm3	5.5	4.5	0.32	0.036	8.9	10.54	53.3	4.58	0.78	0.19	0.07
BC	5.5	4.7	0.35	0.045	7.8	9.79	78.4	6.39	1.02	0.14	0.12

Horizon	Part. Size Dist. (<2mm) anal. gran. Sand Sable	Silt Limon	Clay Argile	F-Clay Argile-F	P Bray 1	P Bray 2	Pyrophos. Fe	Pyrophos. Al	Oxalate Fe	Oxalate Al	Hygro. Moisture Humidite Hygro.
					ppm	ppm	%	%	%	%	%
Ah1	32.77	49.27	17.96	3.65	26.7	55.8					
Ah2	34.63	48.97	16.40	2.81	10.5	21.8					
Ah3	37.01	48.33	14.66	3.23	1.0	15.3					
Ah4	34.86	51.81	13.33	5.02	2.0	18.3					
Ah5	36.46	51.01	12.53	4.81	12.7	24.8					
Ah6	38.92	46.16	14.92	3.81	14.0	27.5					
Bm1	40.50	46.18	13.32	3.87	20.2	70.6	0.19	0.26	1.28	0.31	1.74
Bm2	28.28	55.95	15.77	3.67	19.2	121.0	0.18	0.26	1.28	0.29	
Bm3	26.94	56.54	16.52	2.82	5.6	133.1	0.21	0.20	1.43	0.29	
BC	35.20	57.54	13.26	3.22	4.2	90.9					1.80

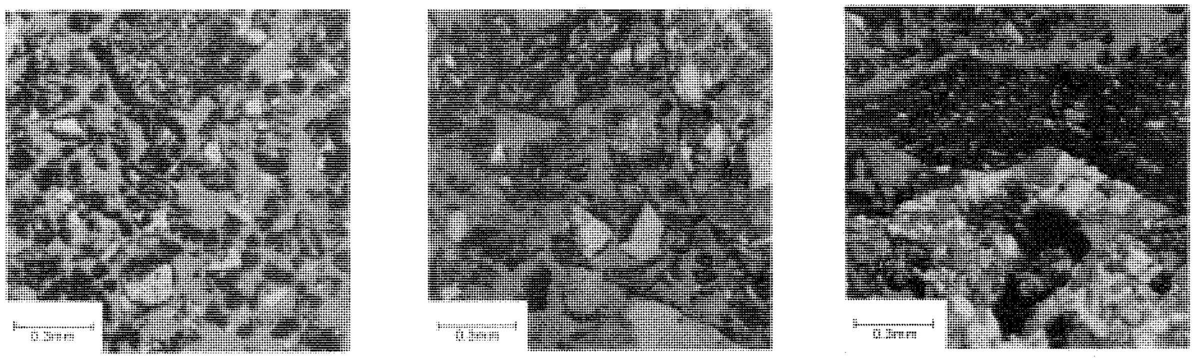
Table 15. Vegetation Structure at the Mt. Kobau site.

Tree Layer: A	Cover Class*
None	
Shrub Layer: B	
B1: Abies lasiocarpa	*r*
B2: Abies lasiocarpa	1
Pseudotsuga menziesii	1
Ribes lacustre	1
Artemisia tridentata	4
Herb Layer: C	
Trisetum spicatum	1
Taraxicum officinale	+
Sedum lanceolatum	+
Antennaria racemosa	1
Achillea millefolium	2
Antennaria rosea	1
Fragaria virginiana	1
Lupinus sp.	2
Penstemon confertus	1
Koeleria macrantha	2
Lomatium sp.	1
Descurania sp.	1
Erigeron sp.	1
Castilleja spp.	2
Bromus carinatus	2
Antennaria dimorpha	1
Agropyron spicatum	2
Polemonium pulcherimum var. calycinum	1
Elymus glaucus	2
Agrostis sp.	1
Geum triflorum	2
Thalictrum sp.	1
Silene sp.	1
Epilobium angustifolium	+
Polemonium sp.	1
Poa interior	+
Danthonia sp.	+
Poa sp.	+
Festuca idahoensis	+
Eriogonum umbellatum	+
Hackelia sp.	+

*Cover according to Braun Blanquet's System as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%
1 - numerous or scattered with cover up to 5%
+ - few, with small cover, 4 - solitary, with small cover

(Recorded for Ministry of Environment, Resource Analysis Branch by M. Rafiq)

Figure 78. Micromorphology of the Orthic Black Chernozemic at the Mount Kobau site



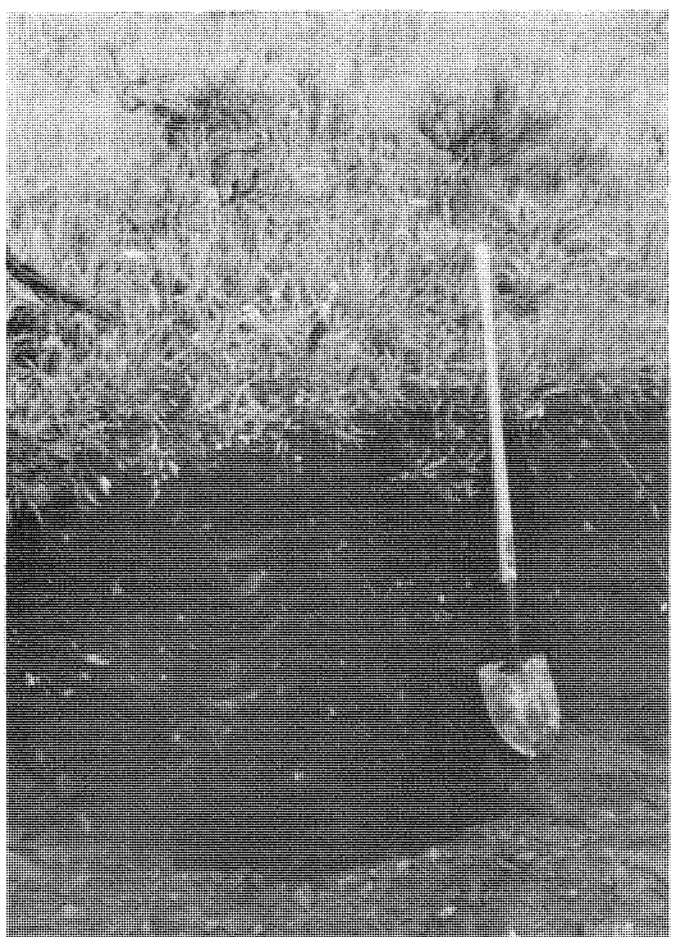
a. partly X b. partly X c. partly X

Ah2 The fabric consists of small mull like aggregates of clay, silt and humic organic matter (50-500μm) (Fig. a) plus metamorphic and igneous rock fragments (C) and organic matter in the voids. Matrans (O) occur around the rock fragments. The felspars, micas and amphiboles in the rock fragments are relatively unweathered.
-1- Granular to intertextic with lithorelicts
-2- Ortho-phyto mullgranic

Bm1 The fabric consists of metamorphic and igneous rock fragments (.5-5mm, F), sand grains (F) and a clay and silt matrix of bridges and small aggregates (Fig. b). There are matrans (O) of silt and clay on the upper surface of many rock fragments (Fig. c).
-1- Silasepic intertextic
-2- Matrigranoidic matriplectic

a

Photographs by J. H. Day, T. Lord



b

FIG. 79 BIG MOUNTAIN SAGEBRUSH COMMUNITY
a) AND ORTHIC SOMBRIC BRUNISOL
b) AT THE MOUNT KOBAU SITE

Description of an Orthic Brown Chernozemic at the Summerland Site.

Classification:	Canada - Orthic Brown Chernozemic, coarse silty, mixed, alkaline, strongly calcareous, mild subhumid family U.S.A. - Aridic Ustochrept, coarse silty, mixed, mesic family F.A.O. - Eutric Cambisol
Location:	Summerland Research Station D.L. 4884 ODYD 49°35'50"N 119°40'00"W of 6th Mer.
Elevation:	440 m a.s.l.
Climate:	Continental with cold winters and hot summers; annual precipitation is 300 mm
Vegetation:	Scattered Big Basin Sagebrush with a strong groundcover of Idaho Fescue
Landform:	lacustrine terrace, eroded, gullied
Parent Material:	fine silty to coarse silty glaciolacustrine deposits
Slope:	simple, crest of slope, 2%, aspect 90°
Drainage:	well drained, moderately pervious, very slow runoff
Land Use:	native grazing

Horizon	Depth (cm)	Description
Ah	0-10	Very dark grayish brown (10YR 3/2, m) and grayish brown (10YR 5/2.5, d); silt loam; weak to moderate, coarse granular; slightly sticky, friable, soft, slightly plastic; plentiful, very fine inped roots obliquely oriented; many, very fine inped pores; slightly acid; clear, smooth boundary to -
Bm1	10-32	Dark brown (10YR 3/3, m) and brown (10YR 5/3, d); silt loam; weak, medium to coarse, subangular blocky; slightly sticky, friable, soft, slightly plastic; plentiful, very fine inped roots, obliquely oriented; many, very fine inped pores; slightly acid; gradual, smooth boundary to -
Bm2	32-56	Dark grayish brown (10YR 4/2, m) and pale brown (10YR 6/3, d); silt loam; structureless, massive; slightly sticky, friable, slightly hard, slightly plastic; few, very fine inped roots, vertically oriented; common, very fine pores; neutral; abrupt, smooth boundary to -
Ck1	56-72	Grayish brown (2.5Y 5/2, m) and light gray (2.5Y 7/2, d); silt loam; structureless, massive, bedded; slightly sticky, friable, slightly hard, slightly plastic; very few, very fine inped roots, vertically oriented; few, very fine pores; strongly effervescence; secondary carbonate is common, medium spots that are rounded, friable and slightly hard; mildly alkaline; gradual, smooth boundary to -
Ck2	72-183	Grayish brown (2.5Y 5/2, m) and light gray (2.5Y 7/2, m); silt loam; weak to moderate medium pseudoplaty, bedded; sticky, soft, plastic; very few, very fine, inped roots, vertically oriented; very few, micro pores; strong effervescence; moderately alkaline.

Described by J.H. Day, 1975.

PARENT MATERIAL DESCRIPTION

The parent material at this location consists of light gray, finely bedded lacustrine silts. The silts are moderately hard when dry and break into platy and blocky structure. Stratification is well defined with silt beds generally ranging from 0.1 to 0.6 m in thickness and are separated by thin beds displaying irregular, wavy bedding and variable textures. Lenses of gravels and sands infrequently occur within the lacustrine bedding and are probably due to freshet run-off from the adjacent hillsides during the period of deposition. Similarly pebbles, cobbles and boulders, believed to be ice rafted, occur sporadically throughout the deposits.

The outstanding surficial feature of this area is the active gullying process that is dissecting these fine textured terraces. The gullies are deep, twisting, and very steep walled and many dry environment erosional and collapse features are evident. Underground piping and associated sink holes commonly occur, the flat top of the lacustrine terrace near the soil pit having depressions related to these processes. As a result of the gullying, the bedding of the lacustrine silts is irregularily tilted and commonly faulted.

The lacustrine sediments and the glacial history of this area are described by Nasmith (1962). These silts were deposited in a glacial lake which existed between a stagnating ice body to the north and a plug of ice cored outwash sediments south of Okanagan Falls. Melting of the ice and erosion by outflow from the glacial lake resulted in lowering of the outlet of the lake at Okanagan Falls, lake level lowering and exposure of the silt deposits.

TABLE 16. ANALYTICAL DATA FOR AN ORTHIC BROWN CHERNOZEMIC AT THE SUMMERLAND SITE
DONNEES ANALYTIQUES DU CHERNOZEMIQUE BRUN ORTHIQUE A STATION SUMMERLAND

Horizon	pH H_2O	pH $CaCl_2$	C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de Bases	Exchangeable Cations Cations échangeables Ca	Mg	K	Na
			%	%		me/100g	%	me/100g	me/100g	me/100g	me/100g
Ah	7.0	6.5	1.67	0.159	10.5	15.04	100	11.34	2.56		
Bm1	7.3	6.6	1.17	0.127	9.2	14.61	100	11.26	2.54		
Bm2	7.9	7.0	0.72	0.078	9.2						
Ck1	8.5	7.7	0.42	0.049	8.6						
Ck2	8.6	8.0	0.19	0.031	6.1						

Horizon	Part. Size Dist. (<2mm) anal. gran. Sand Sable	Silt Limon	Clay Argile	F-Clay Argile-f	P Bray 1	P Bray 2	$CaCO_3$ Equiv.
					ppm	ppm	%
Ah	14.51	65.20	20.29	4.21	21.2	151.6	
Bm1	15.29	67.16	17.55	3.75	10.9	133.2	
Bm2	17.36	66.75	15.89	3.05	5.5	151.2	
Ck1	1.40	79.70	18.90	4.50	0.5	9.6	9.84
Ck2	3.21	80.60	16.19	3.40	2.0	12.0	5.34

CLAY MINERALOGY

Moderate amounts of chlorite, smectite and mica are present in the parent material but decrease toward the surface. Mica remains less affected by the gentle weathering than the other two minerals. Feldspar is a minor- and quartz a trace-constituent in all horizons.

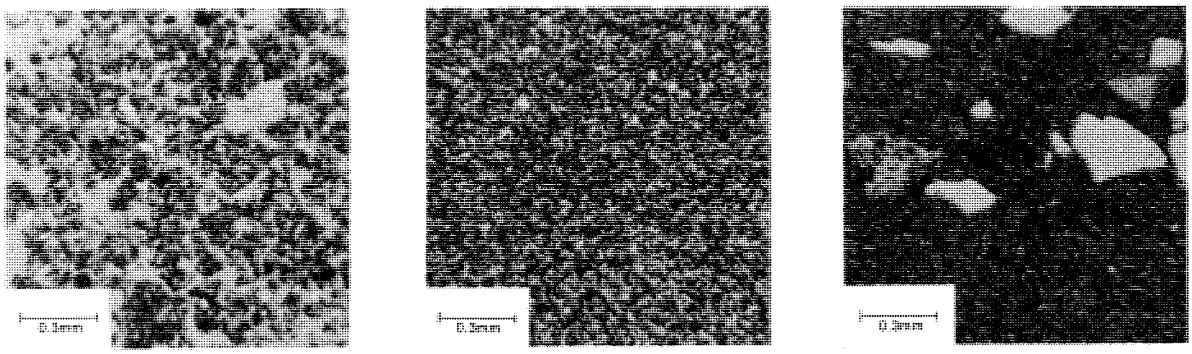
Table 17. Vegetation Structure at the Summerland Station site.

	Cover Class*
Tree Layer: A	
None	
Shrub Layer: B	
B1: None	
B2: Artemisia tridentata	2
Artemisia frigida	1
Centauria diffusa	1
Herb Layer: C	
Agropyron spicatum	4
Achillea millifolium	2
Antennaria racemosa	+
Festuca idahoensis	1
Geocaulon lividum	+
Phlox longifolia	+
Machaeranthera canascens	+
Opuntia fragilis	+

*Cover according to Braun Blanquet's System as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%
1 - numerous or scattered with cover up to 5%
+ - few, with small cover, r - solitary, with small cover

(Recorded for Ministry of Environment, Resource Analysis Branch, by M. Rafiq)

Figure 80. Micromorphology of the Orthic Brown Chernozemic at the Summerland site

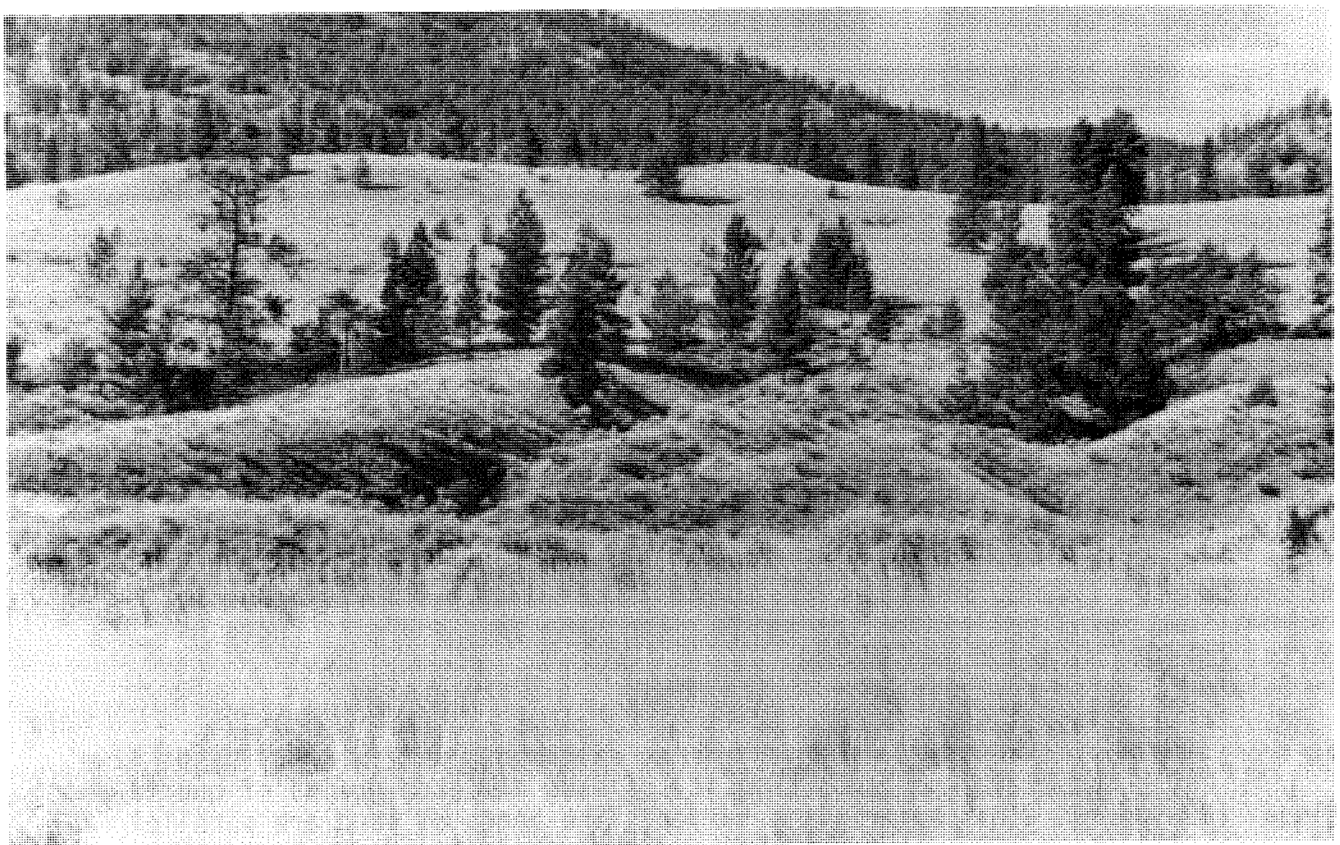


a. partly X b. X polarizers c. plane light

Ah The fabric consists of a dull brown aggregated (Fig. a) and banded matrix of clay, silt and probably humic organic matter with a skeleton framework of fine sand (C) with large sand grains (0.5-1.5mm, R). The matrix occasionally occurs as aggregates (100-500μm). There are numerous organic fragments in voids. The fine sand and silt contains quartz felspar, mica, pyroxenes, amphiboles and shards of volcanic ash.
-1- Silasepic intertextic
-2- Phyto-mull granic/mullgranoidic

Bm The fabric consists of a dull brown matrix of clay, silt and probably some humic organic matter with a skeleton framework of fine sand (C) and medium sand (0.2-0.5mm, R). The fabric is dense with numerous organic fragments and fecal pellets in the voids. The fine sand and silt contains quartz, felspar mica and amphiboles.
-1- Silasepic porphyroskelic.

Ck2 The fabric consists of a very dense calcareous matrix (Fig. b) of fine silt and clay, and bands (Fig. c) of sand skeleton grains of quartz and felspar (50-500μm). This material is varved. The bands of sand are parallel and horizontal (approximately 4mm apart) and the clay/silt matrix is weakly oriented horizontally. There is much mica silt in the matrix.
-1- Masepic porphyroskelic



Photograph by J. H. Day

FIG. 81 PONDEROSA PINE—BUNCHGRASS COMMUNITY ON LACUSTRINE SILTS AT THE SUMMERLAND STATION SITE

Description of an Eluviated Eutric Brunisol at the Kelowna Site.

Classification:	Canada - Eluviated Eutric Brunisol, sandy, mixed, neutral, mild semiarid family U.S.A. - Typic Ustipsamment, sandy, mixed, mesic family F.A.O. - Eutric Cambisol
Location:	Plan B3057 Sec 9 & 10 Tp 26 ODYD Hart Rd. 49°53'25"N 119°24'20"W of 6th Mer.
Elevation:	475 m a.s.l.
Climate:	Continental with cold winters and hot summers; annual precipitation is 340 mm
Vegetation:	Native species are Ponderosa Pine, Snowbush Ceanothus and bunchgrasses
Landform:	undulating glaciofluvial
Parent Material:	sandy glaciofluvial or lacustrine materials
Slope:	simple, midslope, 5%, aspect 270°
Drainage:	rapidly drained, rapidly permeable, very slow runoff
Land Use:	forage crops, orchards, vineyards

Horizon	Depth (cm)	Description
Ap	0-12	Very dark grayish brown (10YR 3/2, m) and grayish brown (10YR 5/2, d); loamy sand; moderate, medium subangular blocky breaking to fine angular blocky and single grain; friable, slightly hard; abundant, medium and coarse roots, vertically oriented; a few fine gravels; medium acid; clear, smooth boundary to -
Ae	12-24	Dark grayish brown (10YR 4/2.5, m) and light brownish gray (10YR 6.5/2, d); loamy sand; moderate, medium subangular blocky to single grain; friable, hard; abundant, medium and coarse roots, vertically oriented; a few fine gravels, medium acid; diffuse, wavy boundary to -
AB	43-57	Dark brown (10YR 3/3, m) and pale brown (10YR 6/3, d); loamy sand; moderate, medium subangular blocky to single grain; friable, slightly hard; plentiful, medium and coarse roots vertically oriented; a few, fine gravels; medium acid; diffuse wavy boundary to -
Bm1	33-43	Dark brown (10YR 4/3, m) and grayish brown (10YR 5/3, d); sand; moderate, medium, subangular blocky to single grain; very friable, slightly hard; plentiful, medium and coarse roots, vertically oriented; a few fine gravels; slightly acid; gradual, wavy boundary to -
Bm2	43-57	Pale brown (10YR 6/3, d); gravelly sand; single grain; loose, slightly hard; few, very coarse roots, vertically oriented; 30% gravels; slightly acid; gradual, wavy boundary to -
BC	57-76	Variegated colours; sand; single grain; loose; few, very coarse roots, vertically oriented; 20% gravels; slightly acid; diffuse, wavy boundary to -

C1	76-120	Variegated colours; sand; single grain; loose; few, very coarse roots, vertically oriented; 20% gravels; slightly acid; diffuse, wavy boundary to -
C2	120-140	Variegated colours; sand; single grain; loose; few, very coarse roots, vertically oriented; 20% gravels; slightly acid.

