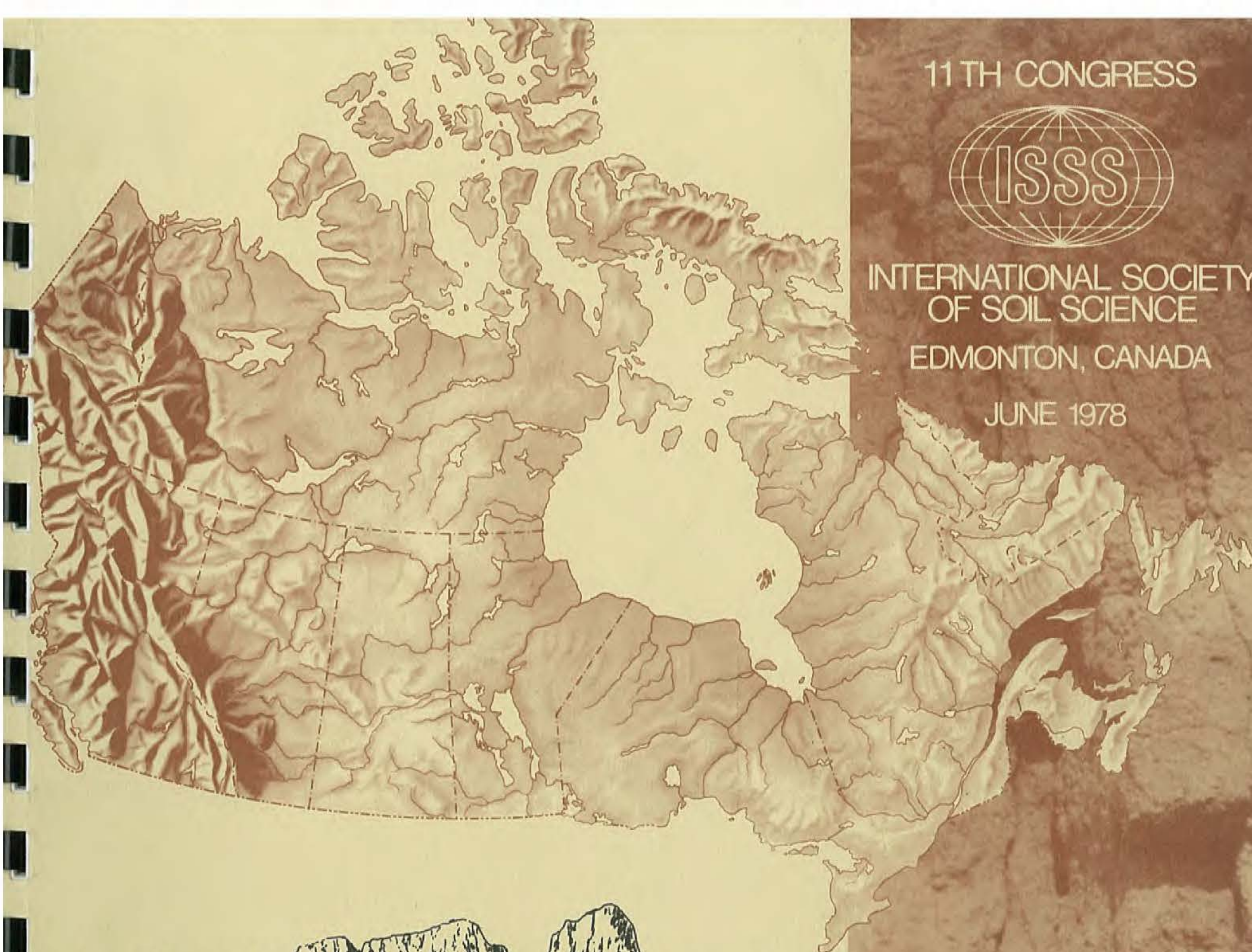

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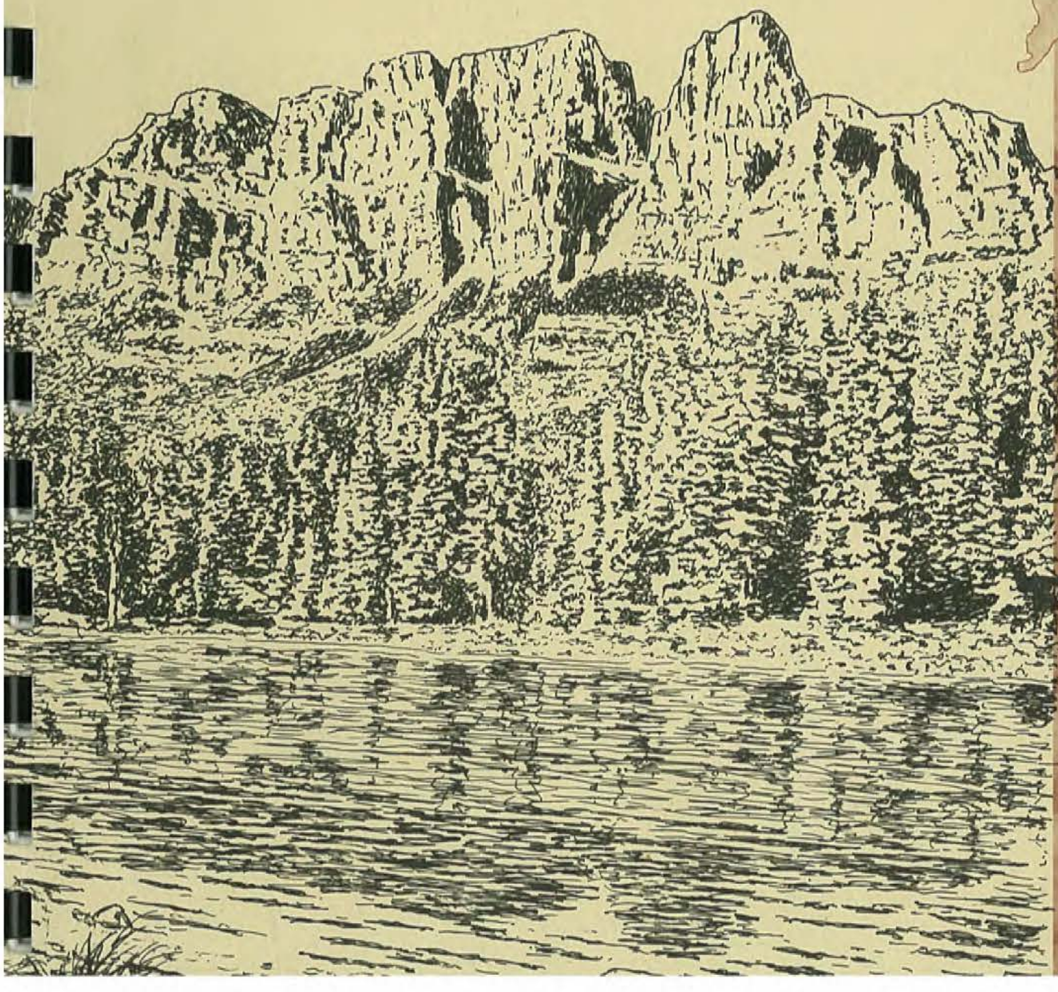

GUIDEBOOK TOURS 8+16

SOILS AND LAND USE IN BANFF AND JASPER NATIONAL PARKS

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GUIDEBOOK

FOR

A SOILS AND LAND USE TOUR IN BANFF AND JASPER NATIONAL PARKS

TOURS 8 AND 16

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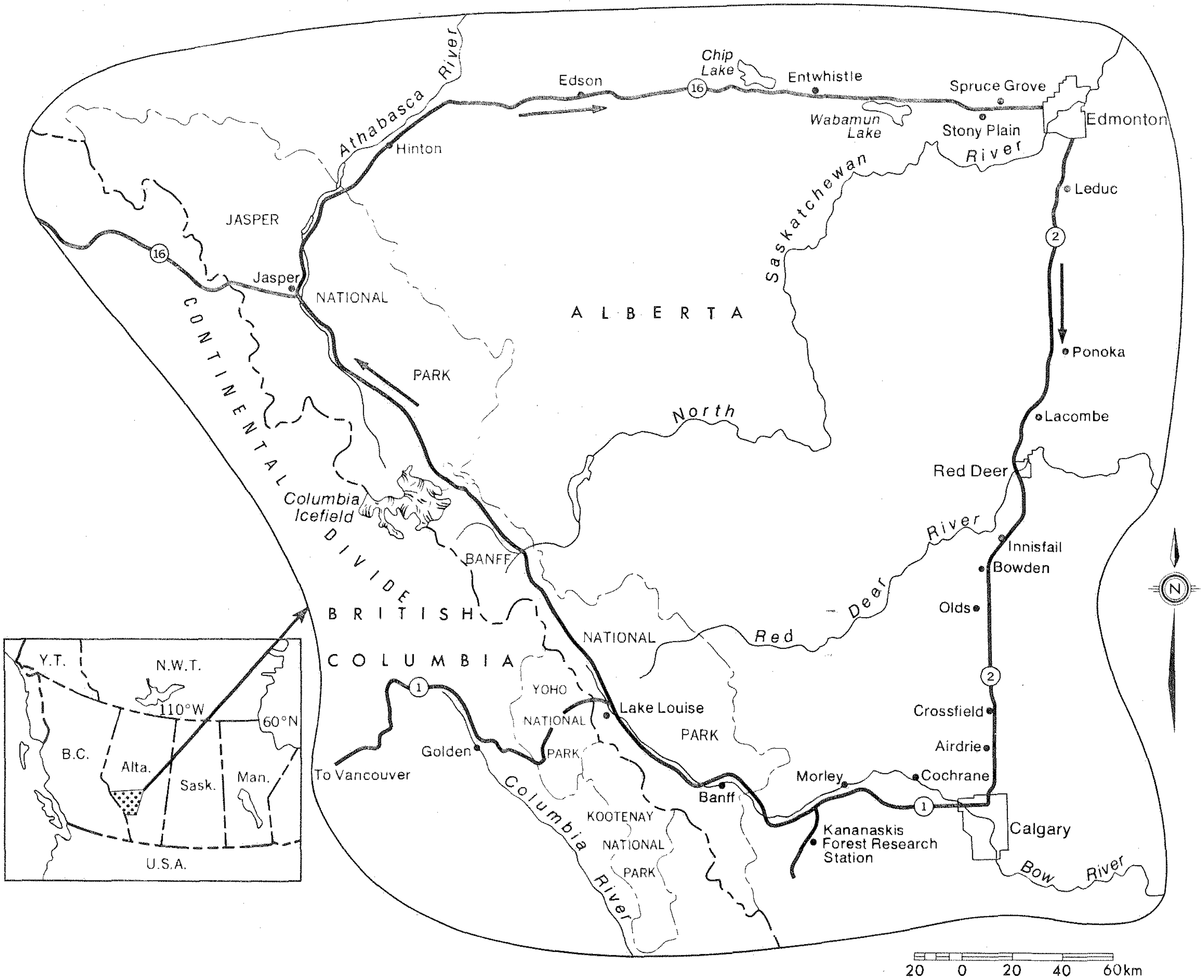

FIG. 1 GENERAL ROUTE MAP

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ACKNOWLEDGEMENTS

Thanks are extended to the many people and organizations who have assisted in tour arrangements and guidebook preparation. The Alberta Research Council and the Soil Research Institute of Agriculture Canada, have contributed personnel time and logistic support for tour preparations. The members of the Banff-Jasper Biophysical Team, namely Ian Corns, Wil Holland, Herb Taylor, Bruce Walker and Russ Wells contributed background information and helped with site selection. Parks Canada personnel at Western Regional Office in Calgary and the Superintendents, Wardens and Interpretive Staff at Banff and Jasper have been most cooperative. The Canadian Forestry Service kindly provided the use of the Kananaskis facilities. H. Charlesworth, Trudy Cotterall, and Don Pluth (also a tour committee member) contributed special articles to the guidebook. Tom Peters contributed the Edmonton to Calgary road log information and Terry Macyk wrote the Hinton to Edmonton section.

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The manuscript was reviewed by Leonard Kozak and edited by Lorne Crosson.

INTRODUCTION

This tour provides an opportunity to experience many of Alberta's landscapes. Even though the tour concentrates on the Rocky Mountains the route also traverses some of the plains and foothills of Alberta.

The theme of the tour is "soils in a mountain environment". The distribution and characteristics of soils in the landscape and land use will be examined.

The tour route follows Highway 2 south for 300 km from Edmonton to Calgary through an area of grain and mixed farming (Fig. 1). The route then follows the Trans Canada Highway westward from Calgary through ranching country, the Rocky Mountain foothills, and into the Rocky Mountains (80 km west of Calgary). The route through Banff National Park follows the Trans Canada Highway across the strike of the front ranges, and then follows Highway 93 (the Icefields Parkway) northward into Jasper National Park. Features of interest in this area include montane, subalpine and alpine ecozones, alpine and valley glaciers, Lake Louise and Moraine Lake, and a look at the mountain soils and land use. From Jasper the tour follows Highway 16 eastward out of the mountains and through the foothills where the prime land use is forest production. From the foothills to Edmonton the route again traverses agricultural lands.

The first part of the guidebook contains an overview of the physiography, climate, vegetation, soils, and land use of the general tour area. The second part of the guidebook contains the annotated road logs. The road logs emphasize landscapes, soils, and land use; and include descriptions of tour stops where soil pits are involved. Detailed descriptions, chemical, physical, and micromorphological data from featured soils are contained in the appendices.

GENERAL ITINERARY

DAY 1 - Edmonton to Banff. Registration for the tour will take place between 0700 and 0830 hours local time at Lister Hall, University of Alberta. The tour will depart at 0830 hours for a 400 km bus trip to Calgary, Kananaskis, and Banff. Lunch will be provided at noon. A soil pit will be examined at the Kananaskis Forest Research Station. A barbeque dinner will follow. Accomodation for the night will be provided at motels and hotels in Banff.

NOTE: Participants should bring a warm jacket!

DAY 2 - Banff - Lake Louise - Banff. The tour will assemble at 0800 hours for a 60 km trip to Lake Louise. Lunch will be provided at noon. The trip will feature examination of two soil pits and a visit to Lake Louise and Moraine Lake. The tour will return to Banff at 1800 hours. Dinner will be provided. Accommodation for the night will be provided at the same motels and hotels in Banff as for Day 1.

DAY 3 - Banff to Jasper. The tour will assemble at 0800 hours for a 300 km bus trip to Jasper. The trip will feature a view of high mountain scenery, a soil pit examination and a lunch stop at Peyto Lake, and a visit to the Columbia Icefield. Accommodation for the night will be provided at motels and hotels in Jasper. Dinner will be provided.