Described by H.A. Luttmerding, June 9, 1976.

CLAY MINERALOGY

Vermiculite, mica and smectite, with minor chlorite and some feldspar, are present in the parent material. They are present in lesser amounts in the solum horizons. X-ray amorphous material is present in the solum horizons and in lesser amount in the parent material.

PARENT MATERIAL DESCRIPTION

The parent material consists of bedded lacustrine sand. A section in this material is exposed in a road cut at the junction of a farm road and the surfaced road on the southwest side of the substation. The following description pertains to this site.

In this section, 0.65 m of medium textured sand overlies 4.0 m of finer sediments. The base of the finer unit is not exposed.

The medium sand is non-compact, massive and moderately well sorted. It is pale olive in colour and shows uniform slight oxidation. It contains scattered coarse sand particles, and granules and pebbles. Sand grains are angular and subangular and some are frosted. They consist chiefly (90 to 95%) of quartz particles with minor amounts of ferromagnesian and lithic fragments.

The lower unit consists of horizontally stratified and laminated light gray very fine sand with subsidiary silt and clay. The sand occurs as units that are 0.2 to 1.1 m thick and separated by silt and clay units that range in thickness between 5 and 10 cm. The silt and clay together constitute 7% of the exposed section. Thin sand and silt partings lie between silt and clay laminae respectively. Within the sand units, ripple-drift laminae and irregular, wavy bedding are common; structures indicate deposition under the influence of a south to north current. The lithologic composition of the sand is the same as that of the overlying unit.

The general characteristics of the very fine sand unit indicate that it is part of the late-glacial lacustrine deposits which are widespread within Okanagan Valley (cf. Nasmith 1962; Fulton, 1969). The overlying medium-textured sand unit probably represents a beach or shoreline facies of the lacustrine sediments.

TABLE 18. ANALYTICAL DATA FOR AN ELUVIATED EUTRIC BRUNISOL AT THE KELOWNA SITE
DONNEES ANALYTIQUES DU BRUNISOL EUTRIQUE ELUVIE A STATION KELOWNA

Horizon	pH H_2O	pH $CaCl_2$	C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de Bases	Exchangeable Cations Cations échangeables Ca	Mg	K	Na
			%	%		me/100g	%	me/100g			
Ap	6.51	5.86	0.68	0.046	14.78	6.13	98.37	4.41	0.81	0.77	0.04
Ae	6.74	5.95	0.23	0.021	10.95	5.38	95.91	3.66	1.01	0.44	0.05
AB	6.83	6.00	0.19	0.015	12.67	5.38	96.10	3.66	1.12	0.33	0.06
Bm1	6.95	6.16	0.12	0.011	10.91	4.67	87.15	2.88	0.93	0.22	0.04
Bm2	7.04	6.24	0.06	0.007	8.57	3.81	100	2.88	0.99	0.24	0.04
BC	7.01	6.21	0.06	0.009	6.67	4.06	100	2.94	1.13	0.28	0.05
C1	6.93	6.26	0.04	0.004	10.00	3.06	100	2.38	0.93	0.23	0.04
C2	7.02	6.30	0.04	0.006	6.67	2.91	100	1.93	0.74	0.22	0.04

Horizon	Part. Size Dist (<2mm) anal. gran. Sand Sable	Silt Limon	Clay Argile	F-Clay Argile-f	P Bray 1	P Bray 2	Pyrophos. Fe	Pyrophos. Al	Oxalate Fe	Oxalate Al	Hygro. Moisture Humidite Hygro.
					ppm	ppm	%	%	%	%	%
Ap	82.68	14.29	3.03	0.68	17.1	32.2	0.02	0.03	0.14	0.06	0.52
Ae	83.54	13.42	3.04	0.67	8.0	25.1	0.03	0.03	0.10	0.05	0.51
AB	86.83	11.16	2.01	0.67	7.5	23.6	0.03	0.03	0.12	0.05	0.51
Bm1	92.04	6.24	1.72	0.48	7.2	26.1	0.03	0.03	0.18	0.04	0.43
Bm2	95.63	2.86	1.51	0.57	6.3	21.1	0.03	0.03	0.13	0.04	0.30
BC	96.10	2.47	1.43	0.48	7.0	21.4	0.03	0.03	0.20	0.05	0.29
C1	97.62	1.93	0.45	0.00	6.8	22.9	0.02	0.03	0.43	0.05	0.27
C2	97.50	2.17	0.33	0.29	6.3	25.1	0.02	0.03	0.27	0.04	0.24

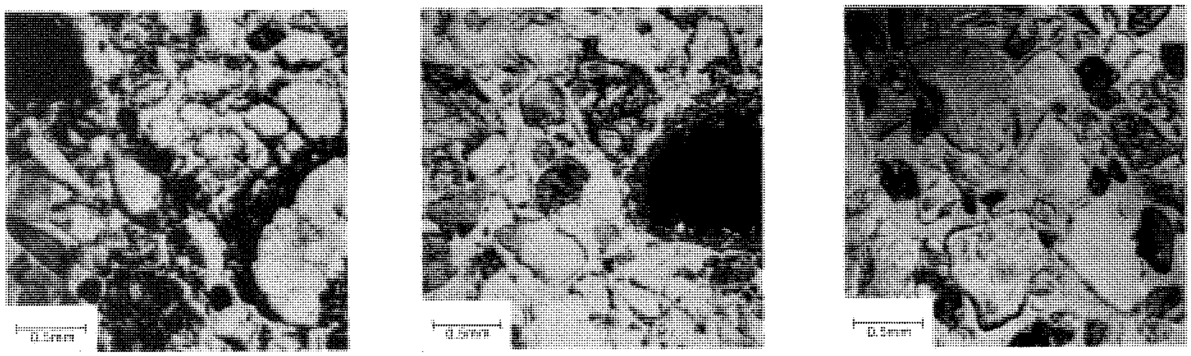
Table 19. Vegetation Structure at Kelowna Substation site (sample from surrounding native vegetation).

Tree Layer: A	Cover Class*
A1: Pinus ponderosa	*1*
A2: Pinus ponderosa	*2*
Shrub Layer: B	
B1: Pinus ponderosa	*2*
B2: Ceanothus velutinus	*2*
Pinus ponderosa	*1*
Herb Layer: C	
Festuca scabrella	*3*
Agropyron spicatum	*2*
Antennaria parvifolia	*2*
Koeleria macrantha	*1*
Huechera cylindrica	*1*
Carex concinnoides	*1*
Apocynum androsaemifolium	+
Balsamorhiza sagittata	+
Arctostaphylos uva-ursi	+
Achillea millifolium	+
Erigonum heracleoides	+
Gaillardia aristata	*r*
Tragopogon dubius	*r*
Moss and Lichen Layer: D	
Dicranum stricta	*2*
Peltigera aphthosa	+

*Cover according to Braun Blanquet's system as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%
1 - numerous or scattered with cover up to 5%
+ - few, with small cover, r - solitary, with small cover

(Recorded for British Columbia Ministry of Environment, Resource Analysis Branch by T. Lea)

Figure 82. Micromorphology of the Eluviated Eutric Brunisol at the Kelowna site



a. plane light b. plane light c. plane light

Ap This horizon is highly porous (Fig. a). It has a framework of rock fragments (O), sand (F), and silt (C) grains of quartz, feldspar and quartzite around which there are moderately thick coatings of clay, organic matter and fine silt. These coatings sometimes coalesce to fill the packing voids. Many of the rock fragments are well weathered. There are large fragments of well decomposed organic matter in many voids.

-1- Intertextic

-2- Matrichlamydic

Ae The highly porous grey fabric (Fig. b) consists of sand (F) and silt (C) grains of quartz, felspar, quartzite, amphiboles and pyroxenes, around which there are thin coatings (up to 30μm thick) of clay, silt and possibly organic matter. Rock fragments are rare and well weathered and often have matrans around them. Organic fragments (O) occur in the packing voids.

-1- Intertextic to granular

-2- Matrigefuric

Bm1 This highly porous fabric (Fig. c) consists of sand (F) and silt (O) grains of quartz, feldspar, quartzite, amphiboles and pyroxenes with thin (up to 20μm) discontinuous coatings of clay and fine silt. Moderately weathered rock fragments (O) also occur.

-1- granular

-2- orthogranic

Description of an Orthic Black Chernozemic at the Vernon site.

Classification:	Canada - Orthic Black Chernozemic, loamy skeletal, mixed, strongly calcareous, cool subhumid family U.S.A. - Typic Haploborall, loamy skeletal, mixed family F.A.O. - Haplic Chernozem
Location:	Vernon Waste Water Project 50°15'N 119°17'W of 6th Mer.
Elevation:	425 m a.s.l.
Climate:	Cool continental
Vegetation:	cropland, mainly alfalfa
Landform:	blanket moraine
Parent Material:	coarse loamy and coarse silty morainal
Slope:	simple, upper slope, 6%; aspect 45°
Drainage:	well drained, moderately pervious, slow runoff
Land Use:	improved forage

Horizon	Depth (cm)	Description
Ah	0-22	Dark gray (10YR 4/1, d); cobbly, gravelly loam; very weak, medium granular; slightly sticky, soft, slightly plastic; plentiful, fine, exped roots, vertically oriented; many, fine pores; slightly acid; clear, smooth boundary to -
Aej	22-40	Pale brown (10YR 6/3, d); cobbly, gravelly loam; weak to moderate, fine to medium subangular blocky; sticky, slightly hard, plastic; plentiful, fine, exped roots vertically oriented; common, fine pores; slightly acid; gradual, smooth boundary to -
BA	40-50	Brown (10YR 5/3, d) and light brownish gray (10YR 6/2, d); cobbly, gravelly clay; moderate to strong, fine to medium, angular blocky; sticky, hard, plastic; few, very fine exped roots, vertically oriented; common, fine, pores; few, very thin clay films in voids or channels only; slightly acid; gradual, smooth boundary to -
Btj	50-57	Dark grayish brown (10YR 4/2, d) and grayish brown (10YR 5/2.5 d, crushed); cobbly, gravelly clay; moderate to strong, medium angular blocky; very sticky, hard, very plastic; few, very fine exped roots, vertically oriented; common, fine pores; common, moderately thick clay skins in many void and channels and on ped faces; slightly acid; gradual, smooth boundary to -
BC	57-67	Brown (10YR 5/3, d) and light brownish gray (2.5Y 6/2, d); cobbly, gravelly clay loam; moderate, medium, angular blocky; sticky, hard, plastic; few, very fine exped roots, vertically oriented; common, fine, pores; neutral; abrupt, smooth boundary to -
Ck	67-175	Olive gray (5Y 5/2, d) and light brownish gray (2.5Y 6/2, d); cobbly, gravelly sandy loam; structureless, massive; slightly sticky, extremely hard, slightly plastic; very few, very fine exped roots, vertically oriented; very few, very fine pores; strong effervescence; mildly alkaline.

Described by J.H. Day, 1975

CLAY MINERALOGY

Chlorite, smectite, mica and vermiculite are present throughout the profile. The parent material and the surface horizons contain the lowest amounts of these minerals, but the BA, Bt and BC have the highest amounts of these minerals which display a moderate degree of X-ray crystallinity. Amphibole present in the Ck and BC horizons is absent in the upper horizons. The persistence of chlorite throughout the profile indicates weak weathering.

PARENT MATERIAL DESCRIPTION

The parent material is a moderately compact till. It consists of 10 to 15% clasts in a matrix of slightly gritty clayey silt. The matrix colour is olive. Clasts are mostly subrounded and subangular pebbles, although a few isolated cobbles and boulders are present. Andesite and argillite are by far the most common clast lithologies, although clasts of limestone, shale, quartzite, schist and various plutonic rocks are also present.

The till overlies bedrock of the Palaeozoic Cache Creek Group which consists chiefly of limestone, but includes minor amounts of argillite, quartzite, andesite, breccia and tuff. The similarity of clast and bedrock lithologies suggests that much of this till was derived locally.

TABLE 20. ANALYTICAL DATA FOR AN ORTHIC BLACK CHERNOZEMIC AT THE VERNON SITE
DONNEES ANALYTIQUES DU CHERNOZEMIQUE NOIR ORTHIQUE A STATION VERNON

Horizon	pH H_2O	pH $CaCl_2$	C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de Bases	Exchangeable Cations / Cations échangeables Ca	Mg	K	Na
			%	%		me/100g	%	me/100g			
Ah	6.8	6.3	3.16	0.284	11.1	21.88	99.3	17.58	2.42	1.48	0.25
Aej	7.1	6.4	0.67	0.068	9.9	13.23	98.0	9.24	2.67	0.56	0.49
BH	7.3	6.3	0.49	0.051	9.6	18.42	98.5	9.52	5.48	0.51	2.63
Btj	7.1	6.5	0.45	0.057	7.9	26.21	100	18.91	7.52	0.50	0.74
BC	7.7	7.0	0.41	0.043	9.5	12.82	100	7.71	3.71	0.25	2.58
Ck	8.6	7.8	0.08	0.008	10.0						

Horizon	Part. Size Dist (<2mm anal. gran. Sand Sable	Silt Limon	Clay Argile	F-Clay Argile-f	P Bray 1	P Bray 2	Bulk D Densité apparente
					ppm	ppm	g/cm^3
Ah	38.05	40.21	22.15	3.35	45.3	24.93	1.18
Aej	42.16	30.36	27.48	5.08	7.1	31.3	
BH	35.56	23.47	40.97	6.19	4.3	35.0	1.84
Btj	23.71	19.84	56.45	8.72	4.1	42.8	
BC	44.27	27.20	28.53	4.78	5.6	70.7	
Ck	67.23	15.90	16.87	3.13	3.2	138.4	1.34

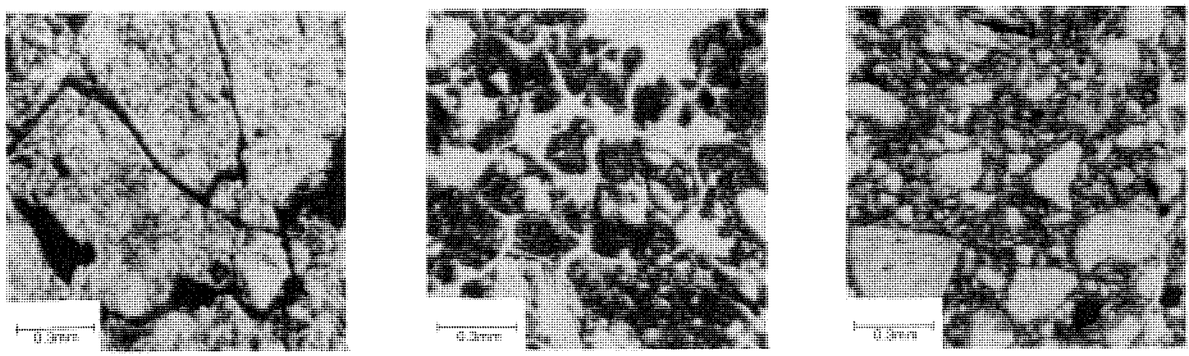
Table 21. Vegetation Structure at the Vernon site (sample from surrounding native vegetation)

	Cover Class*
Tree Layer: A	
A1: *Pseudotsuga menziesii*	1
A2: *Pseudotsuga menziesii*	3
Shrub Layer: B	
B1: *Pseudotsuga menziesii*	1
Amelanchier alnifolia	1
B2: *Pseudotsuga menziesii*	+
Herb Layer: C	
Agropyron spicatum	4
Festuca spp	3
Bromus tectorum	1
Aster campestris	+
Moss and Lichen Layer: D	
Brachytecium asperinum	3

*Cover according to Braun Blanquet's system as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%
1 - numerous or scattered with cover up to 5%
+ - few, with small cover, r - solitary, with small cover

(Recorded for British Columbia Ministry of Environment, Resource Analysis Branch by T. Lea)

Figure 83. Micromorphology of an Orthic Black Chernozemic at the Vernon site



a. X polarizers b. partly X c. plane light

Aej The fabric consists of large rock fragments (1-8mm, F) and sand grains (F) in a brown crudely aggregated matrix of silt, clay and probably humic organic matter with weakly oriented domains. The rock fragments include granitic, basaltic and metamorphic types, the felspars, micas and ferro-magnesium minerals of which are highly weathered. The fabric is moderately porous with vughs and chambers, in which organic fragments (R) occur. There are matrans (20-40μm, O) around some rock fragments.

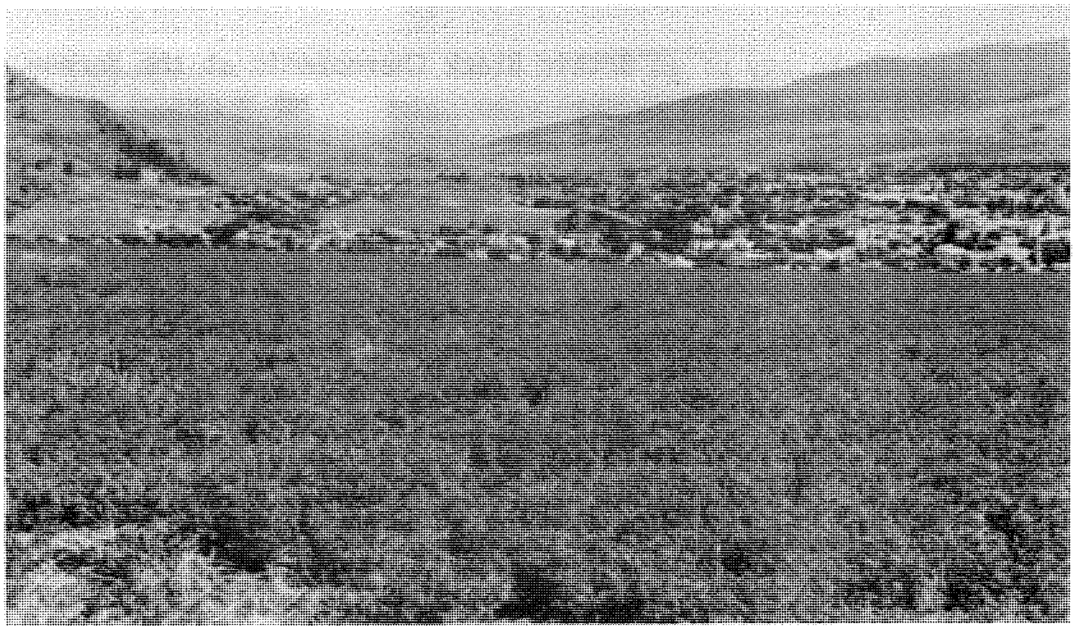
-1- Silasepic intertextic to porphyroskelic with lithorelicts
-2- Ortho-mull granoidic/porphyroskelic

Btj The fabric is a complex of two types of material; a brown well oriented clay (Fig. a) with zones of ferruginous deposits and numerous skew planes (60%); plus a moderately porous weakly aggregated clay matrix with silt and sand skeleton grains (Fig. b) (up to 400μm, C) (40%). Some organic matter fragments (R) occur in the voids. There are no illuviation argillans to make this a true Bt horizon, but there are weak grain matrans (O) in the second fabric type.

-1- Masepic porphyroskelic/skelsepic intertextic
-2- Masepic porphyroskelic/skelsepic matrigranoidic

Ck The fabric consists of many skeleton grains of silt (C), sand (F) and rock fragments (C, up to 10mm) encased in a matrix of clay and silt (Fig. c). The rock fragments are granitic, basaltic and metamorphic types, relatively unweathered. The sand grains are quartz, feldspar, amphiboles and micas. There are calcareous nodules (R). The fabric is moderately porous.

-1- Silasepic porphyroskelic

a 

Photograph by J. H. Day

b 

Photograph by J. H. Day

FIG. 84 a) IRRIGATED ALFALFA ON CHERNOZEMIC SOILS AT THE VERNON SITE
b) ORTHIC BLACK CHERNOZEMIC SOIL AT THE VERNON SITE

Description of an Orthic Gray Luvisol at the Salmon Arm site.

Classification:	Canada - Orthic Gray Luvisol, fine silty, mixed, alkaline, strongly calcareous, cool subhumid family U.S.A. - Typic Cryoboralf, fine silty, mixed family F.A.O. - Albic Luvisol
Location:	I.R. 3 (Switsemalph I.R.) KDYD 50th St. NW 50°42'30"N 119°17'30"W of 6th Mer.
Elevation:	500 m a.s.l.
Climate:	Cool moist continental with annual precipitation of about 550 mm
Vegetation:	Diversified plant communities including Rocky Mountain Douglas Fir, Western Red Cedar, and many shrubs and herbs
Landform:	undulating glaciolacustrine
Parent Material:	lacustrine silts
Slope:	upper slope, 5-9%, aspect 270°
Drainage:	well drained
Land Use:	mixed farming

Horizon	Depth (cm)	Description
L-H	2-0	A mixture of undecomposed to well decomposed needles, twigs and leaves; neutral; abrupt boundary to -
Ae	0-15	Dark grayish brown (10YR 4/2, m) and brown (10YR 5/3, d); silt loam; weak, fine platy breaking to weak subangular blocky; very friable; abundant, micro to coarse roots, inped and exped, randomly oriented; neutral; clear; wavy boundary to -
AB	15-33	Dark yellowish brown (10YR 4/4, m) and brown (10YR 5/3, d); silt loam; moderate, medium to fine subangular blocky; friable; plentiful, micro to coarse roots, exped, randomly oriented; many clay films; slightly acid; gradual, wavy boundary to -
Bt1	33-50	Dark brown (10YR 3/3, m) and brown (10YR 5/3, d); silt loam; moderate, medium to fine subangular blocky; very friable; plentiful, micro to coarse roots, exped, randomly oriented; many clay films; slightly acid; gradual, wavy boundary to -
Bt2	50-67	Dark brown (10YR 3/3, m) and brown (10YR 4/3, d); silty clay loam; moderate, medium to fine subangular blocky; very friable; plentiful, micro to coarse roots, exped, randomly oriented; common to many clay films; slightly acid; clear, wavy boundary to -
Btgj	67-80	Dark yellowish brown (10YR 4/4, m) and olive brown (2.5Y 4/4, m) and light yellowish brown (2.5Y 6/4, d) and light olive brown (2.5Y 5/6, d); silt loam; strong, medium and coarse angular blocky; very firm; common, medium and coarse, distinct mottles; plentiful, micro to coarse roots, exped, randomly oriented; mildly alkaline; diffuse, wavy boundary to -

Cca	80-95	Dark grayish brown (2.5Y 4/2, m) and light brownish gray to light olive brown (2.5Y 6/2-5/4, d); silt loam; massive breaking to angular blocky; very firm; very few, micro to coarse roots, exped, randomly oriented; mildly alkaline; strong effervescence; diffuse boundary to -
Ck1	95-107	Grayish brown (2.5Y 5/2, m) and light gray (2.5Y 7/2, d); silt; massive breaking to angular blocky; very firm; very few, micro to coarse roots, exped, randomly oriented; mildly alkaline; moderate effervescence; diffuse boundary to -
Ck2	107-122	Dark grayish brown (2.5Y 4/2, m) and light gray (2.5Y 7/2, d); silt; massive breaking to angular blocky; very firm; very few, micro to coarse roots, exped, randomly oriented; mildly alkaline; strong effervescence; diffuse boundary to -
Ck3	122+	Grayish brown (2.5Y 5/2, m) and light brownish gray (2.5Y 6/2, d); silt; massive breaking to angular blocky; very firm; very few, micro to coarse roots, exped, randomly oriented; mildly alkaline; strong effervescence.

Described by H.A. Luttmerding, June 4, 1976.

CLAY MINERALOGY

The lowest horizon (Ck3) has moderate amounts of chlorite, smectite, mica, feldspar and amphibole. Chlorite and smectite decrease toward the surface but mica increases; the change is particularly noticeable between the Bt2 and Btgj horizons. Vermiculite has developed above the Bt2 horizon and chlorite remains, both at trace levels. The increase in mica and the appearance of kaolinite above the Bt2 suggest a change of provenance of the sediments represented in the upper 50 cm of the profile.

PARENT MATERIAL DESCRIPTION

The parent material is an olive-coloured, moderately compact lacustrine silt. It is very hard when dry and breaks with a blocky fracture.

This material differs from most post-glacial lacustrine silts in that stratification and other structures are poorly defined here. The silt beds range from 0.2 to 0.5 m in thickness and dip gently southwards (apparent dip). Smaller structures are visible in places on freshly cleaned damp surfaces. For example, there are several sets of finely laminated climbing ripples that have been modified by warping and minor faulting. Such series of laminae consist of alternating layers of relatively fine and relatively coarse silt that are distinguished by darker and lighter colours respectively. Ice rafted pebbles (and less commonly boulders and cobbles) of schist occur here and there within the deposit.

The lacustrine sediments and glacial lake history of this area have been described by Fulton (1969, 1975). Silt deposition in the general vicinity took place in a glacial lake. This lake was impounded along the western margin of a stagnant ice-tongue which occupied (approximately) the site of modern Shuswap Lake. It drained southwards into Okanagan Valley. The site emerged as lake levels began to fall in the Shuswap basin due to subsequent ice retreat and regional isostatic tilting. Thus this site was exposed at a relatively early stage of postglacial time.

TABLE 22. ANALYTICAL DATA FOR AN ORTHIC GRAY LUVISOL AT THE SALMON ARM SITE
DONNEES ANALYTIQUES DU LUVISOL GRIS ORTHIQUE A STATION SALMON ARM

Horizon	pH H_2O	pH $CaCl_2$	C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de Bases	Exchangeable Cations Cations échangeables Ca	Mg	K	Na
			%	%		me/100g	%	me/100g			
LH	7.07	7.05	24.78	1.052	23.56	63.46	100	71.48	5.07	2.29	0.11
Ae	7.52	7.00	0.91	0.066	13.79	14.40	99.44	11.49	1.85	0.95	0.03
AB	6.80	6.41	0.54	0.049	11.02	15.70	86.88	9.69	2.69	1.21	0.05
Bt1	6.58	6.17	0.40	0.038	10.53	19.63	89.35	11.85	4.61	1.02	0.06
Bt2	6.70	6.46	0.40	0.034	11.76	22.26	93.13	13.94	5.75	0.91	0.13
Btgj	7.85	7.59	0.19	0.027		28.21	100	25.61	6.56	0.89	0.11
Cca	8.12	7.82	0.18	0.022		19.03	100	39.42	5.57	0.60	0.07
Ck1	8.18	7.85	0.11	0.020		16.33	100	40.76	5.10	0.47	0.06
Ck2	8.32	7.84	0.13	0.020		14.41	100	42.08	4.05	0.39	0.05
Ck3	8.17	7.84	0.15	0.020		13.12	100	40.64	3.97	0.36	0.04

Horizon	Part. Size Dist (<2mm) anal. gran. Sand Sable	Silt Limon	Clay Argile	F-Clay Argile-f	P Bray 1	P Bray 2	Pyrophos. Fe	Pyrophos. Al	Oxalate Fe	Oxalate Al	Hygro. Moisture Humidite Hygro.
					ppm	ppm	%	%	%	%	%
LH					94.3	219.	0.09	0.09	0.20	0.16	7.06
Ae	9.72	71.39	18.89	4.44	54.6	96.0	0.09	0.03	0.29	0.14	2.14
AB	8.56	70.02	21.42	6.27	33.3	53.2	0.08	0.04	0.26	0.16	2.29
Bt1	4.36	67.85	27.79	10.30	18.6	50.9	0.07	0.05	0.32	0.16	2.84
Bt2	2.16	68.51	29.33	9.98	18.5	60.8	0.07	0.05	0.34	0.16	2.06
Btgj					8.3	83.0	0.03	0.02	0.19	0.19	3.73
Cca	29.26	60.06	10.68	0.21	11.7	49.2	0.02	0.02	0.17	0.13	2.58
Ck1	8.97	79.54	11.49	0.94	13.6	60.4	0.03	0.03	0.18	0.11	2.35
Ck2	5.57	85.03	9.40	0.83	13.1	60.3	0.03	0.03	0.13	0.10	2.19
Ck3	1.13	87.10	11.77	1.25	15.9	60.2	0.02	0.03	0.20	0.11	2.13

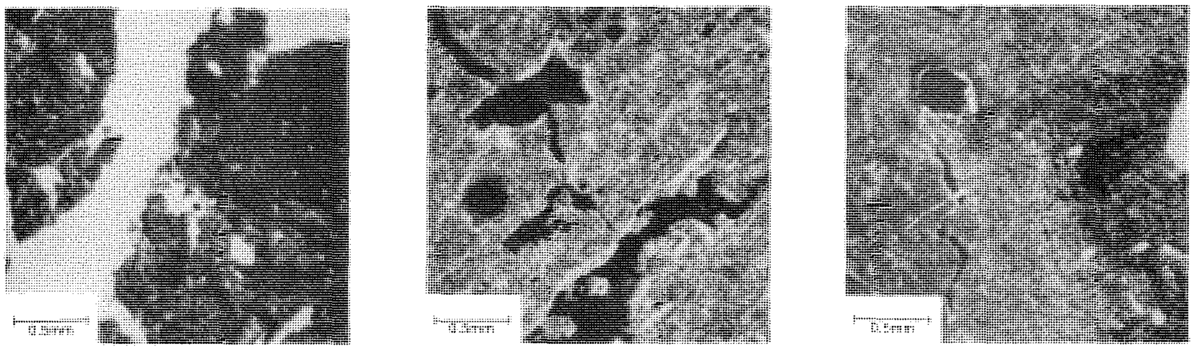
Table 23. Vegetation Structure at the Salmon Arm site (sample from surrounding native vegetation)

Tree Layer: A		Cover Class*
A1:	*Pseudotsuga menziesii*	1
A2:	*Pseudotsuga menziesii*	4
	Betula papyrifera	2
	Populus tremuloides	1
Shrub Layer: B		
B1:	*Thuja plicata*	2
	Pseudotsuga menziesii	2
	Acer glabrum	+
	Pinus monticola	+
B2:	*Paxistima myrsinites*	3
	Thuja plicata	2
	Spiraea betulifolia	1
	Mahonia aquifolium	1
	Lonicera utahensis	+
	Rosa woodsii	+
	Shepherdia canadensis	+
	Acer glabrum	r
Herb Layer: C		
	Chimaphila umbellata	2
	Clintonia uniflora	1
	Goodyera oblongifolia	1
	Disporum trachycarpum	1
	Smilacina racemosa	+
	Pyrola chlorantha	+
	Linnaea borealis	+
	Hieracium albiflorum	
Moss and Lichen Layer: D		
	Pleurozium schreberi	2
	Peltigera aphthosa	1
	Dicranum spp	+
	Mnium spp	+

*Cover according to Braun Blanquet's system as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%
1 - numerous or scattered with cover up to 5%
+ - few, with small cover, r - solitary, with small cover

(Recorded for British Columbia Ministry of Environment, Resource Analysis Branch by T. Lea)

Figure 85. Micromorphology of the Orthic Gray Luvisol at the Salmon Arm site



a. plane light b. X polarizers c. X polarizers

Ae This moderately porous brownish gray fabric (Fig. a) consists of sand grains (0) of quartz and feldspar and silt grains (C) of quartz and feldspar embedded in a compact matrix of clay and fine silt. Rock fragments (R) of metamorphic and igneous origin occur. There are ferruginous concentrations and glaebules (C) with weathering halos. Some organic matter fragments (0) are incorporated in the matrix. Oriented clay appears in the matrix in form of bands of variable thickness and length.
-1- Masepic porphyroskelic

Bt1 The moderately porous brown fabric (Fig. b) consists of sand (0) and silt (C) grains of quartz, quartzite and feldspar embedded in a matrix of fine silt and clay. Ferruginous concentrations and glaebules (C, up to 200μm) occur. Some glaebules have halos. Illuviation argillans and ferriargillans (C-F) occur along some channels and around some vughs and chambers. Zones of moderately oriented clay appear in the matrix (0).
-1- Mosepic porphyroskelic

Ck The dense fabric of this horizon consists of a dull brown weakly bedded clay matrix which contains finely dispersed carbonates with sand (R) and silt (R) skeleton grains (Fig. c). Linear zones of oriented clay (sometimes parallel to the bedding planes) occur, plus papules (0) of well oriented clay within the matrix. Manganiferous and ferruginous zones are found throughout the matrix.
-1- Masepic porphyroskelic

Photograph by T. Lord

FIG. 86 DOUGLAS FIR COMMUNITY ON A GRAY LUVISOL ON LACUSTRINE SEDIMENTS AT THE SALMON ARM SITE

Description of a Brunisolic Gray Luvisol at the Golden Site

Classification:	Canada - Brunisolic Gray Luvisol, fine loamy, mixed, alkaline, strongly calcareous, cold to subhumid family U.S.A. - Typic Cryoboralf, fine loamy, mixed family F.A.O. - Albic Luvisol
Location:	Sec 11 Tp 28 R 22 W.6th Mer. 3.2 km E of Hy 1. 51°17'30"N 116°57'00"W of 6th Mer.
Elevation:	950 m a.s.l.
Climate:	Continental with long cold winters and cool summers; precipitation averages 470 mm/year
Vegetation:	Dominated by Rocky Mountain Douglas Fir, with many species of shrubs and herbs in the understory (see Table 24).
Landform:	loess veneer over morainal blanket
Parent Material:	medium textured morainal (includes loess in surface 40 cm)
Slope:	simple, midslope, 5-9%, aspect 250°
Drainage:	well drained
Land Use:	forestry and mixed farming

Horizon	Depth (cm)	Description
L	9-6	Undecomposed mixture of needles, leaves and twigs; very few roots; slightly acid; abrupt, smooth boundary to -
F-H	6-0	Partially to well decomposed organic material; plentiful, fine to coarse roots, horizontally oriented; neutral; abrupt, smooth boundary to -
Aej	0-5	Strong brown (7.5YR 5/6, m) and light brown (7.5YR 6/4, d); silt loam; weak, fine, subangular blocky; friable; plentiful, fine and coarse roots, randomly oriented; 10% gravels and cobbles; slightly acid; clear, irregular boundary to -
Bm1	5-15	Yellowish red (5YR 4/6, m and 5/8, d); silt loam; weak to moderate, fine subangular blocky; sticky; plentiful, fine and coarse roots, randomly oriented; 10% gravels and cobbly; medium acid; clear, wavy boundary to -
Bm2	15-25	Yellowish red (5YR 5/6, m) and reddish yellow (5YR 6/8, d); silt loam; moderate to weak, fine subangular blocky; few to common clay films; sticky; plentiful, fine and coarse roots, randomly oriented; 10% gravels and cobbles; slightly acid; clear, wavy boundary to -
Bt	25-40	Yellowish red (5YR 5/6, m and 5/8, d and 7.5YR 5/8 d, 5/6 m); silty clay loam; moderate to strong, medium, subangular blocky; firm; plentiful, fine and coarse roots, horizontally oriented; common clay films; 10 to 15% cobbles and gravels; medium acid; clear, wavy boundary to -
IIBmk	40-55	Brownish yellow (10YR 6/6, m) and yellow (10YR 7/6, d); silt loam; weak to moderate, fine subangular blocky; friable; few, medium and coarse roots, horizontally oriented; moderate effervescence; 25% cobbles and gravels; medium acid; diffuse boundary to -

IICk1	55-85	Very pale brown (10YR 7/4, m and 7/5, d); gravelly silt loam; coarse, medium, angular pseudoblocky breaking to weak, medium, subangular pseudoblocky; firm, very few, medium and fine roots, randomly oriented; moderate effervescence, 25% cobbles and gravels; neutral; diffuse boundary to -
IICk2	85-122	Pale yellow (2.5Y 7/4, m) and very pale brown (10YR 7/4, d); gravelly silt loam; coarse, medium, angular pseudoblocky breaking to weak, medium, subangular pseudoblocky; firm; very few, medium and fine roots, randomly oriented; moderate effervescence, 25% cobbles and gravels; neutral; diffuse boundary to -
IICk3	122+	Yellow (2.5Y 7/6, m) and yellow (10YR 8/6, d); gravelly silt loam; coarse, medium, angular pseudoblocky breaking to weak, medium, subangular pseudoblocky, firm; very few, medium and fine roots; randomly oriented; moderate effervescence, 25% cobbles and gravels; neutral.

Described by H.A. Luttmerding, June 3, 1976.

CLAY MINERALOGY

The parent material and all horizons up to the uppermost analyzed (Bm1) are dominated by mica. The Bm1 has moderate-minor mica. The parent material contains traces of chlorite, kaolinite and feldspar, all of which persist throughout the profile. The Bt horizon contains slightly more smectite than all other horizons. A trace of quartz is present only in the Bm1 and Bm2 horizons.

PARENT MATERIAL DESCRIPTION

The parent material consists of a moderately compact silty till. It ranges from 1 to over 3m in thickness. It overlies bedrock that consists of thinly interbedded limestones and phyllites which are probably part of the early Palaeozoic McKay Group (Wheeler, 1963).

The till matrix consists of gritty silt with minor clay. In colour it ranges from pale yellow to reddish yellow. Clast frequency varies from place to place within the till and ranges between 10 and 30%. Pebble sized clasts are most common, although cobbles and boulders are also present. Clasts typically consist of angular fragments of local bedrock - limestone and phyllite - and display all stages of weathering. Weathered and incoherent pebbles of phyllite are common. They are essentially of the same texture as the matrix of the till, and suggest that weathered local bedrock may comprise the bulk of the till matrix.

About 7 m to the west (downhill along the road) of the steps leading to the soil pit, the till is underlain by a mass of reddish yellow compact silt (or clayey silt) within which relict foliation planes and fractures can be discerned. It contains calcite, quartz, mica, kaolinite and mixed layer-clay and iron (probably as ferric oxide). This material is thought to be weathered phyllite *in situ*, and again suggests weathered local bedrock was recycled as till matrix during glaciation.

TABLE 24. ANALYTICAL DATA FOR A BRUNISOLIC GRAY LUVISOL AT THE GOLDEN SITE
DONNEES ANALYTIQUES DU LUVISOL GRIS BRUNISOLIQUE A STATION GOLDEN

Horizon	pH H_2O	pH $CaCl_2$	C	N	C/N	C.E.C. Cap. d'échange cationique	Base Sat. Sat. de Bases	Exchangeable Cations / Cations échangeables Ca	Mg	K	Na
			%	%		me/100g	%	me/100g			
L	5.51	6.53	53.60	1.464	36.61	103.	90.23	79.22	10.56	3.07	0.11
FH	6.46	6.64	54.32	1.992	27.27	159.	99.63	144.61	9.96	2.69	0.12
Aej	6.43	6.27	2.78	0.103	26.99	18.02	83.41	13.42	1.23	0.35	0.03
Bm1	6.17	5.73	1.44	0.075	19.20	14.78	100.	13.90	2.64	0.59	0.09
Bm2	6.54	6.17	0.70	0.054	12.96	13.25	62.42	6.87	0.79	0.52	0.09
Bt	7.33	5.71	1.09	0.056	19.46	12.38	100	25.70	0.85	0.26	0.08
IIBmk	8.22	5.97	0.55	0.070	7.86	6.24	100	32.48	0.73	0.08	0.05
IICk1	8.18	7.30	0.37	0.043	8.61	4.22	100	43.40	0.88	0.07	0.05
IICk2	8.42	7.84	0.08	0.028	2.86	2.81	100	39.92	0.93	0.03	0.05
IICk3	8.38	7.94	0.02	0.025	0.80	2.56	100	38.50	1.06	0.03	0.05

Horizon	Part. Size Dist (<2mm) anal. gran. Sand Sable	Silt Limon	Clay Argile	F-Clay Argile-f	P Bray 1	P Bray 2	Pyrophos. Fe	Pyrophos. Al	Oxalate Fe	Oxalate Al	Hygro. Moisture Humidite Hygro.
					ppm	ppm	%	%	%	%	%
L					21.2	101.6	0.01	0.01	0.03	0.02	12.90
FH					69.8	46.7	0.01	0.04	0.05	0.06	16.78
Aej	25.97	65.93	8.10	1.03	9.2	23.6	0.17	0.10	0.43	0.26	2.43
Bm1	21.38	65.20	13.42	2.68	6.5	13.3	0.10	0.08	0.39	0.34	2.33
Bm2	24.16	63.45	12.39	1.96	4.5	9.-	0.06	0.06	0.32	0.36	2.34
Bt	14.29	54.18	31.53	7.78	2.4	9.1	0.08	0.03	0.33	0.07	1.53
IIBmk	18.94	62.05	19.01	3.94	11.1	33.6	0.03	0.02			0.67
IICk1	21.89	62.16	15.95	2.00	19.1	35.3	0.03	0.01			0.43
IICk2	23.02	61.13	15.85	2.48	13.6	24.2	0.03	0.02			0.26
IICk3	20.41	62.91	16.68	2.10	22.3	22.9	0.02	0.01			0.24

Table 25. Vegetation Structure at the Golden site.

Tree Layer: A		Cover Class*
A1:	*Pseudotsuga menziesii*	1
A2:	*Pseudotsuga menziesii*	4
	Populus tremuloides	3
	Picea glauca	2

Shrub Layer: B		
B1:	*Acer glabrum*	2
	Picea glauca	1
	Alnus incana	+
	Pseudotsuga menziesii	r
	Pinus contorta	r
	Shepherdia canadensis	r
B2:	*Paxistima myrsinites*	4
	Shepherdia canadensis	3
	Spiraea betulifolia	2
	Symphoricarpos albus	2
	Rubus parviflorus	2
	Cornus sericea	1
	Rosa gymnocarpa	1
	Mahonia aquifolium	1
	Juniperus communis	1
	Amelanchier alnifolia	+
	Lonicera involucrata	r
	Viburnum edule	r
	Pseudotsuga menziesii	r
	Populus tremuloides	r
	Picea glauca	r

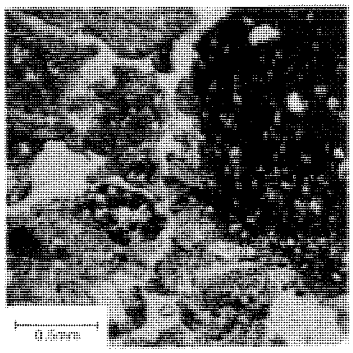
Herb Layer: C	Cover Class*
Aralia nudicaulis	2
Oryzopsis asperifolia	1
Aster conspicuus	1
Disporum trachycarpum	1
Cornus canadensis	1
Chimaphila umbellata	1
Lycopodium complematum	+
Goodyera oblongifolia	+
Osmorhiza chilensis	+
Orthilia secunda	+
Linnaea borealis	+
Corallorhiza spp	+
Epilobium angustifolium	+
Elymus glaucus	+
Aster subspicatus	+
Actaea rubra	r

Moss and Lichen Layer: D	
Drepanodadus uncinatus	1
Peltigera aphthosa	1

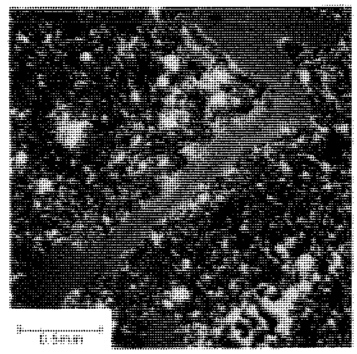
*Cover according to Braun Blanquet's system as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%, 1 - numerous or scattered with cover up to 5%
+ - few, with small cover, r - solitary, with small cover

(Recorded for British Columbia Ministry of Environment, Resource Analysis Branch by T. Lea)

Figure 87. Micromorphology of the Brunisolic Gray Luvisol at the Golden site



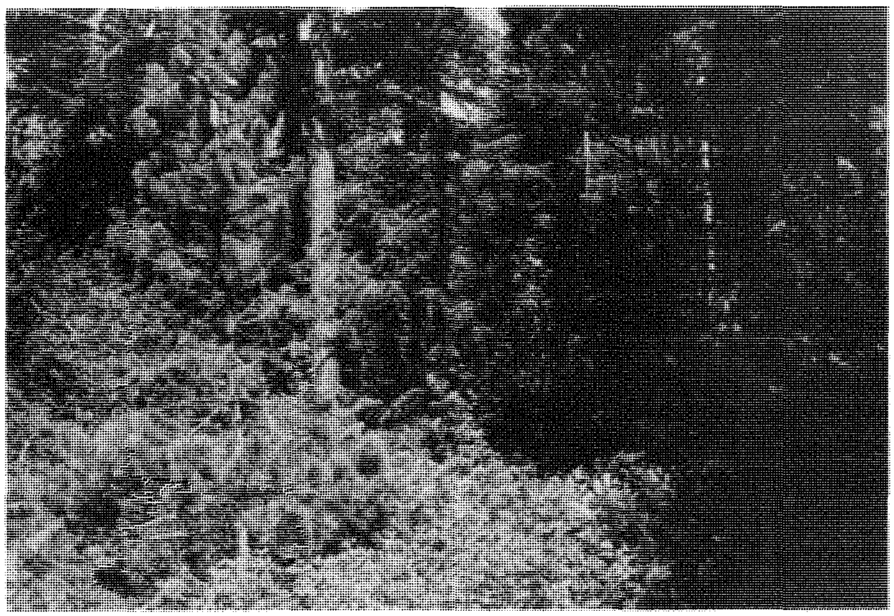
a. plane light



b. partly X

Bm1 The moderately dense brownish gray fabric consists of a matrix of clay and fine silt with skeleton grains of quartz, felspar, amphiboles and pyroxenes (Fig. a). Rock fragments (O) of metamorphic origin occur. There are remnants of organic matter (O), mainly in the voids. There are ferruginous glaebules (C, up to 1-5mm) and weakly oriented argillans (R) occur along some channels and around some vughs.
-1- Masepic-silasepic porphyroskelic

Bt The dense fabric (Fig. b) consists of an orange brown clay matrix with skeleton grains of weathered metamorphic rock fragments (C) and sand (C) and silt (C) grains of quartz and felspar. Illuviation argillans (C, up to 30μm thick) exist around skeleton grains, vughs and chambers and along channels. There are nodules of calcite throughout the matrix and veins of calcite in some rock fragments.
-1- Skel-insepic porphyroskelic



Photograph by T. Lord

FIG. 88 TYPICAL VEGETATION ON THE BRUNISOLIC GRAY LUVISOL AT THE GOLDEN SITE

Description of an Eluviated Eutric Brunisol at the Muleshoe site.