DAY 4 - Jasper Local. The tour will assemble at 0800 hours for a short bus trip to two soil pit locations. Lunch will be provided at noon. The afternoon will be free time. Scenic bus tours will be available. Dinner will be provided. Accommodation for the night will be provided at the same motels and hotels in Jasper as for Day 3.

DAY 5 - Jasper to Edmonton. The tour will assemble at 0800 hours for a 400 km bus trip to Edmonton. There will be one stop to examine a soil pit and to have lunch. The tour should arrive at Edmonton at 1730 hours.

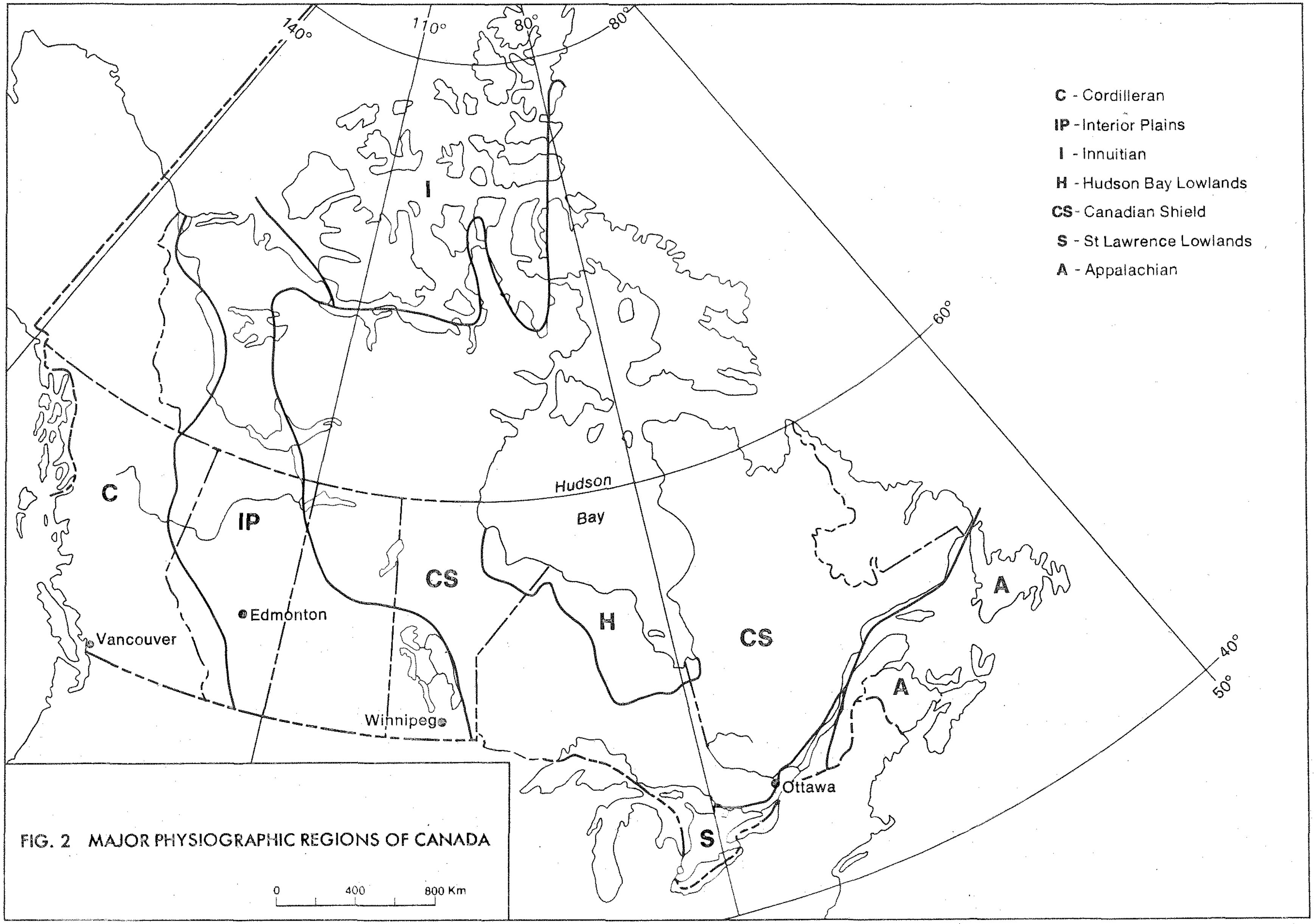


FIG. 2 MAJOR PHYSIOGRAPHIC REGIONS OF CANADA

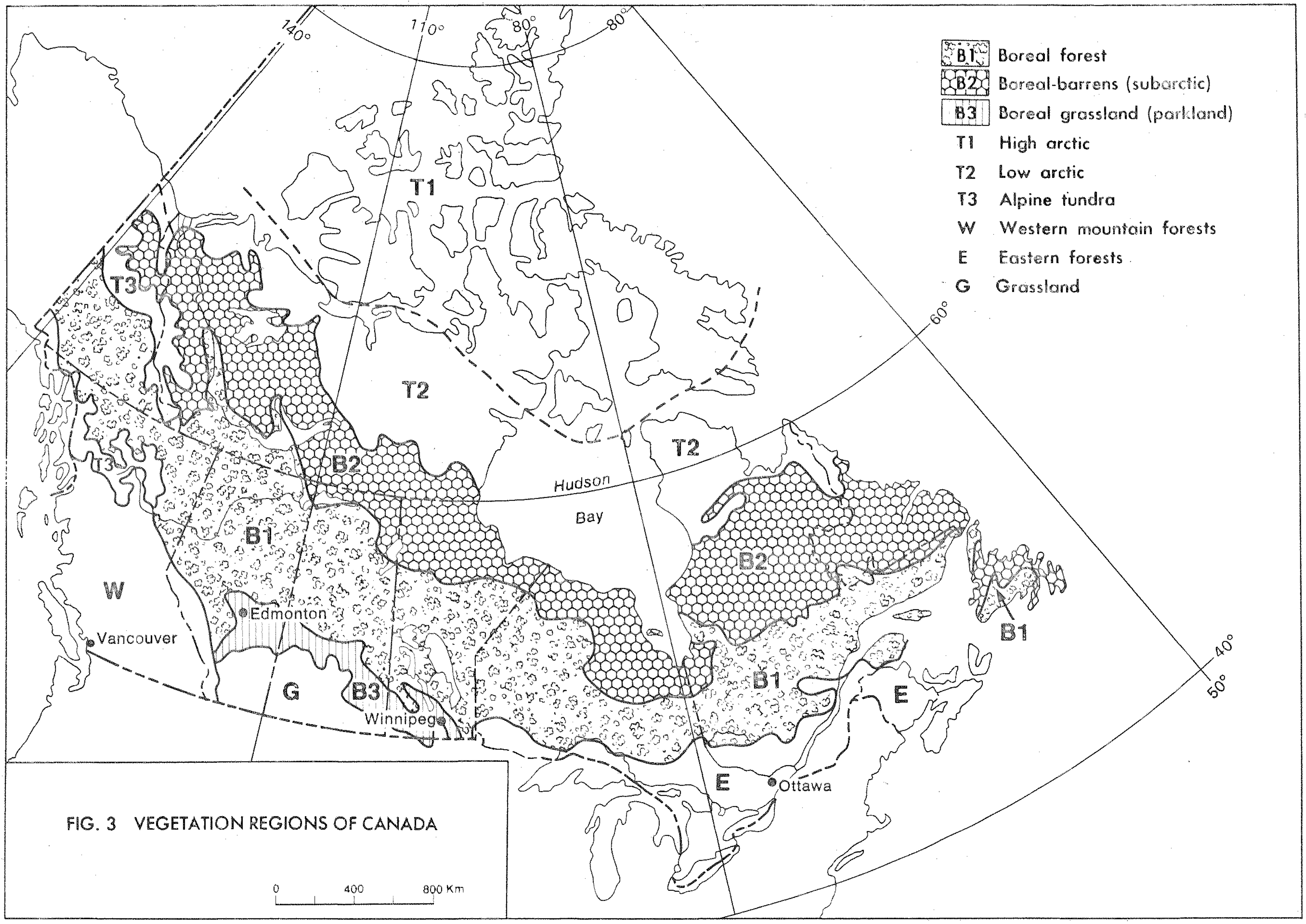


FIG. 3 VEGETATION REGIONS OF CANADA

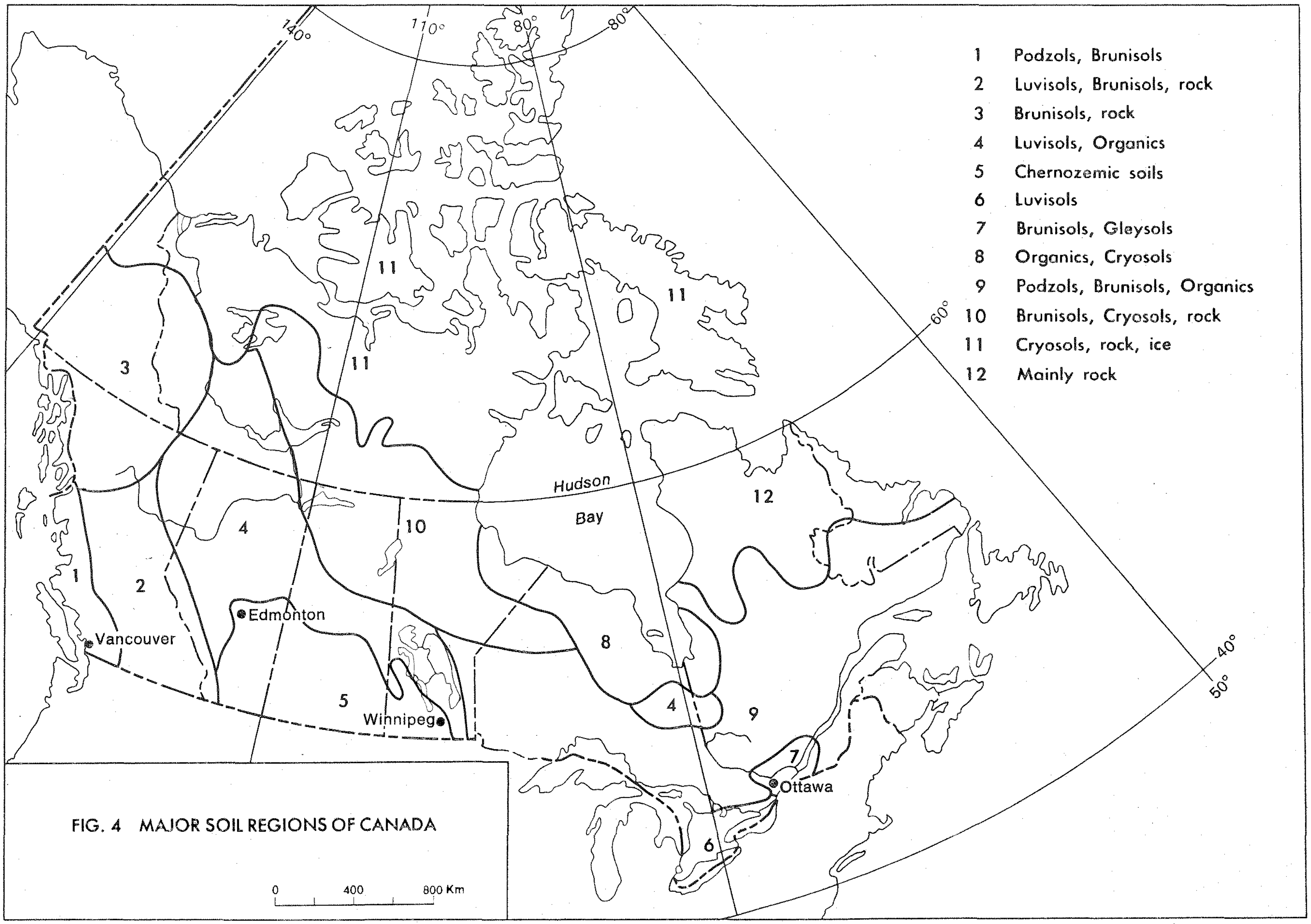


FIG. 4 MAJOR SOIL REGIONS OF CANADA

REGIONAL OVERVIEW