Location:	UTM 11U NG 8980 7020 Along Highway 1A west of Banff and to the east of the Muleshoe picnic site
Elevation:	1400 m a.s.l.
Landform:	12% simple slope, mid slope, southeast
Estimated drainage:	Well drained
Surface runoff:	Moderate
Parent Material:	Calcareous fine loamy to fine silty fluvial sediments
Vegetation:	Representative species include trembling aspen and pine grass (see stand description, Table 8)
Climate:	Continental, with fairly long cold winters and cool summers. Annual precipitation is in the range of 400 to 500 mm
Classification:	Canada - Eluviated Eutric Brunisol U.S.A. - Typic Cryochrept F.A.O. - Calcic Cambisol
Notes:	The soil temperature at 50 cm was 7 C. This pedon shows stratification, and buried Ah horizons indicate the fan has been flooded periodically. The presence of 10 cm of horizon development indicates the landform has been stable for the recent past. Infiltration rate 28 cm/hr, percolation rate 4 min/10 cm

Horizon	Depth (cm)	Description
L-F	5-3	Dark reddish brown (5YR 3/2m), partly decomposed leaves and organic litter; plentiful fine and medium roots; clear wavy boundary; 0 to 3 cm thick
H	3-0	Black (5YR 2.5/1m) well decomposed organic litter; plentiful fine and medium roots; abrupt wavy boundary; 2 to 5 cm thick
Ae	0-5	Brown (7.5YR 4.5/4m) and pink (5YR 7/3d) matrix colors; silt loam; weak fine to medium platy; friable; slightly sticky plentiful fine and medium roots; few very fine and fine vertical pores; no effervescence; estimated coarse fragments 1% fine gravel; abrupt wavy boundary; 4 to 7 cm thick
Bm	5-12	Dark yellowish brown (10YR 3/4m) exped color and dark brown (7.5YR 4/4m) crushed color clay loam; moderate to strong fine to medium subangular blocky; plentiful fine random roots; few very fine pores; estimated coarse fragments 2% fine gravels; abrupt wavy boundary; 4 to 8 cm thick
BCk	12-18	Dark brown (7.5YR 4/2m) exped and brown (10YR 5/3m) crushed colors; loam; weak fine to medium subangular blocky; very friable; few fine and medium random roots; common very fine pores; moderate effervescence; trace of coarse fragments; clear wavy boundary; 5 to 8 cm thick
Ck	18-25	Dark brown (10YR 4/3m) silty clay loam; strong fine to medium subangular blocky; friable; sticky; few fine and medium random roots; common very fine pores; strong effervescence, no coarse fragments; abrupt wavy boundary; 4 to 8 cm thick
Ahkb	25-28	Very dark grayish brown (10YR 3/2m) and reddish brown (5YR 4/4m) exped colors and dark yellowish brown (10YR 3/4m) crushed color; clay; moderate medium roots; common very fine pores; strong effervescence; no coarse fragments; abrupt wavy boundary; 2 to 4 cm thick
Ckb1	28-51	Pale brown (10YR 6/3m) sandy clay loam; moderate fine subangular pseudo blocky structure; friable, slightly sticky; very few fine and medium roots; common very fine and fine pores; strong effervescence; estimated coarse fragments 1% fine gravels; diffuse wavy boundary; 20 to 26 cm thick
Ckb2	51-111	Pale brown (10YR 6/3m) sandy loam; with few fine distinct yellowish brown (10YR 5/8m) mottles; structureless; stratified friable, sticky; very few fine to medium roots; many fine random pores; strong effervescence; estimated coarse fragments 1% fine gravels; abrupt wavy boundary; 55 to 65 cm thick
Ahkb2	111-113	Dark yellowish brown (10YR 3/4m) matrix and crushed color; silt loam; moderate fine subangular blocky; friable; very few medium roots; strong effervescence; 1 to 4 cm thick
Ckb3	113+	Pale brown (10YR 5/3m) sandy clay loam; structureless, stratified; friable; very few medium roots; strong effer-

TABLE 26. ANALYTICAL DATA FOR AN ELUVIATED EUTRIC BRUNISOL AT THE MULESHOE SITE
DONNEES ANALYTIQUES DU BRUNISOL EUTRIQUE ELUVIEE A SITE MULESHOE

Horizon	pH H_2O	pH $CaCl_2$	C Total	$CaCO_3$ Equ.	N Total	C/N	Exch. Cations / Cations Ech. — Neutral Salt / Sel Neutre K	Ca	Mg	Al	Total	Buffered / Tamponée Total	NH_4OAc (pH7) Ca	Mg	Na	K	Dithionite Fe	Al	Mn	Oxalate Fe	Al	Pyrophos. Fe	Al
			%	%	%		me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	%	%	%	%	%	%	%
L-F	6.9	6.8	24.8	-	0.21	120						56.8	57.9	8.71	0.05	1.53							
H	6.0	5.7	28.7	-	1.96	15	3.21	54.1	12.3		69.7	78.2	60.6	13.5	0.00	2.82							
Ae	6.0	5.5	1.77	-	0.16	11	0.36	6.70	2.06		9.12	8.8	6.59	2.05	0.06	0.26							
Bm	7.0	6.6	2.11	3.90	0.19	11	0.38	8.60	3.13		12.1						2.17	0.14	0.08	0.47	0.14	0.28	0.05
BCk	7.6	7.2	4.60	23.0	0.21	9																	
Ck	7.8	7.3	6.87	32.7	0.17	17																	
Ahkb	7.8	7.3	5.74	27.3	0.21	12																	
Ckb1	8.0	7.5		40.6																			
Ckb2	8.1	7.6		45.2																			

Horizon	Avail. Nutrients / Assimilable N	P-Bray	K	S	Org. mat. / mat. org. Extracted / Extrait C	N	Cha/Cfa	FA E4/E6	HA E4/E6	Part Size Dist. (<2mm) / anal. gran. Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile Fine	Bulk D. / dens. app.
	ppm	ppm	ppm	ppm	%	%				%	%	%	%	g/cc
L-F					31.4	49.8	1.25	6.8	5.6					
H	2	21	290	17	33.0	46.7	1.03	8.7	7.3					
Ae	<1	1	90	2						20	54	26	8	1.2
BM	<1	2	130	2	32.1	37.3	0.51	8.4	5.1	35	32	33	14	1.3
BCk										33	41	26	9	1.2
Ck										14	53	33	13	
Ahkb					39.1	33.3	1.76	5.1	5.7	4	45	51	20	
Ckb1										27	50	23	7	1.4
Ckb2										44	39	17	6	

Table 27. Vegetation Structure at the Muleshoe Site

	Cover Class*
Tree Layer:	
Populus tremuloides	5
Shrub Layer:	
Populus tremuloides	+
Rosa acicularis	2
Populus tremuloides	1
Herb Layer:	
Calamagrostis rubescens	4
Thalictrum venulosum	2
Elymus innovatus	2
Viola rugulosa	2
Aster conspicuus	2
Lathyrus ochroleucus	2
Epilobium angustifolium	1
Fragaria virginiana	1
Taraxacum officinale	1
Vicia americana	1
Achillea millefolium	+
Agropyron repens	+
Agropyron subsecundum	+
Aster ciliolatus	+
Astragalus alpinus	+
Castilleja miniata	+
Delphinium glaucum	+
Galium boreale	+
Poa pratensis	+
Senecio indecorus	+
Smilacina stellata	+

*Cover according to Braun Blanquet's system as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%, 1 - 4-1%
+ - less than 1%

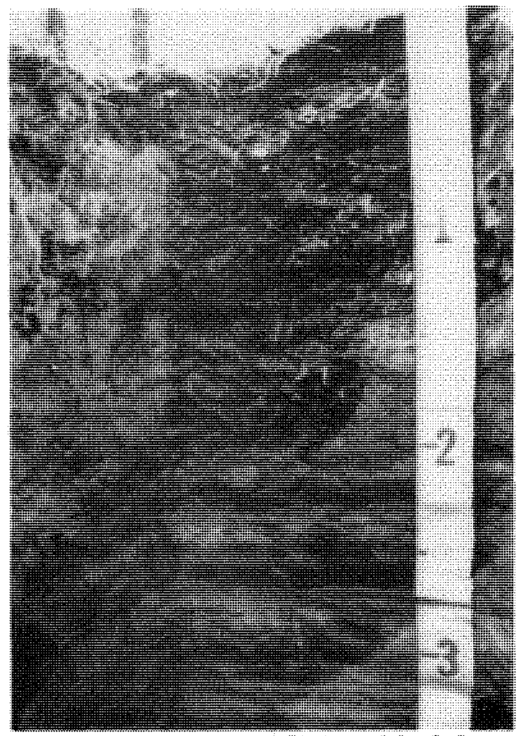
Table 28. Long-term meteorological data for Banff Lat. 51° 11' N Long. 115° 34' W Elevation 1 397 m a.s.l.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Daily Temp C	-11.2	-6.8	-3.8	2.3	7.5	11.2	14.5	13.3	9.1	4.2	-3.8	-8.7	2.3
Mean Daily Max Temp C	-6.1	0.72	2.5	8.3	14.2	17.8	22.3	21	16.0	9.7	0.72	-4.4	8.4
Mean Daily Min Temp C	-16.3	-12.9	-10.1	-3.7	0.72	4.4	6.6	5.7	2.1	-1.3	-8.3	-13.1	-3.8
Extreme Max Temp C	12.2	14.4	17.2	25.6	29.4	33.8	34.4	33.8	30.0	26.1	15.6	12.2	34.4
Extreme Min Temp C	-51.1	-45.0	-40.6	-27.2	0	-3.9	-1.6	-3.3	-16.7	-21.7	40.6	-48.3	-51.1
No. of Days with Frost	30	28	30	26	15	3		1	10	20	28	30	221
Mean Rainfall mm	0.51	1.02	1.52	8.8	42.1	63.8	48.0	48.3	32.0	19.6	5.6	2.5	274
Mean Snowfall mm	355.6	297.2	231.1	299.7	94.0	12.7	0	T	58.4	180.3	318.0	340.0	2187
Mean Total Pptn. mm	33.3	29.5	22.9	36.3	51.0	65.0	48.0	48.3	37.6	36.3	34.8	33.8	478

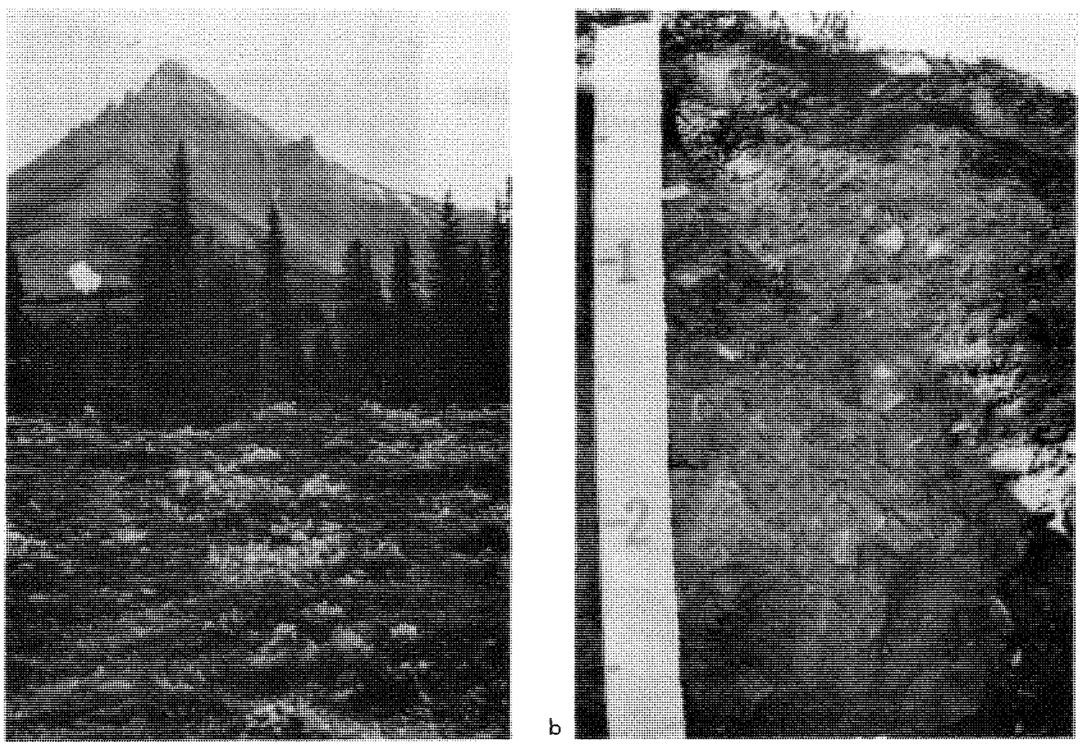
FIG. 89 TREMBLING ASPEN COMMUNITY (a) AND ELUVIATED EUTRIC BRUNISOL ON FLUVIAL SEDIMENTS (b) AT THE MULESHOE SITE

a 

Photograph by G. Coen

b 

Photograph by G. Coen



a b

FIG. 90 UPPER SUBALPINE COMMUNITY (a) AND ORTHO HUMO-FERRIC PODZOL ON TILL (b) AT THE BOW PASS SITE

Description of an Orthic Humo-Ferric Podzol at the Bow Pass site.

Location:	UTM 11U NH 34 30 2930 - Bow Pass About 200 m south of the Peyto Lake Lookout parking area
Elevation:	2130 m a.s.l.
Landform:	Inclined morainal
Slope:	10% simple slope, upper slope east
Estimated drainage:	Well drained
Surface runoff:	Moderate
Parent material:	Silt loam surficial deposit over coarse loamy calcareous till
Vegetation:	Representative species include Engelmann spruce, subalpine fir and heather.
Climate:	Continental, with long cold winters and cool summers. Snow often does not melt until late June or later. Frost may occur any month of the year. Precipitation is probably in the 600 to 800 mm range
Classification:	Canada - Orthic Humo-Ferric Podzol U.S.A. - Entic Cryorthod F.A.O. - Calcic Cambisol
Notes:	The soil temperature at 50 cm was 4 C. There is marked variability in thickness of the Ae horizon over the landscape varying from 0 to 12 cm. Where there are fewer heathers there is often an appreciable thickness of Ah

Horizon	Depth (cm)	Description
F-H	2-0	Dark reddish brown (5YR 3/2m) well decomposed organic litter; plentiful micro and very fine roots; few white mycella; abrupt smoooth boundary; 0 to 4 cm thick
Ae	0-6	Pale brown (10YR 6/3m) silt loam; weak to moderate fine to medium platy; very friable; very fine to medium horizontal roots; few very fine vertical pores; no clay films; no angular gravels; abrupt wavy boundary; 3 to 8 cm thick
Bhf	6-12	Dark reddish brown (2.5YR 3/4m) and strong brown (7.5YR 5/6m) silt loam; moderate to strong coarse platy; friable; few fine roots; few fine vertical continuous inped pores; no clay films; no effervescence; estimated coarse fragments 5% angular gravels; abrupt broken boundary; 0 to 6 cm thick
11Bf	12-27	Strong brown (7.5YR 5.6m) loam; few fine distinct yellowish red (5YR 5/8m) mottles; weak to moderate medium subangular blocky and moderate very fine subangular blocky substructure; very friable; few fine roots; few very fine random pores; no clay films; no effervescence; estimated fragments 7% angular gravels; clear wavy boundary; 14 to 20 cm thick
11BC	27-35	Dark yellowish brown (10YR 4/4m) with pockets of reddish brown (5YR 4/4m) around weathered limestones; loam; few medium distinct reddish brown (2.5YR 3/4m) mottles; weak fine subangular blocky; very friable; few fine random pores; no clay films; no effervescence; estimated coarse fragments 7% angular gravels; clear wavy boundary; 5 to 9 cm thick
11Ck1	35-60	Pale brown (10YR 6/3m) sandy loam to loam; structureless; friable; few fine random roots; common fine random pores; few clay films in voids and channels; moderate effervescence; estimated coarse fragments 10% angular gravels and 5% angular cobbles; clear wavy boundary; 23 to 27 cm thick
11Ck2	60-85	Light yellowish brown (10YR 6/4m) sandy loam to loam; structureless; friable; few fine random roots; few fine random pores; thin clay films in voids and channels; moderate effervescence; estimated coarse fragments 10% angular gravels and 5% angular cobbles; clear wavy boundary; 23 to 27 cm thick
11Ck3	85-110	Pale brown (10YR 6/3m) sandy loam; structureless; friable; no roots; no pores; no clay films; moderate effervescence; estimated coarse fragments 10% angular gravels and 5% angular cobbles; diffuse wavy boundary; 23 to 27 cm thick
11Ck4	110-130+	Pale brown (10YR 6/3m) sandy loam; structureless; friable; no roots; no pores; no clay films; moderate effervescence; coarse fragments 10% angular gravels and 5% angular cobbles

TABLE 29. ANALYTICAL DATA FOR AN ORTHIC HUMO-FERRIC PODZOL AT THE BOW PASS SITE
DONNEES ANALYTIQUES DU PODZOL HUMO-FERRIQUE ORTHIQUE A SITE BOW PASS

Horizon	pH		C	$CaCO_3$	N	C/N	Exch. Cations / Cations Ech. — Neutral Salt / Sel Neutre					Buffered / Tamponée	NH_4OAc (pH7)				Dithionite			Oxalate		Pyrophos.	
	H_2O	$CaCl_2$	Total	Equ.	Total		K	Ca	Mg	Al	Total	Total	Ca	Mg	Na	K	Fe	Al	Mn	Fe	Al	Fe	Al
			%	%	%		me/100g										%						
FH	5.9	5.5	37.1		1.95	19	1.95	61.2	6.00	0.28	69.2	71.7	65.8	7.68	0.00	1.15							
Ae	5.8	4.9	2.88		0.20	14	0.18	3.95	0.97	1.33	5.38	9.2	4.32	1.28	0.84	0.12						0.07	0.08
Bhf	5.7	4.9	7.12		0.31	23	0.31	6.65	1.32	0.94	9.61	28.3	5.47	1.62	0.07	0.12						0.90	0.70
IIBf	5.4	4.5	0.74		0.05	15	0.17	1.75	0.97		3.83	9.5	1.53	1.23	0.20	0.11	2.25	0.31	0.06	1.12	0.24	0.61	0.16
IIBC	6.3	5.7					0.17	4.96	2.88		8.01	8.8	5.56	3.12	0.01	0.13							
IICk1	7.7	7.0		31.7																			
IICk2	8.0	7.3		32.2																			
IICk3	8.1	7.4		36.5																			
IICk4	8.1	7.5		62.9																			

Horizon	Conductivity / Cond. elec.	Water Satur. / eau à satur.	Water Soluble Salts / dét. sur extr. à l'eau				Avail. Nutrients / Assimilable				Mineralogy / Mineralogie (2µm[1])							Part Size Dist. <2mm / anal. gran				Bulk D. / dens. app.	Moisture / Humiditié	
			Ca + Mg	Na	K	SAR	N	P-Bray	K	S	Mica	Chlorite	Kaolin	Smect.	Verm.	Quartz	Felds.	Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile Fine		1/3 atm	15 atm
	mmhos/cm	%	me/l				ppm											%				g/cc	%	
FH							<1	6	96	6														
Ae							<1	4	21	2	tr	0	0	0	2	1	tr	18	72	10	2	0.7	60	10
Bhf							<1	1	19	1	tr	0	0	0	1	2	0	23	66	11		1.1	59	23
IIBf							<1	0	37	0	1	tr	0	0	1	1	0	47	35	18	2	1.1	21	12
IIBC											1	tr	0	tr	1	0	tr	45	34	21	3	1.3		
IICk1	0.3	33	3.0	0.2	0.03	0.2												54	32	14	3	1.7		
IICk2																		54	32	14	3	1.9		
IICk3																		63	25	12	3	1.8		
IICk4																		61	30	9	2	1.9		

[1]Amount estimated from x-ray diffractograms: tr= trace, 1= 2-20%, 2= 20-40%, 3= 40-60%, 4= 60-80%, 5= 80-100%