This tour traverses a wide range of landscapes from grassland plains to high mountains. The tour concentrates on soils and land use in the mountains but comments are made on the prairies and foothills as we drive through these regions. This section of the guidebook presents a brief overview of the landscape elements in the three major physiographic areas.

The Alberta Plain

Physiography

The Alberta Plain is a division of the Interior Plains Region (Figure 6). It is composed of fairly flat-lying Mesozoic and Tertiary sediments covered with glacial drift (Figure 5). Much of this plain lies at elevations near 750 m a.s.l. with rivers entrenched 50 to 100 m, and hills rising to 1,200 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.

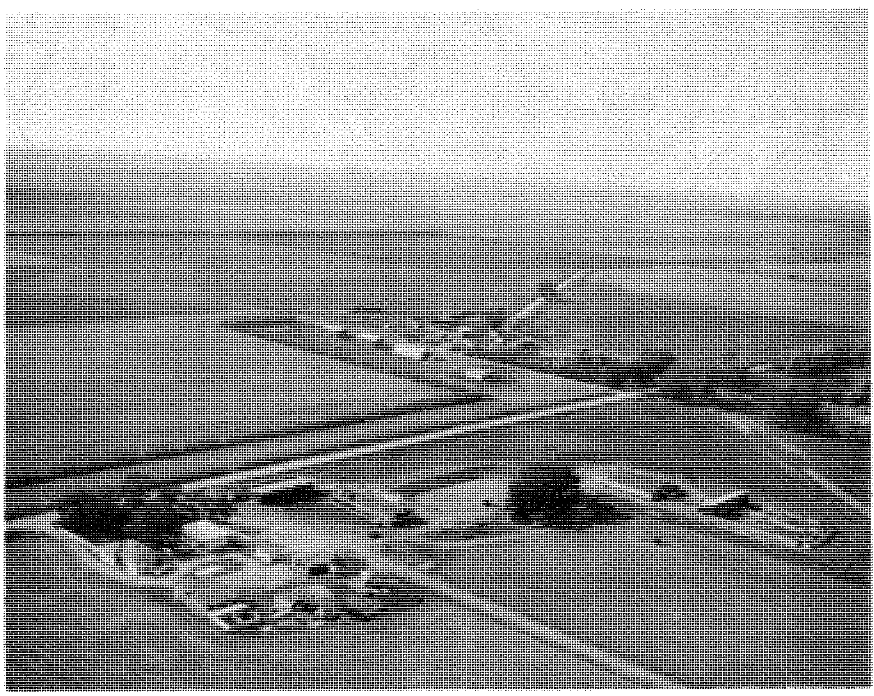
The mean annual precipitation on the edge of the Plains is 300 to 400 mm. This decreases to the south and east (Table 1).

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

Table 1. Temperature and precipitation means of selected points on the tour route.

	Temperature (C)			Precipitation (mm)		
	Mean Annual	Mean January	Mean July	Annual Total	Annual Snow	May to Sept.
Edmonton International Airport (719 m a.s.l.)	1.4	-16.3	16.1	457	1,310	320
Red Deer Airport (904 m a.s.l.)	2.0	-14.9	16.2	472	1,280	310
Calgary International Airport (1,080 m a.s.l.)	3.4	-10.9	16.5	462	1,539	300
Kananaskis (1,390 m a.s.l.)	2.7	- 9.7	14.1	647	2,552	384
Banff (1,397 m a.s.l.)	2.3	-11.2	14.5	477	2,187	249
Lake Louise (1533 m a.s.l.)	-0.1	-14.6	12.4	767	4,820	280
Jasper (1,060 m a.s.l.)	2.8	-12.2	15.2	401	1,370	215
Edson Airport (925 m a.s.l.)	1.7	-14.9	14.9	554	1,680	373

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



Courtesy of Alberta Government

FIG. 5 Level to undulating topography of the Plains.

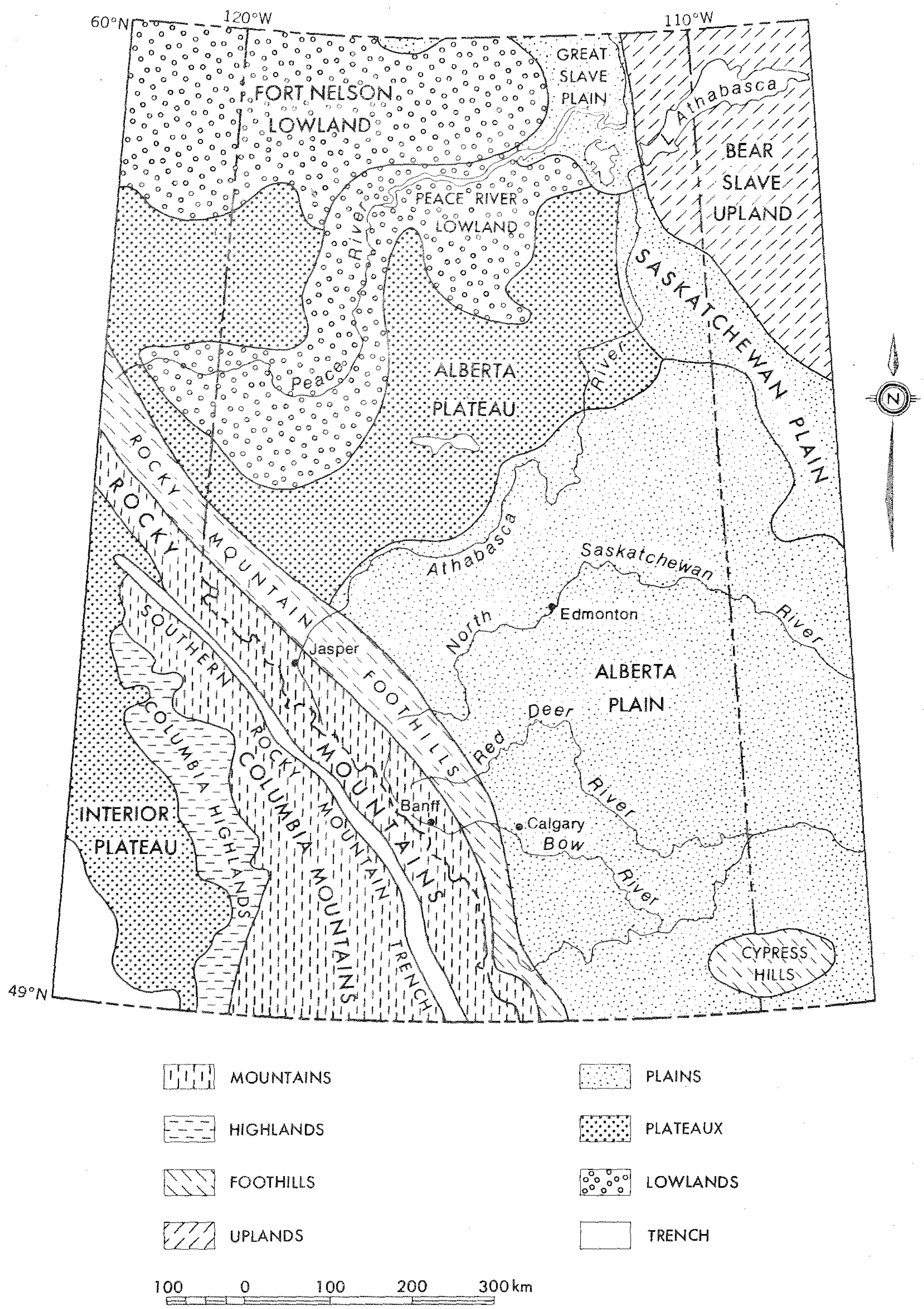


FIG. 6 PHYSIOGRAPHIC REGIONS OF ALBERTA

Figure 7 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 practiced 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 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.

Three distinct phytogeographic areas are encountered in the Plains section of this tour (Figure 8). These are the Grassland region, and the Aspen Grove and Lower Foothills sections of the Boreal region (Rowe 1972).

The tour route skirts the edge of the Grassland region near Calgary (Figure 8). The major grasses are wheatgrass (*Agropyron*), fescue (*Festuca*), and needlegrass (*Stipa*). Grama grass (*Bouteloua*) and sedges (*Carex*) are common. There are occasional shrub patches of snowberry, buckbrush (*Symphoricarpos* spp.), and wolf willow (*Elaeagnus*), and a few poplar (*Populus*) trees. The grassland prairies are dry and windy.

The Aspen Grove section (Figure 8) is a region a transition between the closed boreal forest and the treeless grasslands. The area consists of grasslands dotted with groves of trembling aspen (*Populus tremuloides*) 4 to 8 m high with an understory of snowberry, beaked hazelnut (*Corylus*), chokecherry (*Prunus*) and wild rose (*Rosa*) 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 wheatgrass, needlegrass, and June grass (*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 (*Pinus contorta*) and to a lesser extent trembling aspen are dominant, due largely to fire history. White spruce (*Picea glauca*) is the dominant species in older stands with black spruce (*P. mariana*) and tamarack (*Larix laricina*) present in poorly drained areas. Balsam fir (*Abies balsamea*) and subalpine fir (*Abies lasiocarpa*) occur sporadically.

Soils

The soils in the Plains portion of this tour are predominantly Black Chernozemics in the Aspen Grove section and the Grassland region, and Gray Luvisols in the forest region (Figure 10).

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 1,250 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 Grasslands and 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.

In the Grasslands area individual farms are larger (500 to 1,000 ha) and wheat is the major crop. Farmers utilize large machinery to minimize labor input. Four-wheel drive tractors that pull 15 m of tillage equipment are common. Large cattle ranches, operating on 2,000 or more ha can be found in south-eastern Alberta.