Table 30. Vegetation Structure of the Bow Pass Site

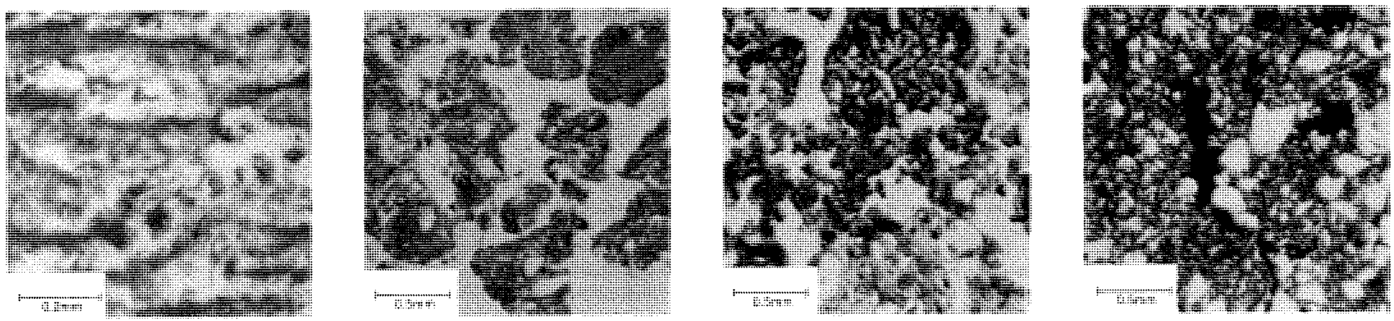
Tree Layer:	Cover Class*
Picea engelmannii	1
Abies lasiocarpa	2
Picea engelmannii	1
Shrub Layer:	
Abies lasiocarpa	1
Picea engelmannii	1
Salix glauca	2
Abies lasiocarpa	1
Picea engelmannii	+
Pinus contorta	+
Herb Layer: C (including dwarf shrubs)	
Phyllodoce glanduliflora	2
Vaccinium scoparium	2
Arnica latifolia	2
Erigeron peregrinus	2
Pedicularis bracteosa	2
Antennaria lanata	2
Selaginella densa	2
Salix arctica	2
Arnica cordifolia	1
Epilobium angustifolium	1
Phyllodoce empetriformis	1
Fragaria virginiana	1
Castilleja raupii	1
Dryas octopetala	+
Erigeron aureus	+
Poa nervosa	+
Potentilla diversifolia	+
Sedum stenopetalum	+
Luzula spicata	+
Hieracium gracile	+
Deschampsia atropurpurea	+
Salix nivalis	+
Trisetum spicatum	+
Equisetum scirpoides	+

*Cover class according to Braun Blanquet's system as follows:
5 - 100-75%, 4 - 74-50%, 3 - 49-25%, 2 - 24-5%, 1 - 4-1%
+ - less than 1%

TABLE 31: Long-term meteorological data for Entrance Lat. 53° 22' N Long. 117° 42' W Elevation 1,006 m a.s.l.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Daily Temp C	-13.4	-7.9	-3.9	2.9	8.3	12.1	14.6	13.3	9.1	4.3	-3.6	-8.8	2.3
Mean Daily Max Temp C	-6.4	-.33	3.8	10.2	16.2	19.7	22.9	21.4	17.1	11.4	2.4	-2.6	9.7
Mean Daily Min Temp C	-19.9	-15.1	-11.0	-4.3	0.3	4.4	6.3	5.2	1.0	-2.8	-9.7	-15.1	-5.1
Extreme Max Temp C	22.2	18.9	20.0	27.8	33.9	34.4	37.8	33.3	32.8	29.4	21.1	17.8	37.8
Extreme Min Temp C	-51.1	-46.7	-42.8	-35.6	-12.2	-6.7	-2.8	-2.8	-19.4	-26.7	-38.9	-17.2	-51.1
No. of Days with Frost	29	27	29	26	16	3	1	2	13	23	28	29	226
Mean Rainfall mm	.51	.25	1.02	8.4	49.8	84.8	75.1	79.3	35.6	9.9	2.3	1.8	348
Mean Snowfall mm	254	241.3	238.8	241.3	35.6	0	0	0	27.9	124.5	218.4	228.6	1610
Mean Total Pptn. mm	26.4	24.4	24.9	33.8	55.1	84.8	75.2	79.3	38.6	22.4	24.4	24.4	513

Figure 91. Micromorphology of the Orthic Humo-Ferric Podzol at the Bow Pass site.



a. plane light b. plane light c. plane light d. plane light

Ae This horizon is loosely packed dark grayish brown material with banded fabric type C (Fig. 91a). The bands are thin (<200μm) being separated by thin elongated vughs and short skew planes. There are many areas in which the banding has been interrupted by channels. Volcanic ash is extremely abundant and the overall appearance of this horizon under crossed nicols is almost isotic. There is very little sand, and silt is not abundant. Pale to dark brown, raw to moderately humified organic material (40-4000μm) is (C) and includes a little fungal hyphae.
-1- isotic porphyroskelic with banded fabric type C
-2- banded matrigranoidic

Bfh This horizon consists of very loosely packed light brown aggregates (50-5000μm) with most 1-2mm) (Fig. 91b) and (C) medium to dark brown moderately humified organic material (<3mm). About half of the aggregates contain little or no volcanic ash while the rest contain a fair amount. Thin (<50mm) matrans are (O) occuring on almost all sand grains. Diffuse sesquioxidic nodules (<1mm) are (VR) and there are a few gravel-sized rock fragments (quartzite, sandstone and siltstone).
-1- argillasepic porphyroskelic aggregates
-2- matrigranic

IIBf This horizon is loosely packed brown material that consists of strongly fused aggregates (100-5000μm with most 500-1000μm) (Fig. 91c). Nodules are (C) and consist of about equal amounts of large diffuse sesquioxidic nodules (<3mm) and clay nodules (<500μm) that occasionally occur as clusters (2mm) of smaller nodules (<100μm). Weakly oriented silty argillans (<200μm) are (R), and sand and gravel-sized rock fragments are (O-C).
-1- insepic porphyroskelic aggregates
-2- matrigranoidic porphyroskelic//matrigranoidic

IIBC This horizon is loosely packed brown material consisting mainly of moderately fused aggregates (<1mm) with many orange brown areas of loose to weakly fused aggregates with weak birefringence and no sand or silt. Weakly to moderately oriented irregular clay nodules (<2mm) are (O), often have the appearance of translocated clay, and in some areas look more like fillings in intergranular spaces than nodules. Diffuse sesquioxidic nodules (<300μm with most 80-100μm) are (VR-R) and gravel-sized rock fragments (sandstone, siltstone, shale) are (C). Weakly to moderately oriented argillans (<120μm) are (R-O) and occur on free grains, channels and aggregate surfaces with some as matrans on the large grains.
-1- in-skelsepic porphyroskelic aggregates with agglomeroplasmic areas
-2- matrigranoidic porphyroskelic//matrigranoidic

IICk1 This horizon consists of very loosely packed brown aggregates (2-10mm) and gravel (<12mm with carbonate>> sandstone and siltstone). The aggregates are moderately to loosely packed and appear to result from fusion of smaller aggregates (Fig. 91d). They contain (C) carbonates as gravel, sand, and coarse silt, (R) diffuse clay nodules as patches and stringers, and (R) weakly oriented embedded grain and vugh argillans. Matrans occur on the loose gravel and when coarser than 200μm look more like adhered aggregates than matrans.
-2- ortho-matrigranic

IICk4 This horizon is moderately packed grayish calcareous material with (C-F) vughs (<2.5mm with most 0.5-1mm) and interconnected vughs. In the occasional areas of the interconnected vughs it would appear that this type of void results from strong coalescence of aggregates. Carbonates are (F) and occur as abundant gravel, sand, coarse silt and fine matrix material. Weakly to moderately oriented vugh argillans (<160μm) are (R-O) and occasionally contain silt and become matrans.
-1- silasepic porphyroskelic

Overlander Site

Setting.

The site has an elevation of 1,060 m a.s.l. in an area with a loess blanket overlying till. The topography is undulating with slopes of 3 to 5%. The site is located on a crown position.

Climate.

The area has a subhumid, continental climate with moderate precipitation. Long term meteorological data (30 years, Table 31) are available for Entrance which is about 18 km northeast of the site.

Land Use.

Forest capability of the area is Class 4 according to the Canada Land Inventory System, producing about 2.0 m^3 wood per year. White Spruce and Lodgepole Pine are the possible commercial species at the site, both suitable for either saw-log or pulpwood production.

Other possible land uses are watershed management, recreation and wildlife. Grazing in this area is not recommended because it would severely interfere with the regeneration of the forest following logging.

Site Productivity.

Species:	*Picea glauca*
Stand Age:	200 years
Stand Height:	21 m
Site Index:	12 m at age 70 years
Basal Area:	48.5 m^2/ha
Volume:	247 m^3/ha (merchantable)
	349 m^3/ha (total)

Soils.

The unique soils (Dumanski 1970; Dumanski and Pawluk 1971) discussed in this section are confined by 53°10' and 53°20' north latitude and by 117°55' west longitude. They lie within the borders of the Athabasca River Valley, which is a broad, regional depression ranging from 15 to 20 km in width, with a local relief ranging from about 300 to 525 m.

In this area the late Cretaceous shales and sandstones are commonly overlain by moderately calcareous Obed till (Roed 1968) which is a Cordilleran till derived mainly from the Front and Main Ranges of the Rocky Mountains. The Obed till is very cobbly, olive brown to olive black in color, medium to coarse textured, and contains about 18 to 30% carbonates. It has an average thickness of about 3 m. Outwash terraces and deposits of lacustrine silts and clays overlie Obed till in local areas.

Superimposed on the previously mentioned deposits is an extensive blanket of calcareous eolian material. This material is generally grayish brown (2.5Y 5/2) in color, friable to loose in consistence and strongly calcareous. It commonly consists of a mixture of fine and very fine sand, with varying amounts of both finer and coarser particles. It is up to 60 m thick in the vicinity of Brûlé Lake (Roed 1968) but thins rapidly toward the east. The source regions of the eolian material are the floodplains of the Athabasca River in Jasper National Park and the shores of Brûlé Lake. The loess is transported by southwesterly winds channeled through the Athabasca River Valley. There are no wind data appropriate to this area nor is there a long term local observer record.

In this area soil development is a function of ancient climatic conditions with some modification from modern climates. Results of field and laboratory studies indicate these soils have had a polygenetic origin. The presence of humified, surficial horizons with physical make-up that differs from the "paleo" B horizon suggests a hiatus in deposition of sufficient time to allow for the formation of the "paleo" B horizon. The soils possess well developed Ahk horizons regardless of the fact that soils in surrounding areas are Gray Luvisols. Within the "paleo" B translocation of both clay and iron has occurred in a material with free lime.

The following sequence of events is postulated:

1) Deposition of calcareous eolian material following withdrawal of the Obed glacier.

2) Colonization of this material by plants. This would result in the release of iron present in the primary carbonates, the dissemination of which would form the "paleo" B horizon.

3) Subsequent resumption of loess deposition, coupled with litter comminution by various soil fauna, began the formation of an Ahk horizon in which there were considerable quantities of primary carbonates. In western portions of the region, rapid burial preserved the "paleo" B horizon.

4) In regions where the "paleo" B remained within the zone of active pedogenic weathering, internal transformations took place.

The dissemination of calcareous eolian material from the source eastward appears to result in a geographic zonation of carbonate content, sand content and soil reaction. A mean rate of loess accumulation can be calculated for a variety of sites in the area. For the last 8,000 years at Brûlé Lake (3 km west of this site), an area of active accretion, the rate is 0.7 mm per year. At other less actively accreting sites a rate as low as 0.2 mm per year has been calculated.

A "rate of soil formation" may be expressed as a relative function interpreting the major periods of loess hiatus and of soil formation from the paleosol record. For the period from 8,000 years B.P. to 4,300 years B.P. a maximum five episodes of accumulation and four episodes of soil formation may be recognized.

Throughout the area the relative rates of loess accumulation have essentially controlled soil formation. At any point in time (post 8,000 years B.P.) the soil at any one site relative to another may have been developing under conditions of unlike equilibria. The alkaline reaction throughout the soil profile and the very high percentage of the cation exchange complex occupied by calcium appear to adversely affect the growth of White Spruce. Trees commonly appear to be stunted, possess a dense branching habit and show a characteristic reddening at the tips of the needles. These calcareous soil areas are also problematic in terms of reforestation by use of seedlings.

The soils occurring in the area surrounding the site are dominantly Cumulic Regosols in combination with significant amounts of Orthic Brunisols, Eluviated Brunisols and minor inclusions of gleyed soils. The major difference between most of these soils is the thickness of the Ahk horizon.

Description of an Orthic Melanic Brunisol at the Overlander site.

Classification:	Canada - Orthic Melanic Brunisol U.S.A. - Cumulic Cryoboroll F.A.O. - Calcic Chernozem
Location:	UTM 11U MJ 461 991 About 1 km northwest of the Overlander Motel, east of Jasper National Park gate
Elevation:	1060 m a.s.l.
Climate:	Subhumid continental with moderate mean annual precipitation in the range of 450 to 550 mm
Vegetation:	Representative species include a predominance of 200 year old White Spruce with an understory of Fuzzy-spiked Wild Rye Grass (see stand description, Table 22)
Landform:	eolian blanket over undulating moraine. The blanket thins to veneer eastward from Brûlé Lake
Parent Material:	At this site there is about 1 m of modern silt loam calcareous wind-blown material over about 20 cm of what appears to be the immediate post pleistocene loess silt loam surficial deposits recognized throughout much of the Rockies. Below this is dense calcareous gravelly and cobbly till (cordilleran)
Slope:	3 to 5% complex slopes, crest
Drainage:	well drained
Notes:	The annual increments of calcareous eolian material, except for occasional lapses, govern pedogenic development.

Horizon	Depth (cm)	Description
L-F	2-0	Partially decomposed leaf and needle remains; moderately effervescent
Ahk1	0-20	Black (10YR 2.5/1m), very dark gray (10YR 3/1d); silt loam; weak, fine granular; very friable; abundant, micro and very fine, oblique roots; many, micro, continuous interstitial pores; clear, wavy boundary; mildly alkaline; 15 to 24 cm thick
Bmk1	20-23	Brown to dark brown (7.5YR 4/4m), brown (7.5YR 4/2d); silt loam; weak, fine subangular blocky; very friable; abundant micro and very fine, oblique roots; many, micro, continuous, interstitial pores; clear, wavy boundary; moderately alkaline; 1 to 4 cm thick

Ahkb1	23-25	Black (10YR 2.5/1m), very dark gray (10YR 3/1d) silt loam; weak, fine granular; very friable; abundant, micro and very fine, oblique roots; many, micro, continuous, interstitial pores; abrupt, wavy boundary, moderately alkaline; 0 to 3 cm thick
Ckb1	25-43	Very dark grayish brown, (10YR 3/2m) silt loam; weak, fine subangular pseudoblocky; very friable; plentiful, very fine and fine, oblique roots; many, micro, continuous, interstitial pores; abrupt, wavy boundary; moderately alkaline; 12 to 26 cm thick
Ahkb2	43-45	Black (10YR 2.5/1m), very dark gray (10YR 3/1d) silt loam; weak, fine granular; very friable; plentiful, very fine and fine, oblique roots; many, micro, continuous, interstitial pores; abrupt, wavy boundary; moderately alkaline; 0 to 3 cm thick
Ckb2	45-58	Dark brown (10YR 3/3m), grayish brown (10YR 5/2d) silt loam; weak, fine subangular pseudoblocky; very friable; plentiful, very fine and fine, oblique roots; common, micro and very fine continuous; interstitial pores; gradual wavy boundary; moderately alkaline; 8 to 16 cm thick
Ckb3	58-63	Dark brown (10YR 3/3m), grayish brown (10YR 5/2d) silt loam; weak, fine subangular pseudoblocky; very friable; plentiful, very fine and fine, oblique roots; common, micro and very fine, continuous, interstitial pores; abrupt, wavy boundary; moderately alkaline; 3 to 5 cm thick
Bmkb1	63-68	Dark brown (7.5YR 4/4m), brown (7.5YR 5.4d) silt loam; weak, fine subangular blocky; very friable; plentiful, very fine and fine, oblique roots; common, micro and very fine, continuous, interstitial pores; clear, wavy boundary; moderately alkaline; 2 to 7 cm thick
Ahkb3	68-73	Dark reddish brown (5YR 2/2d), silt loam, weak, fine granular; very friable; plentiful, very fine and fine, oblique roots; many micro, continuous interstitial pores; clear, wavy boundary; moderately alkaline; 2 to 6 cm thick
Ckb4	73-81	Dark brown (10YR 3.3m), grayish brown (10YR 5.2d) silt loam; weak, fine subangular pseudoblocky; plentiful, very fine and fine, oblique roots; common, micro and very fine, continuous, interstitial pores; clear, wavy boundary; moderately calcareous; 4 to 10 cm thick
Bmkb2	81-86	Dark brown (7.5YR 4.4m), brown (7.5YR 5.2d) silt loam; weak, fine subangular blocky; very friable; plentiful, very fine and fine, oblique roots; many, micro and very fine, continuous interstitial pores; clear, wavy boundary; moderately calcareous; 3 to 6 cm thick

Ahkb4	86-88	Dark brown (7.5YR 3/2m), dark grayish brown (10YR 4.2d) silt loam; weak, fine granular; friable; few, very fine and fine, oblique roots; common, micro, continuous interstitial pores; abrupt, wavy boundary; moderately alkaline; 0 to 3 cm thick
Ahkb5	88-93	Dark brown (7.5YR 3/2m), dark brown (10YR 4/3d) silt loam; weak, fine granular; friable; few, very fine and fine, oblique roots; common, micro, continuous, interstitial pores; clear, wavy boundary; moderately alkaline; 3 to 6 cm thick
Bmkb3	93-100	Brown (7.5YR 4/4m), light brown (7.5YR 6/4d) silt loam; weak, fine subangular blocky; friable; few, very fine and fine, oblique roots; many, micro and very fine, discontinuous oblique, denitritic, tubular pores; clear, wavy boundary; moderately alkaline; 4 to 9 cm thick
11Bmk	100-110	Yellowish red (5YR 4/8m), reddish yellow (7.5YR 6/6d) loam; weak, fine subangular blocky; friable; few, very fine and fine, oblique roots; many, micro and very fine, discontinuous dentritic, tubular pores; clear, wavy boundary; moderately alkaline; 6 to 12 cm thick
11BCk	110-122	Strong brown (7.5YR 5/6m), reddish yellow (7.5YR 6/6d) loam; weak, fine subangular blocky; friable; very few, very fine and fine, oblique roots; many micro and very fine discontinuous dendritic, tubular pores; few pebbles and cobbles; clear, wavy boundary; moderately alkaline; 8 to 20 cm thick
111Ck1	122-132	Yellowish brown (10YR 5/4m), pale brown (10YR 6/3d) sandy loam; single grain; friable; very few, very fine, oblique roots; numerous pebbles and cobbles; clear, wavy boundary; strongly alkaline; 7 to 15 cm thick
111Ck2	132-150+	Grayish brown (2.5YR 5/2m), pale yellow (2.5YR 7/4d) loam or sandy loam; friable; numerous pebbles and cobbles; moderately alkaline

TABLE 32. ANALYTICAL DATA FOR THE ORTHIC MELANIC BRUNISOL (CALCAREOUS, CUMULIC) AT THE OVERLANDER SITE

DONNEES ANALYTIQUES DU BRUNISOL MELANIQUE ORTHIQUE (CALCAIRE, CUMULIQUE) A SITE OVERLANDER

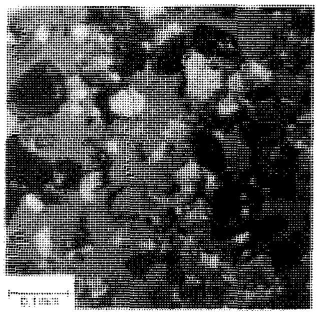
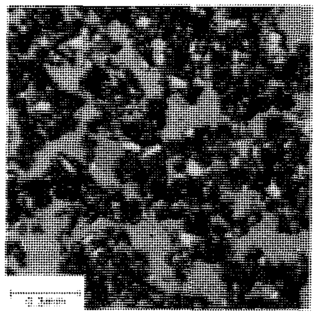
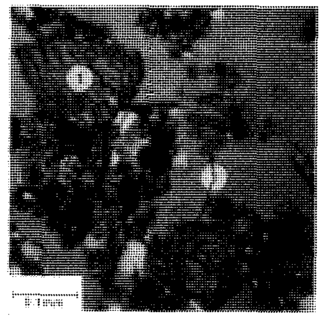
Horizon	pH H_2O	pH $CaCl_2$	C Total	$CaCO_3$ Equ.	N Total	C/N	Dithionite Fe	Dithionite Al	Dithionite Mn	Oxalate Fe	Oxalate Al	Pyrophos. Fe	Pyrophos. Al
			%				%						
Ahk1	7.7	7.0	10.4	23.7	0.35	22	0.82	0.03	0.02	0.37	0.06	0.07	0.01
Bmk1	8.0	7.3	6.1	3.15	0.17	13	0.98	0.03	0.02	0.38	0.05	0.06	0.01
Ckb1	8.0	7.5	8.7	22.6	0.24	25	0.74	0.02	0.02	0.32	0.06	0.06	0.02
Ckb2	8.2	7.6	6.3	30.7	0.14	19	0.92	0.03	0.02	0.50	0.08	0.09	0.02
Ckb3	8.2	7.7	6.5	38.2	0.13	15	0.82	0.02	0.01	0.42	0.05	0.08	0.02
Bmkb1	8.3	7.7	4.9	17.2	0.08	36	1.03	0.03	0.03	0.53	0.07	0.08	0.03
Ahkb3	8.3	7.7	5.3	9.2	0.13	32	1.03	0.02	0.02	0.64	0.04	0.08	0.01
Ckb4	8.3	7.7	5.6	18.9	0.13	26	0.89	0.01	0.02	0.50	0.03	0.11	0.02
Bmkb2	8.3	7.7	5.0	31.9	0.11	11	1.05	0.04	0.03	0.56	0.05	0.10	0.02
Ahkb4	8.4	7.7	5.2	23.5	0.18	13	1.11	0.04	0.04	0.62	0.06	0.11	0.01
Ahkb5	8.4	7.7	3.7	10.0	0.16	16	1.33	0.08	0.06	0.91	0.12	0.12	0.03
Bmkb3	8.4	7.6	1.6	5.9	0.08	11	1.27	0.09	0.04	0.77	0.15	0.05	0.01
IIBmk	8.3	7.7	0.3	0.9	0.09	2	1.46	0.07	0.03	0.24	0.02	0.05	0
IIBCk	8.2	7.6	0.4	1.6	0.04	5	1.50	0.08	0.03	0.23	0.04	0.06	0.02
IIICk1	8.5	7.7		19.1			0.84	0.03	0.02	0.21	0.02	0.05	0.02
IIICk2	8.4	7.8		35.2			0.76	0.03	0.01	0.16	0.01	0.02	0.01

Horizon	Avail. Nutrients / Assimilable N	P-Bray	K	S	Org. mat. / mat. org. Extracted / Extrait C	N	Cha/Cfa	FA E4/E6	HA E4/E6	Part Size Dist. <2mm / anal. gran. Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile Fine
	ppm				%					%			
Ahk1	3	0	53	4	41.0	38.3	0.92	5.6	1.8	22	66	12	2
Bmk1										21	68	11	2
Ckb1	2	0	25	4						24	66	10	1
Ckb2										21	68	11	3
Ckb3										25	62	13	4
Bmkb1					45.1	28.4	0.46	21.0	5.5	29	63	8	2
Ahkb3					53.3	45.3	2.08	28.5	1.6	27	63	10	2
Ckb4										20	70	10	3
Bmkb2										14	76	10	1
Ahkb4										10	79	11	2
Ahkb5					51.1	40.8	1.19	18.7	2.8	13	75	12	2
Bmkb3					58.9	40.1	0.74	22.0	5.2	19	64	17	7
IIBmk										40	43	17	6
IIBCk										51	33	16	8
IIICk1										65	28	7	3
IIICk2										53	36	11	4

Table 33. Vegetation Structure at the Overlander Site

	Cover Class
Tree Layer:	
Picea glauca	*50%*
Shrub Layer:	
Betula papyrifera	*10%*
Rosa acicularis	
Shepherdia canadensis	
Amelanchier alnifolia	
Lonicera dioica	
Viburnum edule	
Juniperus communis	
Rosa sp.	
Herb Layer:	
Elymus innovatus	*85%*
Geocaulon lividum	
Linnaea borealis	
Pyrola secunda	
Hedysarum alpinum	
Mertensia panicultata	
Mitella nuda	
Galium boreale	
Streptopus amplexifolius	
Zygadenus elegans	
Cypripedium calceolus	
Arctostaphylos uva-ursi	
Rubus pubescens	
Carex sp	
Pyrola sp	
Luzula sp	
Viola sp	
Disporum sp	
Moss and Lichen Layer:	
Abietinella abietina	*60%*
Hypnum sp	

Figure 92. Micromorphology of the Orthic Melanic Brunisol at the Overlander Site.


a. partly X b. partly X c. partly X d. partly X

Ahkl This horizon consists of a dark, loosely packed, randomly distributed mixture of mineral grains (<100µm), dominantly carbonate and quartz, and organic material at various stages of decomposition. The organic material ranges in size from slightly decomposed root fragments more than 1mm long to humified aggregates about 20µm in diameter. Fungal hyphae and mycorrhiza mantles are (C); sclerotia are (R) and fecal pellets are (O). Clusters of secondary carbonate grains are (O).
-1- granular with intertextic areas
-2- matrigefuric-humi-phyto-orthogranic

Bmkbl This horizon consists of a dark brown, loosely packed, randomly distributed mixture of mineral grains (<100µm) and organic material. In the mineral fraction, ferruginous clayey grains are (C) and secondary carbonate grains occur as (O) clusters and (R) partial to complete channel calcans. The organic material generally shows more humification than in the Ahkl and there are less fragments and more aggregates. Fungal hyphae and mycorrhiza mantles are (O), and sclerotia are (VR).
-1- granular with common intertextic to agglomeroplasmic areas
-2- matrigefuric-phyto-humi-orthogranic

Bmkb3 This horizon is moderately packed, brown material in which the fine matrix material coats (thin matrans <15 µm) most of the sand grains and extends to form aggregates (<2mm with most <500 µm) which exhibit varying degrees of fusion. In most areas the fusion is quite strong and the s-matrix has a porous appearance with (C-F) vughs and interconnected vughs (<1 mm) and (O) channels. The s-matrix exhibits weak birefringence and has a particle size generally less than 100 µm. Primary carbonates are (O) as sand and silt and secondary carbonates are (R) as nodules and calcans. Well humified black organic fragments (100-500 µm) are (R-O) and volcanic ash as equant hacky grains (<150 µm) are (C). This (<20 µm) weakly oriented argillans are (R).