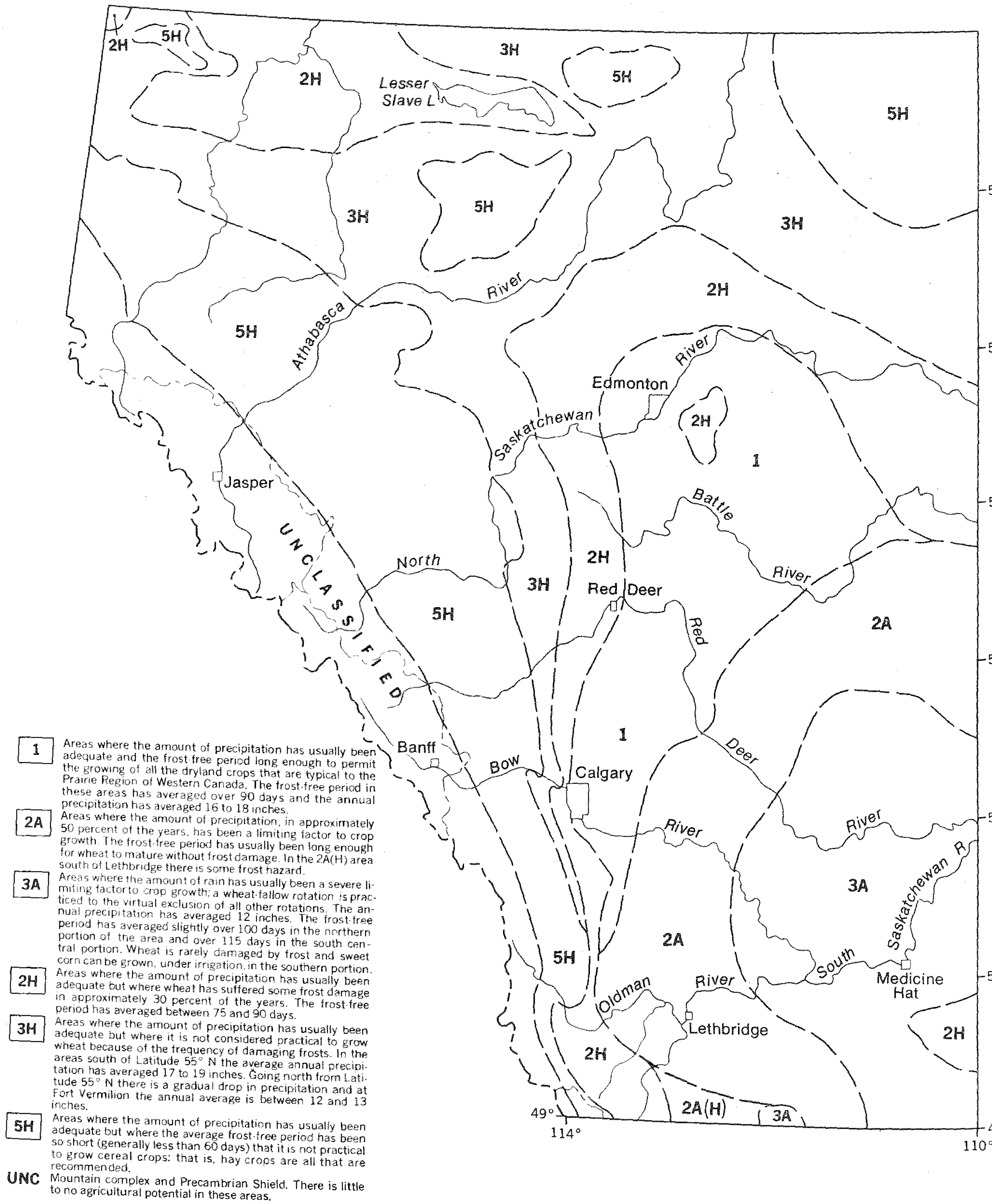


FIG. 7 AGROCLIMATIC AREAS OF SOUTHERN ALBERTA

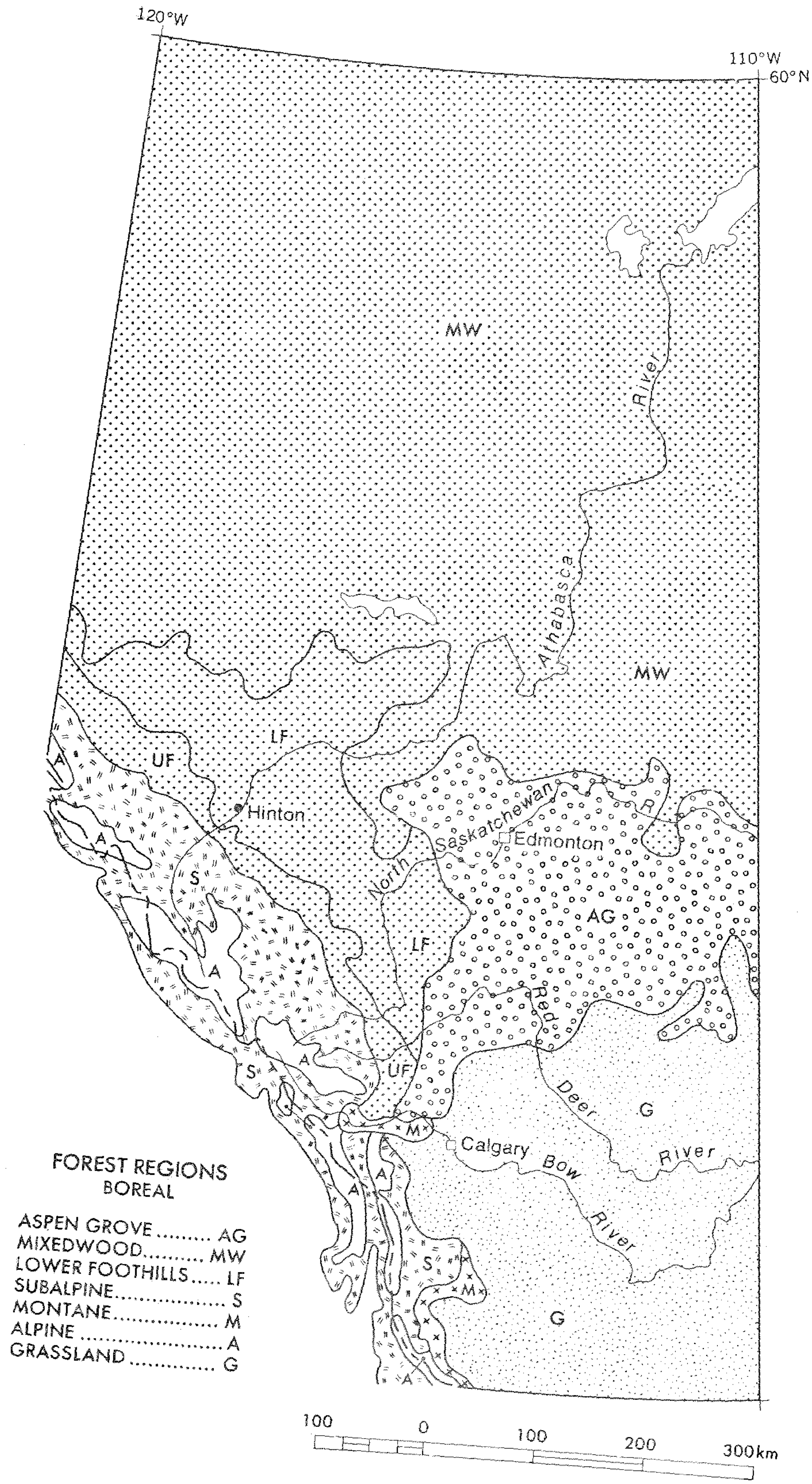


FIG. 8 FOREST REGIONS OF ALBERTA

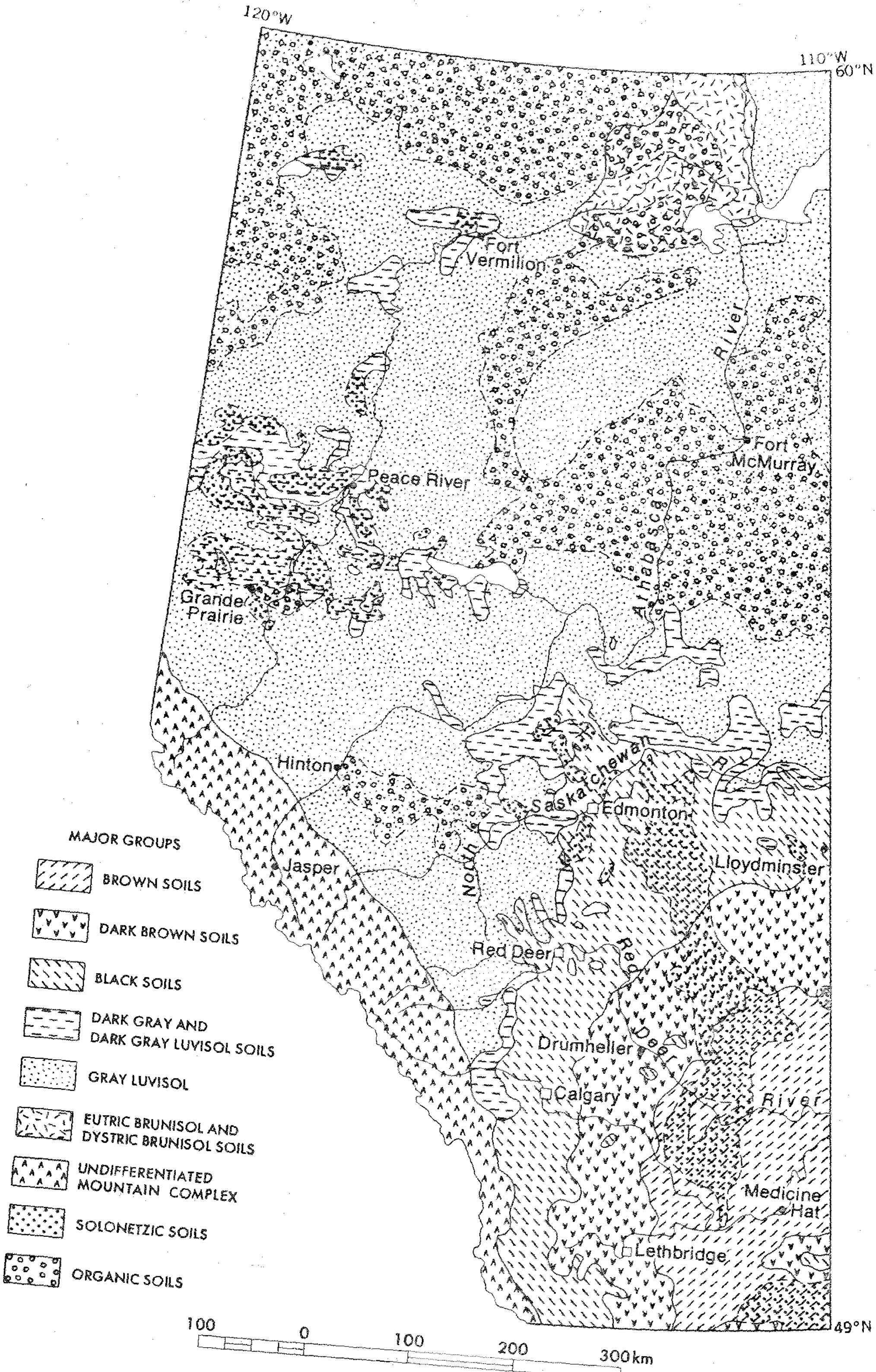


FIG. 9 SOIL GROUP MAP OF ALBERTA

THE CANADA LAND INVENTORY (C.L.I.) rates land capability for various uses including agriculture, forestry, recreation, ungulates, and waterfowl production. Soil capability for agriculture is rated from Class 1 (no limitations) to Class 7 (no capability) based on climate (agroclimatic areas) and soil limitations. The seven capability classes for agriculture are:

Class 1 - Soils in this class have no significant limitations in use for crops.

Class 2 - Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.

Class 3 - Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.

Class 4 - Soils in this class have severe limitations that restrict the range of crops or require special conservation practices or both.

Class 5 - Soils in this class are capable of producing perennial forage crops, and improvement practices are feasible.

Class 6 - Soils in this class are capable of producing perennial forage crops, and improvement practices are not feasible.

Class 7 - Soils in this class have no capability for arable culture or permanent pasture.