-1- agglomeroplasmic
-2- matriplectic//matrigranoidic, porphyroskelic-matrigranoidic

plate - matrigranoidic

Bmkb3 - Volcanic ash

IIBCk The fabric consists of randomly distributed sand grains of a wide range of sizes up to 1 mm, more or less continuously coated with brownish weakly oriented matrix material that bridges between the grains to form a continuous network. Porosity is moderate and the packing of grains is moderately close. Thin, moderately oriented skeleton grain and vugh argillans are (R) and manganiferous nodules (<200 µm) are (VR). The skeleton grains are dominantly quartz and mica with some carbonates, feldspar and rock fragments.

-1- intertextic
-2- matriplectic (plate)

APPENDIX E NITROGEN DISTRIBUTION IN CANADIAN SOILS

Samples for this study were chosen from the different climatic and vegetation zones of the country. Every soil order (major type of soil) in Canada was represented by at least one set of profile samples. They were selected primarily from samples taken from the ISSS tour sites, hence most of the samples were from the more southerly and warmer soils. In all 92 mineral and 18 peat soils were analyzed. The amino acid, amino sugar and ammonia contents were determined by the use of an automatic amino acid analyzer after hydrolysis of the soil by refluxing the sample for 24 hrs with 6 normal HCl. Total and acid-insoluble nitrogen were determined by the Kjeldahl method and clay-fixed ammonium by Bremner's method (Black et al., Methods of Soil Analysis, Amer. Soc. Agron. P1229). Internal standards were run with each sample with the amino acid analysis and the standard error of 28 of these was calculated and found to be less than 2%. We have also found that the acid hydrolysis error is small. Sampling error is, in general, not known although it was found to be small for some peat soils.

Data for the amino compounds were calculated as mg/g soil and as ratios (x-amino N of compound x 100/amino acid N). The latter method eliminated the effect of the wide variability of the nitrogen content of the soil samples and gave the molar ratios of the compound in the soil: i.e. the "average" mineral soil had 11.9 moles of aspartic acid and 9.5 moles of glucosamine per 100 moles of amino acid N (Table 1). The amino sugars are probably associated with the soil "carbohydrate" rather than with the soil "protein" but for comparative purposes they were calculated in the same way as the amino acids.

The resulting data were first grouped according to the nitrogen content of the samples, i.e. greater than 1% N, 0.4-1% N etc. but the amino acid composition of the soil "protein" did not appear to be related to this. The data were then grouped for the LFH, A, B, and C horizons and also for the Ah, Ap, Ae, Bhf, Bh, Bm and Bt layers. Again few significant differences in the amino acid composition could be found.

Data for the average amino acid composition and the standard deviation for 92 mineral soils, 6 LFH and 2 'O' horizons of these and 18 peat soils are shown in Table 1. Since the analytical and sampling errors appear to be relatively small and would not account for all of the standard deviation it appears that there were real but relatively small and random differences in the amino acid composition of the different samples. Inspection of the data for the individual soils supported this conclusion - for instance some samples had very small or barely detectable amounts of hydroxyproline while with other soils it made up 1-2 percent of the amino acid nitrogen. The amino sugar composition was more variable - see the larger relative standard deviation - and the glucosamine/galactosamine ratio varied from 2:1 for the LFH horizons to 1:1 for the peat soils.

In general, however, the soil "protein" which is probably largely the result of microbial degradation and synthesis is remarkably similar in its amino acid composition. For example the amount of tyrosine is usually about ½ that of phenylalanine and isoleucine 2/3 that of leudine. Black and Weiss (Amino Acid Handbook, C.C. Thomas 1956) have stated "Inspection of the data in this monograph indicates that the heterogeneous proteins of actively metabolizing living matter -- have approximately the same overall pattern of amino acids. Special proteins -- are not so well balanced". The soil "protein", probably derived from the heterogeneous proteins of microorganisms and plants, is also similar in composition.

Amino acid nitrogen makes up over half of the total nitrogen of the LFH and 'O' horizons. This underestimates the true protein nitrogen since there is probably some amine nitrogen (about 5%) not included in this. In all the mineral soils probably about 40% is "protein" nitrogen (including amine), 5% is amino sugar nitrogen, 18% hydrolyzable unidentified nitrogen and 13.5% is insoluble in the acid used for hydrolysis. Clay-fixed ammonium made up 17% of the total nitrogen and much of the hydrolyzable ammonium came from this.

The complete data for the nitrogen distribution of these soils is collected in a mimiographed publication of the Soil Research Institute, Canada Department of Agriculture, Ottawa, Ontario by Dr. Fred Sowden.

ANALYTICAL METHODS FOR NITROGEN DISTRIBUTION

For the nitrogen distribution work, ground 1.000 or 2.000 g. air dry samples are refluxed for 24 hr with 130 ml 6 N HCl, filtered through a sintered glass crucible, the residue washed, dried, weighed, and its Kjeldahl-N determined. The filtrates and washings are taken to dryness several times on a rotating evaporator to remove HCl, the residue from this dissolved in 0.05 N HCl and made up to 10 or 25 ml. The forms of nitrogen:- amino acids, amino sugars and ammonium- are determined on aliquots of this using a Technicon amino acid analyser. In some instances, ammonium is also determined on aliquots of the hydrolysates by making them alkaline with MgO, steam-distilling the ammonia and Nesslerizing. These results agree well with the amino acid analyser determination.

The amino acid and amino sugar data are reported in two ways (air dry basis):- as mg/g soil and as molar ratios. For the latter, the total number of micromoles of amino acid nitrogen is calculated and the x-amino N of each amino acid is calculated as a percentage of this. Although the amino sugars are not amino acids, the N of each amino sugar is calculated as a percent of the total amino acid N. These data show (for the first 50 or so samples we have analyzed) that the soil "protein" contains 11.9 molecules of aspartic acid, 5.6 molecules of threonine, 2.5 molecules of arginine (10 molecules of arginine N) -- etc., per 100 molecules of "protein" nitrogen and the soil "carbohydrate" contains 10.2 molecules of glucosamine on the same basis. At the bottom of the table where the data are reported in mg, the sum (or total) mg of x-amino acid and total amino acid N is given. Since half of the amino sugars are decomposed to ammonium and other compounds under the hydrolysis conditions we used, the amino sugar values reported are those found multiplied by 2 in both tables. In the mg table, therefore, part of the N is counted twice - as ammonium and as amino sugar. The mg total N and acid-insoluble N is also shown in this table.

At the bottom of the 'ratio' table, I have reported the percentage of total accounted for in the various forms of nitrogen:- total amino acid, hexosamine (or amino sugar), ammonium, and acid-insoluble N. In this table, a correction is made for the fact that part of the ammonium comes from loss of amino sugar (i.e. half the percentage of amino sugar N is subtracted from the percentage of ammonium N). These nitrogen percentages are calculated from single Kjeldahl-N determinations that we had obtained, primarily to help us select the size of the aliquot to be used for the amino acid determinations. For the Manitoba samples, we have received the total-N data from the Manitoba soil survey laboratory; in some instances, these data differ from ours and appear to give more consistent percentages for the various nitrogen fractions. Perhaps all these "percentage of total N" data should be recalculated when the "official" total N values become available. Although it has little to do with the N analysis, this table also shows the percentage of the sample that was not soluble in boiling 6 N HCl; the amount of sample described (100 - figure shown) would include the moisture contained in the air-dry sample.

Table 34. Proportions of different nitrogen components of mineral and organic horizons of representative Canadian soils.
Ratios $\left(\frac{\text{amino N of component x 100}}{\text{amino acid N}}\right)$

No. of Soils	Mineral Soils (92)	LFH Horizons (6)	O (TC)[3] Horizons 2	Peat Soils 18
Aspartic Acid	11.9±2.3	9.5±0.7	9.1±1.7	8.7±1.2
Glutamic Acid	8.6±1.1	8.1±0.3	7.8±0.3	6.6±0.7
Serine	5.6±0.9	6.2±0.6	7.0±0.1	6.1±0.7
Threonine	5.5±0.6	5.8±0.2	6.2±0.0	6.4±0.6
Glycine	11.4±0.9	10.7±0.7	10.8±0.2	11.2±1.0
Alanine	8.3±0.8	8.1±0.2	7.9±0.4	9.1±0.3
Valine	4.9±0.7	5.8±0.3	5.8±0.04	6.3±0.4
Isoleucine	3.0±0.4	3.5±0.3	3.7±0.03	4.0±0.4
Leucine	4.8±0.8	6.0±0.5	6.0±0.1	6.0±0.5
Tyrosine	1.1±0.4	1.4±0.3	1.4±0.3	2.0±0.4
Phenylalanine	2.3±0.4	2.8±0.2	2.8±0.1	3.2±0.2
Proline	4.1±0.7	5.1±0.4	5.7±0.2	4.8±0.4
OH-proline	0.4±0.4	0.8±0.2	1.2±0.1	1.3±0.8
Methionine	0.6±0.4	0.6±0.2	0.7±0.01	0.7±0.1
Cystine	0.4±0.3	0.3±0.1	0.4±0.03	0.5±0.2
Cysteic Acid	1.0±0.7	0.5±0.2	0.4±0.01	0.2±0.1
Meth. Sulphox.	0.3±0.3	0.2±0.04	0.2±0.04	0.2±0.1
Ornithine	1.0±1.1	0.4±0.1	0.4±0.01	0.6±0.3
Lysine	3.7±0.5	3.3±0.2	2.9±0.3	3.1±0.2
Histidine	1.4±0.3	1.6±0.4	1.5±0.5	1.5±0.3
Arginine	2.5±0.3	2.9±0.2	2.6±0.1	2.3±0.1
Misc.	2.0±1.1	0.6±0.3	1.1±0.7	1.2±0.3
Glucosamine	9.5±3.0	9.5±3.1	7.4±0.7	8.3±2.9
Galactosamine	5.3±1.9	4.1±1.2	4.6±0.8	8.7±4.3
Amino Acid N[1]	35.9±11.5	51.3±7.5	52.7±2.3	40.7±6.4
Hexosamine N[1,2]	5.3±2.1	7.0±2.7	6.4±0.5	6.8±2.7
Ammonia N[1,2]	27.5±12.9	14.9±2.6	14.4±5.7	11.1±1.7
Acid insol. N[1]	13.5±6.4	15.3±7.3	17.3±1.6	24.0±5.5
Clay-fixed N[1]	17.0	-	-	-
Hyd. unident.	17.8	11.5	9.2	17.4

[1] as percent of total N; [2] corrected for hydrolysis loss; [3] turbic cryosol

TABLE 35. SELECTED ORGANIC FRACTION PROPERTIES FROM 5 SOIL SITES ON TOUR 3

Soil Site	Horizon	Extractable C (as % total C)	Ch/Cf	Ch as % soil	Ch as % Total C	E4/E6 (HA)	C/N (HA)	$E_{465}^{1\%}$*	Soil %C	Soil C/N
Mount Seymour Duric Ferro-Humic Podzol	L	26	3.64	8.41	20	9.8	30	37	41.7	40
	F1	46	3.96	9.77	37	8.5	37	46	26.7	33
	F2	18	6.75	8.38	15	10.0	90	24	55.1	78
	H	39	8.14	14.7	34	7.6	48	60	42.9	89
	Ae	70	0.98	1.56	34	6.3	23	86	4.54	31
	Bhf1	63	0.91	2.88	30	7.4	19	71	9.57	23
	Bhf2	74	0.16	0.57	10	7.2	13	54	5.53	32
Similkameen Mine Orthic Gray Luvisol	Ah								7.69	18
	Ae1	38	0.72	0.23	16	5.4	12	60	1.44	16
	Ae2	39	0.53	0.09	14	5.3	11	69	0.63	16
	AB	40	0.58	0.10	15	5.6	16	94	0.70	17
	Bt	36	0.21	0.03	6				0.54	14
Mount Kobau Sombric Dystric Brunisol	Ah1	49	1.17	1.78	26	5.9	13	82	6.80	12
	Ah2	57	1.41	1.31	33	5.8	15	106	3.93	12
	Ah3	56	1.26	1.06	32	5.6	12	128	3.37	10
	Ah4	62	1.24	1.06	34	5.7	12	130	3.10	12
	Ah5	60	1.22	0.94	33	5.8	11	142	2.82	12
	Ah6	59	1.14	0.78	32	5.7	12	147	2.47	11
	Bm1	61	0.18	0.06	9	-	9	48	0.63	8
	Bm2	59	0.19	0.05	10	-	11	96	0.48	11
Summerland Station Orthic Brown Chernozemic	Ah	37	1.90	0.40	24	4.1	15	142	1.67	11
	Bm1	37	1.92	0.28	24	4.2	14	151	1.17	9
	Bm2	33	1.32	0.14	19	4.5	11	118	0.72	9
Vernon Orthic Black Chernozemic	Ah	49	2.81	1.13	36	4.0	17	182	3.16	11
	Ae	33	0.98	0.11	16	4.4	13	160	0.67	10
	BA	26	0.41	0.04	8		11	94	0.49	10
	Bt	28	0.22	0.02	5				0.45	8

* $E_{465}^{1\%}$ = extinction coefficient at 465 nm, 1% concentration and 1 cm pathlength (an index of colour intensity of HA).

Comments *

Extractable %	indicates degree of humification ie. L F,H NB Mount Seymour F2 = decayed wood higher in podzolic B than Chernozemic B or Luvisolic B
Ch/Cf	Podzolic L-H (especially H) grassland Ah Bm Bt or Bjf general trend ie. leached profiles have higher fabric in illuvial horizons ? is Mount Kobau Bm illuvial
E_4/E_6 (HA)	lowest in Chernozemic Ah & Bm (? most mature) intermediate in Luvisolics & Mount Kobau Ah highest in Podzolic FH & B (immature) highest of all in decayed wood of Mount Seymour (v immature HA)
C/N (HA)	higher in Podzolic than Luvisolic or grassland
$E_{465}^{1\%}$ (HA)	high value means most strongly coloured HA ? = more condensed, more mature molecule highest values for Chernozemics (grassland) Ah, Bm, Ae (140-180) including deepest Ah of Mount Kobau next luvisolics, lowest for podzolics NB Mount Kobau has youngest (least mature) Ah1 increasing to Ah6 NB Mount Seymour: lowest E_{465} for L & decayed wood (F2) then F1 or H

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APPENDIX F FORMAT FOR VEGETATION PLOT DESCRIPTIONS AT SOIL SITES

Stand Descriptions include a separation of layers and listing of species with coverage assessment in the plot. Definition of layers is as follows:

A1: Tall tree layer consisting of trees forming the uppermost layer of forest canopy
A2: Low tree layer consisting of trees forming subdominant layer of forest canopy, its lower limit is 5 m.
B1: Tall shrub layer consisting of wood plants whose height ranges from 2 m to 5 to 5 m.
B2: Low shrub layer consisting of woody plants whose height does not exceed 2 m, excluding dwarf shrubs such as *Vaccinium scoparium, Empetrum nigrum, Cassiope tetragona,* and so on.
Ch: Herb layer consisting of herbaceous plants regardless of their height.
Cw: Part of herb layer consisting of dwarf shrubs which are excluded from the Ch layer.
Db: Moss layer consisting of bryophytes.
Dl: Part of the moss layer consisting of lichens.

COVER CLASS: Coverage was assessed in the following six classes (after Braun Blanquet 1932 with a slight modification).

Cover Class 5:	covering 1 to 3/4 of the area of a plot
4:	1/2 to 1/4
3:	1/2 to 1/4
2:	1/4 to 1/20
1:	1/20 to 1/100
±:	less than 1/100

Nomenclature used throughout this guidebook follows Vascular Plants of British Columbia, Roy L. Taylor and Bruce MacBryde, 1977. Appendix F lists most of the commonly occurring vascular plants and mosses along the tour route by scientific and common names. Where names are different in the two provinces, the Alberta common names are shown in brackets.

Scientific Name	Common Name
Trees	
Abies amabilis	Pacific Silver Fir
Abies balsamea	(Balsam Fir)*
Abies grandis	Grand Fir
Abies lasiocarpa	Alpine Fir (Subalpine fir)
Acer circinatum	Vine Maple
Acer glabrun	Rocky Mountain Maple
Acer macrophyllum	Bigleaf Maple
Alnus rubra	Red Alder
Betula paprifera var. *papyrifera*	Common Paper Birch
Betula papyrifera var. *subcordata*	Pacific Paper Birch or White birch
Betula pumila	Bog Glandular Birch (Swampbirch)
Chamaecyparis nootkatensis	Yellow Cedar
Cornus nuttallii	Western Flowering Dogwood
Corylus cornuta	Beaked Filbert, (Beaked Hazelnut)
Larix laricina	Tamarack
Larix lyalli	Alpine Larch
Picea engelmannii	Engelmann Spruce
Picea glauca	White Spruce
Picea mariana	Black Spruce
Picea sitchensis	Sitka Spruce
Pinus albicaulis	Whitebark Pine
Pinus contorta var. *latifolia*	Lodgepole Pine
Pinus contorta var *contorta*	Shore Pine
Pinus flexilis	Limber Pine
Pinus monticola	Western White Pine
Pinus ponderosa	Ponderosa Pine
Populus balsamifera subsp *trichocarpa*	Black Cottonwood
Populus tremuloides	Trembling Aspen
Pseudotsuga menziesii var. *glauca*	Rocky Mountain Douglas Fir (Douglas fir)
Pseudotsuga menziesii var. *mensziesii*	Coast Douglas fir
Taxus brevifolia	Western Yew
Thuja plicata	Western Red Cedar
Tsuga heterophylla	Western Hemlock
Tsuga mertensiana	Mountain Hemlock
Shrubs	
Alnus incana subsp. rugosa	Speckled Mountain Alder
Alnus incana subsp. tenuifolia	Thin-leaved Mountain Alder
Amelanchier alnifolia	Saskatoon (Saskatoon-berry)
Artemisia tridentata subsp. *tridentata*	Big Basin Sagebrush
Artemisia tridentata subsp. *vasyana*	Big Mountain Sagebrush
Arctostaphylos uva-ursi	Kinnikinnick
Cassiope spp.	Cassiope
Ceanothus velutinus	Snowbush Ceanothus
Chimaphila umbellata	Common Western Pipsissewa
Chrysothamnus nauseosus	Common Rabbitbrush
Clematis verticellaris	Purple Clematis
Cornus sericea subsp. *occidentalis*	Western Red Osier Dogwood

*names used in Alberta ( )