In rating land capability for forestry, 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 while 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 or drainage. The classification is based on known or inferred information about the land 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. The seven capability classes for forestry are:

Class 1 - Lands having no important limitations to the growth of commercial forests.

Class 2 - Lands having slight limitations to the growth of commercial forests.

Class 3 - Lands having moderate limitations to the growth of commercial forests.

Class 4 - Lands having moderately severe limitations to the growth of commercial forests.

Class 5 - Lands having severe limitations to the growth of commercial forests.

Class 6 - Lands having severe limitations to the growth of commercial forests.

Class 7 - Lands having severe limitations which preclude the growth of commercial forests.

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 10). 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 1,300 to 2,000 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 Sub-alpine forests to the west and the Lower Foothills to the east (Figure 8). 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. Subalpine fir is present but is less prevalent than in the mountains and tamarack occurs occasionally in poorly drained areas at lower elevations.

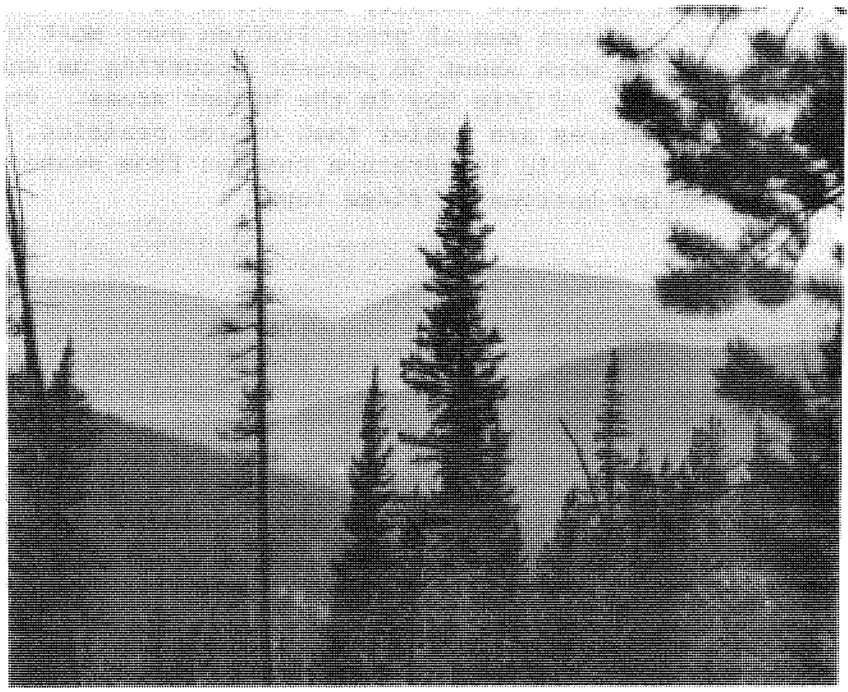
Soils

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.