Cornus sericea subsp. *sericea*	Common Red Osier Dogwood
Cytisus scoparius	Scotch Broom
Elaeagnus commutata	Silverberry, Wolfwillow
Gaultheria shallon	Salal
Holodiscus discolor subsp. *discolor*	Creambush, Oceanspray
Juniperus communis	Ground Juniper
Juniperus horizontalis	Creeping Juniper
Juniperus scopulorum	Rocky Mountain Juniper
Kalmia microphylla	Western Swamp Kalmia
Ledum groenlandicum	Common Labrador Tea
Lonicera dioica	Glaucus-leaved Honeysuckle (Twining Honeysuckle)
Lonicera involucrata	Twinberry Honeysuckle (Bracted Honey-suckle)
Lonicera utahensis	Utah Honeysuckle
Mahonia aquifolium	Tall Oregon-Grape
Mahonia nervosa	Dull Oregon-Grape
Myrica gale	Sweet Gale
Oploplanax horridus	Devil's Club
Paxistima myrsinites	Oregon Boxwood
Phyllodoce empetriformis	Red Mountain-heather (Red or Purple Heather)
Phyllodoce glanduliflora	Cream Mountain-heather (Yellow Heather)
Potentilla fruticosa	Shrubby Cinquefoil
Potentilla diversifolia	Blue-leaved Cinquefoil (Cinquefoil)
Prunus virginiana	Choke Cherry
Purshia tridentata	Antelopebush
Ribes lacustre	Black Swamp Gooseberry
Rosa acicularis	Prickly Rose
Rosa gymnocarpa	Baldhip Rose
Rosa woodsia subsp. *ultramontana*	Pearhip Wood's Rose
Rosa woodsia subsp. *woodsii*	Wood's Rose
Rubus parviflorus	Western Thimbleberry
Rubus pubescens	Dwarf Red Blackberry (Dewberry)
Rubus spectabilis	Salmonberry
Rubus ursinus subsp. *macropetalus*	Pacific Trailing Blackberry
Salix arctica	Arctic Willow
Salix nivalis	Net-leaved Dwarf Willow
Salix scouleriana	Scouler's Willow
Shepherdia canadensis	Soopolallie (Canadian Buffalo-berry)
Spiraea douglasii	Hardhack
Spiraea betulifolia subsp. *lucida*	Birch-leaved Spirea (White Meadow-sweet)
Symphoricarpos albus	Common Snowberry
Symphoricarpos mollis	Trailing Snowberry
Symphoricarpos occidentalis	Western Snowberry (Buckbrush)
Vaccinium alaskaense	Alaskan Blueberry
Vaccinium caespitosum	Dwarf Blueberry (Dwarf Bilberry)
Vaccinium ovalifolium	Oval-leaved Blueberry
Vaccinium oxycoccos	Bog Cranberry
Vaccinium parvifolium	Red Huckleberry
Vaccinium scoparium	Grouseberry (Grouse-berry)

Vaccinium uliginosum	Bog Blueberry
Vaccinium vitis-idaea	Mountain Cranberry (Bog Cranberry)
Viburnum edule	High Bush Cranberry (Low-bush Cranberry)

Herbs

Achillea millefolium	Common Yarrow
Achyls triphylla	American Vanilla Leaf
Actaea rubra	Red Baneberry
Agropyron repens	Quack Grass
Agropyron spicatum var. *inerme*	Beardless Bluebunch Wheatgrass
Agropyron spicatum var. *spicatum*	Bluebunch Wheatgrass
Agropyron subsecundum	Slender Wheatgrass (Bearded Wheatgrass)
Antennaria lanata	Woody Pusseytoes
Antennaria microphylla	Rosy Pusseytoes
Antennaria parvifolia	Nuttall's Pusseyfoot
Antennaria racemosa	Racemose Pusseytoes
Apocynum androsaemifolium	Spreading Dogbane
Aquilegia flavescens	Yellow Columbine
Aralis holboellii	Holboell's Rock Cress
Aralia nudicaulis	Wild Sarsaparilla
Arenaria spp.	Sandwort
Arnica cordifolia	Heart-leaved Arnica
Arnica latifolia	Broad-leaved Arnica
Aster campestris	Meadow Aster
Aster ciliolatus	Lindley's Aster
Aster conspicuous	Showy Aster
Aster subspicatus	Douglas Aster
Astragalus alpinus	Alpine Milk-vetch
Astragalus miser	Timber Milk-vetch
Athyrium filix-femina	Common Lady Fern
Balsamorhiza sagittata	Arrow-leaved Balsamroot
Blechnum spicant	Deer Fern
Bouteloua spp.	Grama Grass
Bromus tectorum	Drooping Brome Grass
Calamagrostis canadensis	Bluejoint Small Reed Grass
Calamagrostis rubescens	Pine Grass
Calypso bulbosa subsp. *occidentalis*	Fairyslipper
Carex concinna	Low Northern Sedge
Carex concinnoides	Northwestern Sedge
Carex scirpoidea	Sedge
Castilleja miniata	Common Red Indian Paintbrush (Red Paintbrush)
Castilleja raupii	Raup's Indian Paintbrush (Indian Paintbrush)
Clintonia uniflora	Blue Bead Clintonia
Corallorhiza maculata subsp. *maculata*	Spotted Coralroot
Corallorhiza maculata subsp. *mertensiana*	Western Coralroot
Cornus canadensis	Canadian Bunchberry
Cornus unalaschhensis	Western Cordilleran Bunchberry
Cypripedium calceolus	Small Yellow Ladys-slipper (Yellow Ladys'-slipper)

Delphinium glaucum	Glaucous Delphinium
Dicentra formosa subsp. *formosa*	Pacific Bleedingheart
Disporum trachycarpum	Rough-fruited Fairybells (Fairy-bells)
Dryas drummondii	Yellow Mountain-avens (Yellow Dryad)
Dryas octopetala	White Mountain-avens (White Dryad)
Dryopteris assimilis	Spiny Shield Fern
Elymus glaucus	Blue Wild Rye Grass
Elymus innovatus	Fuzzy-Spiked Wild Rye Grass (Hairy Wild Rye)
Empetrum nigrum subsp. *nigrum*	Black Crowberry
Epilobium angustifolium	Fireweed
Equisetum scirpoidea	Dwarf Scouring-Rush (Horsetail)
Erigeron aureus	Golden Fleabane (Fleabane)
Erigeron periginus	Subalpine Fleabane (Fleabane)
Eriogonum heracleoides	Parsnip-flowered Umbrella Plant
Festuca idahoensis	Idaho Fescue
Festuca scabrella	Rough Fescue
Fragaria chiloensis subsp. *lucida*	Pacific Coast Strawberry
Fragaria virginiana subsp. *glauca*	Blue-leaved Wild Strawberry
Fragaria virginiana subsp. *platypetala*	Broad-petaled Wild Strawberry
Gaillardia aristata	Brown-eyed Susan
Galium boreale	Northern Bedstraw
Gentianella amarella	Northern Gentian (Felwort)
Geocaulon lividum	Northern Red-fruited Comandra (Bastard Toad-flax)
Geum macrophyllum var *macrophyllum*	Large-leaved Avens
Goodyera oblongifolia	Large-leaved Rattlesnake Orchid
Hedysarum alpinum	Alpine Hedysarum (Sweetvetch)
Hedysarum boreale	Northern Hedysarum (Sweetvetch)
Hedysarum sulphurescens	Sulphur Hedysarum (Sweetvetch)
Heuchera cylindrica	Round-leaved Alumroot
Hieracium albiflorum	White Hawkweed
Hieracium gracile	Slender Hawkweed
Koeleria macrantha (K. cristata)	Prairie Koeleria (June Grass)
Lathryrus ochroleucus	Cream-coloured Pea Vine (Pea Vine)
Leucanthemum vulgare	Oxeye Daisy
Lilium columbianum	Columbia Lily
Linnaea borealis	Northern Twinflower (Twin-flower)
Lomatium spp.	Lomatium
Lupinus nootkatensis	Nootka Lupine
Lupinus polyphyllus	Big Leaved Lupine
Luzula spicata	Spiked Wood-rush (Wood Rush)
Lycopodium annotinum	Stiff Club-moss
Lycopodium complanatum	Ground-cedar
Lysichiton americanum	American Skunk-cabbage
Machaeranthera canescens	Hoary Transyaster
Mertensia paniculata	Smooth-panicled Mertensia (Tall Mertensia)
Mitella nuda	Common Mitrewort (Bishop's cap)
Orchis rotundifolia	Round-leaved Orchis (Round-leaved Orchid)
Orthilia secunda (Pyrola secunda)	Few Flowered One-sided Wintergreen (One-sided wintergreen)

Oryzopsis asprifolia	Rough-leaved Rice Grass
Osmorhiza chilensis	Mountain Sweetcicely
Oxytropis campetris	Field Locoweed
Oxytropis deflexa	Pendant-pod Locoweed (Reflexed Locoweed)
Pedicularis bracteosa	Bracted Lousewort (Lousewort)
Penstemon fruticosus	Shrubby Penstemon
Phlox longifolia	Long-leaved Phlox
Platanthera spp. *(Habenaria spp.)*	Rein Orchid (Bog Orchid)
Poa nervosa	Blue Grass (Bluegrass)
Poa pratensis	Kentucky Blue Grass (Kentucky Bluegrass)
Polypodium glycyrrhiza	Licorice Fern
Polystichum munitum	Sword Fern
Pteridium aquilinum	Western Bracken
Pyrola asarifolia	Common Pink Pyrola (Common Pink Wintergreen)
Pyrola chlorantha (P. virens)	Green Pyrola (Greenish-flowered Wintergreen)
Rubus pedatus	Five-leaved Creeping Raspberry
Sedum lanceolatum	Lance-leaved Stonecrop
Sedum stenopetalum	Narrow-petaled Stonecrop (Common Stonecrop)
Selaginella densa	Common Selaginella (Little Club-moss)
Senecio indecorus	Rayless Mountain Ragwort (Groundsel)
Smilacina racemosa	False Solomon's Seal
Smilacina stellata	Star-flowered False Solomon's Seal (Star-flowered Solomon's Seal)
Solidago multiradiata	Norhtern Golden rod (Goldenrod)
Stenanthium occidentale	Western Mountain-bells (Bronze-bells)
Stipa spp.	Needle Grass
Streptopus amplexifolius	(Twisted stalk) Cucumberroot Twistedstalk
Streptopus roseus var. *curoipes*	Simple-stemmed Twisted Stalk
Taraxacum officinale	Common Dandelion
Thalictrum venulosum	Veiny Meadowrue
Tiarella trifoliata	Trifoliate-leaved Foamflower
Tragopogon dubius	Yellow Salsify
Trientalis latifolia	Broad-leaved Starflower
Trillium ovatum hibbersonii	Hibberson's Western White Trillium
Trillium ovatum ovatum	Western White Trillium
Trisetum spicatum	Spike Trisetum
Vahlodea atropurpurea (Deschampsia atropurpurea)	Mountain Vahlodea (Mountain Hair Grass)
Vicia americana	American Vetch (Wild Vetch)
Viola canadensis	Canada Violet (Western Canada Violet)
Zigadenus elegans	Elegant Death-Camas (White Camas)

Mosses

Abietinella abietina	
Aulacomnium palustre	Swamp Moss
Barbilophozia hatcheri	Liverwort
Brachythecium asperrimum	
Campylium spp.	

Dicranum fuscescens	Crane's Bill Moss
Dicranum polysetum	
Dicranum strictum	Brittle Moss
Drepanocladus uncinatus	
Eurhynchium oreganum	
Hylocomium splendens	Step Moss
Hypnum spp.	
Isothecium spiculiferum	Shaggy Moss
Leucolepis menziesii	Palm-tree Moss
Mnium insigne	Badge Mnium
Plagiothecium undulatum	Wavy Moss
Pleurozium schreberi	
Ptilium crista-castrensis	Plume Moss
Polytrichum commune	Hair-cap Moss
Polytrichum juniperinum	Oat Moss
Rhacomitrium canescens	Grey-frayed Cap Moss
Rhizomnium glabrescens	
Rhytidiadelphus loreus	Little Shaggy Moss
Rhytidiadelphus triquetrus	
Rhytidiopsis robusta	Robust Moss
Sphagnum spp.	Peat Moss
Thuidium recognitum	
Tortula princeps	

Lichens

Abietinella abietina	
Alectonia spp.	
Cladonia spp.	Reindeer Lichen
Hypogymnia spp.	
Letharia spp.	
Parmelia spp.	
Parmeliopsis spp.	
Peltigera apthosa	Dog Lichen
Peltigera canina	
Stereocaulon spp.	
Usnea spp.	

APPENDIX 'G'

Table 36. Mean monthly precipitation, mean annual precipitation, mean annual rainfall, mean annual snowfall, mean number of days with measurable rainfall, mean number of days with measurable snowfall, mean number of days of precipitation for selected stations.

Station (elevation)	Mean total precipitation (mm)													Mean annual rain-fall (mm)	Mean annual snow-fall (cm)	Number of Days			Type of Normal*
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year			Rain	Snow	precipi-tation	
Vancouver International Airport (5 m)	147.3	116.6	93.7	61.0	47.5	45.2	29.7	37.1	61.2	122.2	141.2	165.4	1068.1	1017.8	52.4	156	12	161	1
Hollyburn Ridge (936 m)	365.8	272.5	243.6	204.7	117.6	112.8	88.6	123.4	201.9	387.1	393.2	427.7	2938.9	2128.5	810.8	128	76	182	4
Abbotsford Airport (60 m)	207.3	163.8	145.0	104.1	72.9	59.9	37.8	49.0	86.6	170.4	190.5	215.1	1502.4	1424.8	78.3	162	17	172	2
Hope (46 m)	227.3	177.0	136.9	108.2	61.5	55.1	35.6	46.0	104.4	181.9	217.7	249.4	1601.0	1448.4	161.9	169	22	181	1
Allison Pass (1320 m)	253.7	164.1	126.2	95.3	66.8	61.5	33.5	48.0	69.9	112.5	192.5	227.6	1451.6	486.3	965.4	86	110	177	8 & 5
Princeton (685 m)	48.3	32.8	17.5	16.5	25.1	30.7	25.7	24.1	19.6	26.7	41.7	50.3	359.0	210.6	157.0	68	52	115	1
Keremeos (423 m)	28.2	16.5	12.7	16.5	21.1	30.0	21.8	20.3	13.7	16.0	22.1	30.5	249.4	188.7	60.3	59	19	76	1 & 2
Osoyoos (321 m)	44.2	25.4	22.9	21.8	29.0	36.6	21.1	24.6	15.5	23.9	31.5	45.7	342.2	273.4	68.7	68	19	86	8 & 4
Oliver (300 m)	30.2	20.6	21.3	21.6	27.7	31.5	21.3	25.7	15.5	23.1	27.4	33.0	298.9	242.3	57.0	75	21	93	8 & 4
Penticton (336 m)	31.5	20.8	16.5	23.1	27.7	35.6	24.6	22.4	18.0	19.8	25.7	30.5	296.2	232.2	69.2	77	28	100	1
Summerland Agriculture Canada (447 m)	30.5	17.8	14.7	21.8	26.4	34.8	26.4	24.9	19.3	21.6	25.7	32.3	296.2	220.0	74.4	75	24	99	1
Kelowna Agriculture Canada (477 m)	30.2	21.1	14.2	27.4	31.0	36.6	23.4	22.9	25.7	29.5	31.5	47.7	336.2	250.9	85.3	66	23	88	8 & 3

Table 36 Continued — Mean monthly precipitation, mean annual precipitation, mean annual rainfall, mean annual snowfall, mean number of days with measurable rainfall, mean number of days with measurable snowfall, mean number of days of precipitation for selected stations.

Station (elevation)	Mean total precipitation (mm)													Mean annual rain-fall (mm)	Mean annual snow-fall (cm)	Number of Days			Type of Normal*
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year			Rain	Snow	precip-tation	
Vernon (415 m)	39.9	26.9	19.8	20.6	33.5	44.5	30.5	33.3	34.0	30.5	32.3	47.0	392.8	288.3	103.4	87	27	109	1
Armstrong (360 m)	49.8	33.5	22.9	23.9	33.5	42.2	32.8	34.8	35.6	39.1	40.4	59.4	447.9	312.6	134.7	70	27	97	2
Salmon Arm (498 m)	61.5	39.4	29.5	29.7	37.8	48.3	38.1	43.2	38.1	48.5	52.1	64.5	530.7	374.6	156.2	86	34	117	2 & 1
Sicamous (420 m)	65.3	45.5	24.9	33.5	43.2	59.4	48.0	47.0	55.9	55.1	54.1	72.1	604.0	418.4	185.8	99	44	140	8 & 4
Revelstoke (449 m)	151.4	108.5	72.1	56.6	51.3	74.2	57.2	64.0	75.9	105.9	121.4	157.7	1096.2	703	411.6	121	60	170	2
Glacier (1228 m)	193.8	165.4	125.7	90.7	64.0	87.1	76.5	80.5	101.6	133.9	168.9	204.7	1492.8	523.2	969.5	95	105	192	8 & 5
Golden (775 m)	61.2	37.3	22.1	25.7	31.5	39.9	34.8	37.1	35.1	35.8	47.2	64.8	472.5	266.8	203.8	43	31	74	1 & 2
Lake Louise (1509 m)	82.8	63.2	45.0	52.8	50.8	62.0	59.2	58.7	50.0	59.9	85.1	98.0	767.5	285.1	481.7	62	74		1 & 2
Banff (1375 m)	33.3	29.5	22.9	36.3	51.1	65.0	48.0	48.3	37.6	36.3	34.8	33.8	476.9	273.9	218.7	71	64	129	1
Jasper (1044 m)	30.2	24.1	14.7	22.6	34.8	49.8	47.5	48.0	34.8	30.2	32.5	33.0	402.2	273.1	136.9	80	52	126	1
Entrance (990 m)	26.4	24.4	24.9	33.8	55.1	84.8	75.2	79.2	38.6	22.4	24.4	24.4	513.6	349.0	161.2	53	39	89	2
Edson (910 m)	31.0	25.9	23.4	26.9	59.7	84.3	104.1	77.5	45.5	24.1	25.7	25.9	554.0	386.1	167.8	70	48	114	7
Edmonton Industrial Airport (666 m)	25.1	20.1	16.8	23.4	37.3	74.7	83.3	71.6	35.8	18.5	18.5	21.3	446.4	324.5	132.1	68	60	121	1

Table 36 Continued

Mean monthly precipitation, mean annual precipitation, mean annual rainfall, mean annual snowfall, mean number of days with measurable rainfall, mean number of days with measurable snowfall, mean number of days of precipitation for selected stations.

* Code	Type of Normal
1	30 years between 1941 and 1970, or more
2	25 to 29 years between 1941 and 1970
3	20 to 24 years between 1941 and 1970
4	15 to 19 years between 1941 and 1970
5	10 to 14 years between 1941 and 1970
6	less than 10 years
7	combined data for 2 or more stations
8	adjusted
9	estimated

Reference - Environment Canada, Atmospheric Environment. Canadian Normals, Precipitation. Volume 2-S1, 1941-1970. Downsview, Ontario. 1975.

Table 37 Growing degree days and hours of bright sunshine per year for selected stations

Station (elevation)	Years of Record	Average annual growing degree days above 5.6°C	Average annual growing degree days above 5.0°C	Extreme minimum growing degree days above 5.6°C	Extreme minimum growing degree days above 5.0°C	Extreme maximum growing degree days above 5.6°C	Extreme maximum growing degree days above 5.0°C	Bright sunshine per year (hours)
Vancouver International Airport (5 m)	34	1876	2003	1555	1670	2344	2476	1931
Hollyburn Ridge (936 m)	14	899	974	628	701	1232	1303	-
Abbotsford Airport (59 m)	30	1822	1947	1458	1567	2307	2449	-
Hope (50 m)	33	2015	2131	1658	1761	2444	2571	-
Princeton (685 m)	34	1513	1599	1253	1336	1888	1984	-
Keremeos (423 m)	34	2326	2434	2041	2147	2731	2848	-
Osoyoos (321 m)	21	2360	2467	2112	2217	2654	2765	
Oliver (300 m)	34	2122	2225	1800	1895	2411	2523	2012
Penticton (336 m)	34	2010	2115	1722	1876	2434	2544	-
Summerland Agriculture Canada (447 m)	34	2107	2211	1853	1951	2497	2603	1992
Kelowna Agriculture Canada (477 m)	20	1851	1945	1521	1615	2203	2297	-
Vernon (415 m)	34	1811	1905	1599	1691	2176	2282	1915
Armstrong (360 m)	32	1767	1862	1548	1643	2106	2205	-

Table 37 Growing degree days and hours of bright sunshine per year for selected stations
Continued

Station (elevation)	Years of Record	Average annual growing degree days above 5.6°C	Average annual growing degree days above 5.0°C	Extreme minimum growing degree days above 5.6°C	Extreme minimum growing degree days above 5.0°C	Extreme maximum growing degree days above 5.6°C	Extreme maximum growing degree days above 5.0°C	Bright sunshine per year (hours)
Salmon Arm (498 m)	34	1849	1944	1550	1642	2183	2283	1638
Sicamous (420 m)	19	1888	1985	1643	1739	2218	2319	-
Revelstoke (449 m)	25	1764	1856	1418	1507	2083	2170	-
Glacier (1228 m)	12	908	975	754	812	1102	1165	-
Golden (775 m)	32	1488	1572	1259	1337	1718	1799	-
Lake Louise (1510 m)								-
Banff (1375 m)								1739
Jasper (1044 m)								-
Entrance (990 m)								-
Edson (910 m)								2000
Edmonton Industrial Airport (666 m)								2356

Reference - Yorke, B.J., and G.R. Kendall. Daily Bright Sunshine, 1941-1970. Canada Department of the Environment Atmospheric Environment Service. CLI-6-72. Downsview, Ontario. 1972.

Growing degree day information supplied by Climatology Section, Resource Inventory Branch, British Columbia Ministry of the Environment. Victoria, British Columbia. 1976.

Table 38 Mean daily temperature, mean annual temperature, mean daily maximum temperature, mean daily minimum temperature, extreme maximum temperature in July, extreme minimum temperature in January for selected stations.

Station (elevation m)	Mean daily temperature (°C)													Mean Daily Maximum (°C)	Mean Daily Minimum (°C)	Extreme Maximum July (°C)	Extreme minimum Jan. (°C)	Type of Normal(s)*
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual					
Vancouver International Airport (5 m)	2.4	4.4	5.8	8.9	12.4	15.3	17.4	17.1	14.2	10.1	6.1	3.8	9.8	13.4	1.9	31.7	-17.8	1
Hollyburn Ridge (936 m)	-2.2	-0.2	0.3	2.7	6.6	10.1	13.5	12.8	10.9	5.6	1.1	-0.9	5.0	9.1	0.9	33.3	-21.7	8 & 5
Abbotsford Airport (60 m)	1.3	4.2	5.6	8.6	12.2	14.9	16.9	16.7	14.4	10.1	5.7	3.1	9.5	14.3	4.6	37.8	-21.1	2
Hope (46 m)	-0.6	3.4	5.7	9.4	13.2	16.0	18.6	18.3	15.6	10.4	4.8	1.6	9.7	14.3	5.1	40.0	-22.8	1
Allison Pass (1320 m)	-8.3	-5.6	-3.6	0.9	5.0	8.3	12.2	11.4	8.2	2.9	-3.2	-6.6	1.8	7.3	-3.8	31.7	-34.4	8 & 5
Princeton (685 m)	8.1	-3.1	1.0	6.2	10.8	14.4	17.6	16.8	12.8	6.4	-0.9	-5.7	5.7	12.3	-0.9	41.7	-41.1	1
Keremeos (423 m)	-3.6	0.9	4.9	10.2	14.9	18.2	21.7	20.8	16.5	9.8	2.9	-1.3	9.7	15.1	4.2	41.1	-30.6	1
Mt. Kobau Observatory (1868 m)	-8.6	-4.9	-4.5	-0.8	5.0	8.4	12.7	12.4	7.7	2.0	-4.8	-7.7	1.4	5.0	-2.2	----	-----	8
Osoyoos (321 m)	-2.8	0.5	4.8	10.2	15.1	19.1	22.1	20.9	16.2	9.7	3.7	-0.9	9.8	14.9	4.7	38.3	-22.8	4
Oliver (300 m)	-3.6	0.2	4.2	9.7	14.3	17.8	20.9	19.7	14.9	8.6	2.5	-1.2	9.0	15.5	2.5	42.8	-30.6	1
Penticton (336 m)	-2.9	0.3	3.7	8.7	13.4	17.1	20.1	19.2	14.7	8.7	3.1	-0.4	8.8	14.5	3.1	40.6	-26.7	1
Summerland Agriculture Canada (447 m)	-3.6	0.0	3.7	9.0	13.8	17.5	21.0	19.9	15.4	9.0	2.6	-1.2	8.9	14.0	3.8	40.0	-30.0	1
Kelowna Agriculture Canada (477 m)	-5.1	-1.3	2.1	7.6	12.8	16.6	19.8	18.6	14.2	7.6	1.2	-2.3	7.7	13.2	2.1	37.2	-31.7	3

Table 38 Continued

Mean daily temperature, mean annual temperature, mean daily maximum temperature, mean daily minimum temperature, extreme maximum temperature in July, extreme minimum temperature in January for selected stations.

Station (elevation m)	Mean daily temperature (^oC)													Mean Daily Maximum (^oC)	Mean Daily Minimum (^oC)	Extreme Maximum July(^oC)	Extreme minimum Jan.(^oC)	Type of Normals *
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual					
Vernon (415 m)	-6.0	-1.8	2.7	8.7	13.9	17.0	20.2	18.8	14.3	7.7	1.9	-1.6	8.0	13.3	2.7	40.0	-35.0	4 & 1
Armstrong (360 m)	-6.4	-2.5	1.8	7.9	12.7	16.4	19.2	17.9	13.2	6.9	0.8	-3.2	7.1	13.4	0.7	40.6	-42.2	1
Salmon Arm (498 m)	-5.1	-1.3	2.3	7.9	12.9	16.6	19.6	18.6	14.2	7.7	1.4	-2.2	7.7	13.2	2.2	41.1	-35.0	1
Sicamous (420 m)	-4.4	-1.3	2.4	7.7	13.3	17.4	20.2	19.1	14.0	7.8	1.6	-2.3	8.0	12.5	3.4	36.7	-30.0	4
Revelstoke (449 m)	-5.9	-1.8	1.9	7.2	12.8	16.4	19.4	18.2	13.7	7.0	0.8	-3.6	7.2	12.6	1.7	40.6	-34.4	2 & 1
Glacier (1228 m)	-11.3	-7.3	-3.7	2.2	7.5	11.5	14.4	13.2	8.9	2.6	-4.4	-8.0	2.1	7.1	-2.8	36.7	-35.6	5 & 1
Golden (775 m)	-10.8	-5.3	-0.4	5.8	11.4	15.2	18.0	16.5	11.9	5.6	-2.3	-7.8	4.8	11.5	-1.9	40.0	-46.1	1
Lake Louise (1509 m)	-14.6	-9.6	-6.4	0.2	5.9	9.6	12.4	11.4	7.3	1.8	-7.1	-12.4	-0.1	7.4	-7.6	34.4	-52.9	1
Banff (1375 m)	-11.2	-6.8	-3.8	2.3	7.5	11.2	14.5	13.4	9.1	4.2	-3.8	-8.7	2.3	8.4	-3.9	34.4	-51.1	
Columbia Icefield (3000 m)	-	-	-	-	-	6.3	9.1	8.2	4.8	-	-	-	-	-	-	-	-	8
Jasper (1044 m)	-12.2	-6.6	-2.7	3.3	8.7	12.5	15.2	14.1	9.9	4.8	-3.8	-9.1	2.8	9.1	-3.4	33.9	-46.8	1
Entrance (990 m)	-13.4	-7.9	-3.5	2.9	8.3	12.1	14.6	13.3	9.1	4.3	-3.6	-8.8	2.3	9.7	-5.1	37.8	-51.1	2 & 1
Edson (910 m)	-14.0	-9.0	-4.7	2.7	8.6	12.3	14.9	13.5	9.1	3.8	-5.2	-11.1	1.7	8.6	-5.2	37.8	-48.3	7
Edmonton Industrial Airport (666 m)	-14.7	-10.5	-5.4	4.0	10.9	14.7	17.5	15.9	10.9	5.4	-4.2	-10.7	2.8	8.1	-2.5	34.4	-44.4	1

*Code	Type of Normal
1	30 years between 1941 and 1970, or more
2	25 to 29 years between 1941 and 1970
3	20 to 24 years between 1941 and 1970
4	15 to 19 years between 1941 and 1970
5	10 to 14 years between 1941 and 1970
6	less than 10 years
7	combined data from 2 or more stations
8	adjusted
9	estimated

Reference

Environment Canada, Atmospheric Environment. Canadian Normals, Temperature. Volume 1-SI, 1941-1970. Downsview, Ontario. 1975.

Table 39 Frost data for selected stations*

Station (elevation)	Averages based on 1941-70 period of record: Years of Record	Average Frost-free period (days)	Average last spring frost (date)	Average first fall frost (date)	Extremes based on full period of record: Years of Record	Last Spring frost (date): Earliest	Last Spring frost (date): Latest	First fall frost (date): Earliest	First fall frost (date): Latest	Longest frost-free period (days)	Shortest frost-free period (days)
Vancouver International Airport (5 m)	30	212	Mar. 31	Oct. 30	33	Mar. 5	Apr. 30	Oct. 2	Nov. 28	246	161
Hollyburn Ridge (936 m)	11	130	May 22	Sept.30	11	May 4	June 30	Sept.12	Oct. 19	159	99
Abbotsford Airport (59 m)	26	170	Apr. 30	Oct. 18	26	Apr. 4	May 28	Sept.13	Nov. 22	200	129
Hope (50 m)	30	198	Apr. 16	Nov. 1	33	Mar.15	May 14	Sept.30	Dec. 8	259	153
Allison Pass (1320 m)	12	31	July 1	Aug. 2	12	June 9	July 15	July 16	Aug. 25	47	17
Princeton (685 m)	30	100	June 3	Sept.12	33	May 7	July 6	Aug. 19	Oct. 7	144	54
Keremeos (423 m)	30	186	Apr. 14	Oct. 18	56	Mar.12	May 7	Sept.16	Nov. 13	228	146
Osoyoos (321 m)	17	182	Apr. 16	Oct. 16	17	Mar.19	May 11	Sept.17	Nov. 21	226	147
Oliver (300 m)	30	138	May 12	Sept.28	46	Mar.30	June 30	Sept. 7	Oct. 22	198	114
Penticton (336 m)	30	143	May 10	Oct. 1	30	Apr.22	June 13	Sept.12	Oct. 19	172	91
Summerland Agriculture Canada (447 m)	30	175	Apr. 26	Oct. 19	55	Apr. 4	May 24	Sept.24	Nov. 18	208	150
Kelowna - Res. Station Agriculture Canada (477 m)	20	150	May 8	Oct. 6	20	Apr.20	May 27	Sept.16	Oct. 24	176	120
Vernon (415 m)	19	156	May 1	Oct. 5	46	Apr. 8	June 13	Sept. 6	Nov. 13	194	90

Continued......

Table 39 Continued   Frost data for selected stations

Station (elevation)	Averages based on 1941-70 period of record: Years of Record	Average Frost-free period (days)	Average last spring frost (date)	Average first fall frost (date)	Extremes based on full period of record: Years of Record	Last Spring frost (date): Earliest	Last Spring frost (date): Latest	First fall frost (date): Earliest	First fall frost (date): Latest	Longest frost-free period (days)	Shortest frost-free period (days)
Armstrong (360 m)	30	122	May 17	Sept. 17	57	Apr. 18	June 11	Aug. 16	Oct. 19	154	73
Salmon Arm (498 m)	30	149	May 7	Oct. 3	60	Apr. 7	June 3	Sept. 10	Nov. 3	193	113
Sicamous (420 m)	17	169	Apr. 27	Oct. 14	17	Apr. 10	May 14	Sept. 12	Nov. 2	199	131
Revelstoke (449 m)	29	140	May 14	Oct. 2	69	Apr. 16	July 8	Aug. 19	Oct. 7	180	33
Glacier (1228 m)	14	85	June 12	Sept. 6	54	May 13	July 13	July 27	Oct. 6	127	43
Golden (775 m)	30	101	May 31	Sept. 10	68	May 6	July 13	July 17	Oct. 8	140	46
Lake Louise (1510 m)	30	17	July 7	July 25	64	June 17	July 15	July 16	Aug. 30	67	0
Banff (1375 m)	30	72	June 13	Aug. 26	76	May 18	July 15	July 16	Sept.20	113	3
Jasper (1044 m)	30	84	June 7	Aug. 31	54	May 5	July 10	July 23	Sept.27	127	21
Entrance (990 m)	26	51	June 27	Aug. 20	50	May 25	July 15	July 16	Sept.18	101	3
Edson (910 m)	30	67	June 18	Aug. 25	55	May 13	July 15	July 16	Sept.23	126	3
Edmonton Industrial Airport (660 m)	30	127	May 14	Sept. 19	33	Apr. 26	June 21	Sept. 6	Oct. 12	156	88

*Reference: Hemmerick, G.M., and G.R. Kendall. Frost Data, 1941-1970. Environment Canada, Atmospheric Environment. CLI 5-72. Downsview, Ontario. 1972.

APPENDIX H. IRRIGATION IN THE OKANAGAN

C. Brownlee, B.C. Ministry of Agriculture, Kelowna

Irrigation in the Okanagan got its start in the early part of this century with the beginning of fruit growing on a commercial scale. Private companies established most of the original systems, sold land for orchard use, and guaranteed delivery of the water. Water was diverted from creeks and transported to the orchards in open ditches. As the trees grew and more land was developed, dams were built in the hills to provide storage water for the dry summer months. Large water losses experienced with open ditches resulted in the need for lining them with concrete or replacement with wood, concrete or metal flumes.

As time progressed and replacement costs increased, most of the companies sold their irrigation systems to the growers who organized themselves into Water Improvement Districts or Irrigation Districts under the Water Act of the provincial legislature.

In addition to the above districts, water has been delivered and stored by other bodies such as the City of Penticton, the Municipality of Summerland and the Woods Lake Water Company. Many ranchers and fruit growers have developed their own storage, pumping plants, and delivery works as well.

In the fruit-growing areas, irrigation by the furrow method was used for many years while in other areas both furrow and flood methods were employed. Following the Second World War, improved equipment encouraged the use of sprinkler irrigation. Since that time it has rapidly taken over for all crops in all areas. It is estimated that over 95% of the irrigated land in the Okanagan Valley is now irrigated by sprinklers and new lands being irrigated for the first time are almost exclusively sprinkler irrigated. In very recent years, trickle irrigation has been introduced into the orchard areas and a minor acreage is presently being irrigated by this method.

In the Okanagan Basin the presently irrigated area amounts to approximately 24 300 ha, most of which lies on a series of benches or terraces between 100 to 200 m above the valley floor. Of this total, 65% or 15 785 ha are irrigated through irrigation districts, the remaining 35% by private individuals.

To sustain an irrigated agriculture over this area requires a total annual gross irrigation diversion of about 248 330 000 m^3. To place this in perspective, the total annual domestic, municipal and industrial demand is approximately 58 161 500 m^3, giving a total annual water demand of 306 491 500 m^3. Irrigation requirements, therefore, account for 81% of the total gross abstraction of water resources in the Okanagan Basin.

All, or practically all irrigation requirements are met by surface water supplies. It is estimated that the average quantity of water flowing into Okanagan Lake during the snow-melt is 470 520 000 m^3. This amount is not available in its entirety however since from it must be deducted evaporation losses and the water stored in reservoirs or diverted directly onto irrigated lands. The present storage on Okanagan Lake amounts to approximately 444 380 000 m^3 with an emergency total storage capacity of about 550 247 000 m^3.

Storage of irrigation water is essential in this area to ensure a sufficient water supply throughout the irrigation season. The total developed tributary storage of 129 025 733 m^3 is generally considered just sufficient to supply the annual irrigation demand for most of the area under irrigation district management. In some districts, however, Okanagan Lake water is used entirely while in other districts it has had to be used to augment their existing supply.

A rough estimate of the potentially irrigable land in the Okanagan Basin is placed at 74 115 ha. Using similar diversion requirements to the existing irrigated lands, the total gross diversion for irrigation of this area is estimated to be 670 491 000 m^3. Since almost all of the potential storage capacity of the tributary watersheds has already been developed, it is generally believed that additional water supplies will be required for any significant future expansion of irrigated acreage land in the basin.

With the increasing demands on the basin water supplies for irrigation, domestic and industrial uses, emphasis on more efficient use of water is being directed to the irrigator from all levels. Through a cost sharing agreement (Federal, Provincial and local) under the Agricultural and Rural Development Act (A.R.D.A.) most of the irrigation district systems have been rehabilitated, or are in the process of rehabilitation, with the result that considerable improvements in storage, distribution and management have been possible. In some cases it is believed a 30% saving in water may be realized, mainly by reducing conveyance losses. This will be partly offset, however, by the inclusion of domestic water supplies along with the irrigation, and by increasing to adequate levels the irrigation supply for some of the presently irrigated soils.

Along with the improved district systems, irrigation districts are starting to enforce regulations restricting the use of water. This is generally carried out through regulatory bylaws restricting the flow per hectare and more recently by making the use of flow control valves compulsory. These valves have had the effect of not only reducing the water requirement, but also of providing a more balanced supply system and a more uniform application of the irrigation water over the land. Coupled with this has been the development of more specific information on irrigation systems design and operation of the individual grower systems to effect higher efficiences in water use.

A variety of irrigation systems can be found in the Okanagan and Similkameen valleys, most of which involve sprinklers. Ditch or furrow irrigation has been almost entirely replaced and trickle or drip irrigation has only recently been introduced. The standard portable pipe equipped with small sprinklers is still the most prevalent in the tree fruit areas. The advent of increasing labour costs and higher density tree plantings has led to the use of over-tree sprinkling, utilizing larger sprinklers and higher pressures. The most popular over-tree systems are solid sets (permanent installations with sprinklers fixed to high risers) or portable hose and tripod. Solid set, under-tree systems utilizing small diameter aluminum or PVC pipe fitted with low volume sprinklers is also popular depending upon the degree of tree density. In the non-orchard areas, mechanical systems such as the wheel move, pivot or rain guns may be observed, the wheel move being the most popular where fields are rectangular and reasonably flat.

APPENDIX I RANGELANDS OF BRITISH COLUMBIA

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Location: Most of the rangelands of B.C. are located between the Rocky Mountains and the Coast Range and extend about 400 km northward from the United States border, except for the Peace River section. The grazing resources consists of about 1.2 million ha of native grasslands and about 7.3 million ha of forested range. The grasslands are found in the valleys of the Chilcotin, Fraser and Thompson Rivers and the Nicola and Okanagan valleys. The forested ranges are relatively open forests, generally well suited to integrated or multiple resource use. Forestry, ranching, wildlife, recreation and watershed management may all be important in these areas and contribute materially to the overall land use.

The grasslands, although limited in extent, are of vital importance in the range industry as sources of spring, fall and winter grazing which reduces the length of expensive winter feeding.

Description - Grassland Range: The grasslands belong to the bunchgrass type of the Pacific Northwest. Three distinct zones are recognized, differing in botanical composition, forage yield, season of use and reaction to grazing. Bluebunch Wheatgrass (*Agropyron spicatum*), the principal grass of the region is a dominant in all three zones but the associated species differ considerably.

The Wheatgrass-Sagebrush zone occurs in the valleys at elevations up to 600 m approximately, and has the driest and warmest climate in the region. This zone supports a relatively sparse vegetation of Bluebunch Wheatgrass and other bunchgrasses and Big Basin Sagebrush (*Artemisia tridentata*). This range type is well suited for early spring and late fall grazing and where sufficient acreage is available, for winter use as well.

The Wheatgrass-Bluegrass zone occurs at elevations of about 600 to 800 m a.s.l., and is slightly cooler and moister than the Wheatgrass-Sagebrush type. The vegetation, where not altered by misuse, consists mainly of Bluebunch Wheatgrass, Sandberg Bluegrass (*Poa sandbergii*)) and a number of forbs. Sagebrush is absent or rare and the only common shrub is Common Rabbitbrush (*Chrysothamnus nauseosus*). This zone is suitable for spring-fall grazing.

The Wheatgrass-Fescue zone occurs at elevations of 800 to 1000 m a.s.l. or more and represents the most highly productive of the grassland types. The principal climax species are Bluebunch Wheatgrass and Rough Fescue (*Festuca scabrella*). In addition, there is an abundance of forbs including yarrow (*Achillea*), fleabane (*Erigeron*), lupines (*Lupinus*) and balsamroot (*Balsamorhiza*). This type is best used as late spring and early fall range.

Forest Ranges: The forest grazing types occupy a much greater area than the grasslands. In portions of the region the livestock populations do not fully utilize the available acreages of forest range. The forest ranges fall naturally into three zones, namely, Ponderosa Pine, Douglas Fir and Spruce-Fir.

The Ponderosa Pine zone is limited in extent, occurring mainly as a fringe along the lower edge of the forested lands. Often the transition between the Ponderosa Pine and Douglas Fir types is as extensive as the pine zone itself. The well developed undercover vegetation resembles that of the grasslands. The principal species include Bluebunch Wheatgrass, Prairie Koeleria (*Koeleria cristata*), Rough Fescue, Common Rabbitbrush and several perennial forbs. This type is valuable for late spring and fall use.

The extensive Douglas Fir zone supplies most of the forest grazing. Soil moisture is usually adequate for growth throughout the summer months but temperatures limit the growing season to three months or less.

The climax tree cover consists mainly of Rocky Mountain Douglas Fir (*Pseudotsuga menziesii var. glauca*) but, due to widespread fires, a large part of the zone is now occupied by Lodgepole Pine (*Pinus contorta*) and Trembling Aspen (*Populus tremuloides*). Disturbance by fire has had a marked influence on grazing values. Areas dominated by aspen usually possess a better forage cover than those with conifers, while sites occupied by dense young stands of either pine or Douglas Fir produce almost no forage.

Over much of the zone the tree stand is relatively open, and there is a well developed undercover of herbs and shrubs. The principal grass is Pine Grass (*Calamagrostis rubescens*), while many broadleaved plants, including vetch (*Vicia*), peavine (*Lathyrus*), aster (*Aster*), wild rose (*rosa*) and willow (*Salix*) provide valuable forage. The season of use in this zone is from mid-June to the end of September.

The third forest zone is the Spruce-Fir, situated above the Douglas Fir zone in a climate that is cool and relatively moist with a short growing season. The Spruce-Fir type is extensive but grazing is limited largely to meadows and openings. The tree cover is relatively dense. The undercover is sparse and consists mainly of low shrubs such as blueberry (*Vaccinium*) along with mosses and lichens. The production of forage species is usually too low to warrant grazing use. In the meadows the cover consists of sedges and, in the drier openings, California Oat Grass (*Danthonia intermedia*).

Alpine ranges occur at elevations above 1 950 m a.s.l. and have a very short growing season. The vegetation is a mixture of alpine grasses, forbs and sedges. This zone is used for only a short while in mid-summer.

Livestock Management: In the average ranch operation, the grasslands are grazed in spring and fall, the timber ranges in summer and a combination of meadow and range grazing with supplementary feeding provides winter forage.

Spring turn-out time varies with local conditions. In the Thompson Valley, in the Kamloops area, the grazing season starts about mid-April when the lower ranges are ready for use. The animals move upward into the higher grassland zones as the forage develops and usually reach the wheatgrass-fescue zone near the end of May. The timber range is ready for use by mid-June and supplies good forage until the end of September. The grazing period varies with altitude, and the livestock are generally drifted up to higher elevations during the summer as the feed becomes dried out or depleted in the lower areas.

Cattle graze mainly in the Douglas Fir zone, then the meadows of the Spruce-Fir and alpine zones, reaching the latter about mid-July. All livestock are brought back to grassland ranges usually by late September or early October because of danger from storms at the higher elevations, and the seasonal decline in quality of forage on the timbered areas. The stock are then shifted to the winter ranges and meadows until feeding becomes necessary due to forage depletion or heavy snows.

In districts containing major valleys, the livestock are wintered on the benches and meadows, where climatic conditions are favourable and feed supplies handy. This situation prevails over most of the southern part of the ranching area. Further north, in the Cariboo and Chilcotin districts, favourable wintering spots are less common and many livestock are wintered on native meadows above the 1000 m level. In these areas, the hay is cut and cattle graze on the aftermath until snow depth makes feeding necessary.

Forage Productivity: The different range types vary greatly in forage productivity. Average productivities for each of the major zones are given below: Sagebrush-Wheatgrass, 1.2 ha/animal-unit-month (AUM); Fescue-Wheatgrass, .5 ha/AUM; Douglas Fir-Pine Grass, 2 to 4 ha/AUM depending largely on density of tree canopy; sedge meadows, .4 ha/AUM.

Most of the grassland ranges are privately owned or held under lease from the Lands Service; some are administered by the Forest Service. Most of the forested lands in the Interior are unalienated and held by the Provincial Government. They are administered by the Range Division of the Forest Service. Grazing on these areas is allocated on a permit basis.

History: The range livestock industry in British Columbia rapidly followed the early development of the Interior of the province which in itself has a short history. It owed its start to the gold rush in the Fraser River in 1858. Prior to this time, the Interior was left largely to fur traders. To meet the demand of the gold miners, cattle were driven north from areas in Oregon and Washington to the Cariboo gold fields via the Okanagan Trail. Shortly after the first influx of cattle, ranches were established in the Interior. When the gold mining slowed up, the cattle industry suffered a severe setback until the construction of the Canadian Pacific Railway in the early 1880's. Heavy cattle losses from a number of severe winters between 1879 and 1897, however, helped to keep the cattle numbers down and reduced the overgrazing. After these difficult years ranchers saw the necessity of feed reserves and began to grow their own winter feed - a major step in stabilizing the ranching industry in the province. By the time the market offered by the Klondike gold rush in 1898 dropped, the province was sufficiently well settled to provide a permanent market for local beef.

Grazing in the early days was confined almost entirely to the grasslands, so it was not long before these areas were being fully utilized. Fencing of the ranges in the Kamloops-Nicola district was underway before the end of the 19th century, indicating that the ranges must have been stocked to nearly capacity by that time. The shortage of grassland range forced the increased use of forage range for summer grazing.