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 1,100 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.



Courtesy of Alberta Government

FIG. 10 THIN DEPOSITS OF GLACIAL DRIFT BLANKET RIDGED AND ROLLING BEDROCK IN THE ROCKY MOUNTAIN FOOTHILLS

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.

The Rocky Mountains

Physiography*

The Rocky Mountains (Figure 11) comprise the southeastern part of the 1,500,000 sq km Canadian Cordillera and are 100-500 km wide by 1,500 km long. They are underlain essentially by Proterozoic to Mesozoic (Table 2) 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 12). 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.

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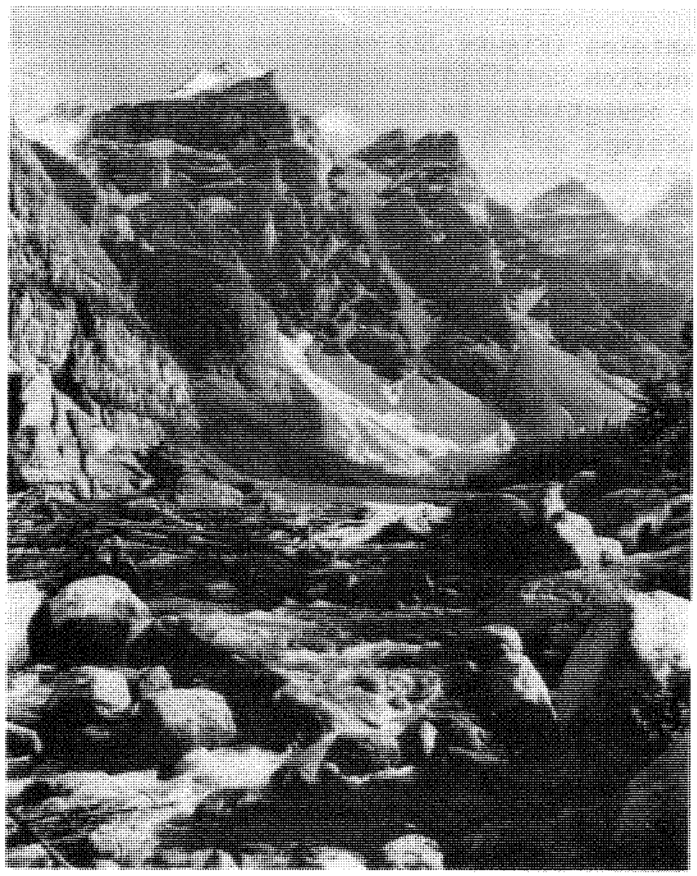
* Adapted from material provided by H.A.K. Charlesworth, Dept. of Geology, University of Alberta.



Courtesy of Alberta Government

FIG. 11 The rugged topography of the Valley of Ten Peaks is typical of the Rocky Mountains.

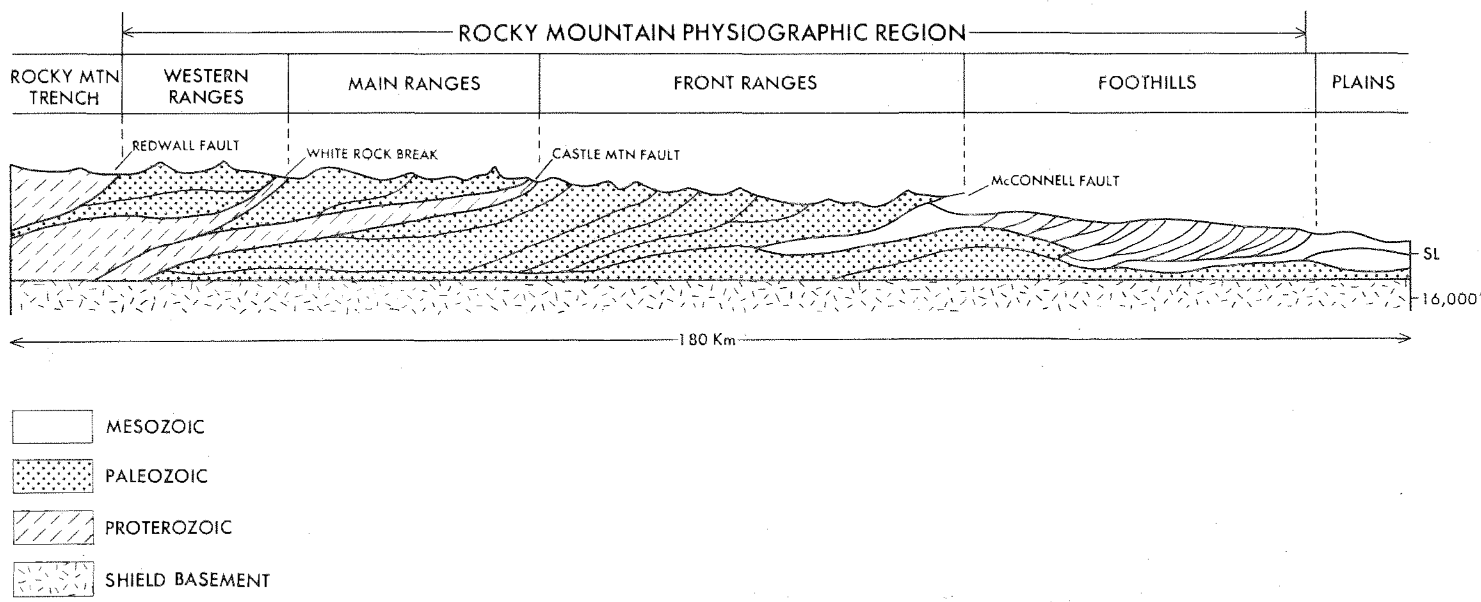


FIG. 12 REGIONAL STRUCTURE OF THE ROCKY MOUNTAINS

Table 2. 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	1,000	First Fossils
	Helkian	1,800	
	Aphebian	2,600	
ARCHEOZOIC	Archean	3,000	Canadian Shield
	Katarchean	3,600	

Climate*

The climate 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 Table 1.

There is considerable variability in amounts and yearly distribution of precipitation through the mountains (Table 1). 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: montane, subalpine, and alpine. These zones reflect a macroclimate gradation with elevation (Figure 13).

The montane zone is characterized by xeric grasslands in the valley bottoms and sub-xeric to mesic lodgepole pine ecotone to Douglas-fir (*Pseudotsuga menzeisii*) and trembling aspen ecotone to white spruce on the lower valley sides (Figure 14). 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 15). The characteristic tree species of the subalpine forests are subalpine fir and Engelmann spruce (*Picea engelmannii*). 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 (*Larix lyallii*) as far north as Hector Lake, and scattered pockets of whitebark pine (*Pinus albicaulis*) and limber pine (*P. flexilis*).

In the transition area from subalpine to alpine the tree cover becomes discontinuous, forming strips and islands separated by heath and meadow communities. Subalpine 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 2,300 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 2,200 m and 2,000 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, heathers (*Phyllodoce* and *Cassiope* species), dwarf willows (*Salix* species), and various herbs, sedges, and grasses of the moist meadow communities are common (Figure 16).

In the upper, exposed alpine areas dryad (*Dryas octopetala*) and sedges (*Carex* and *Kobresia*) 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

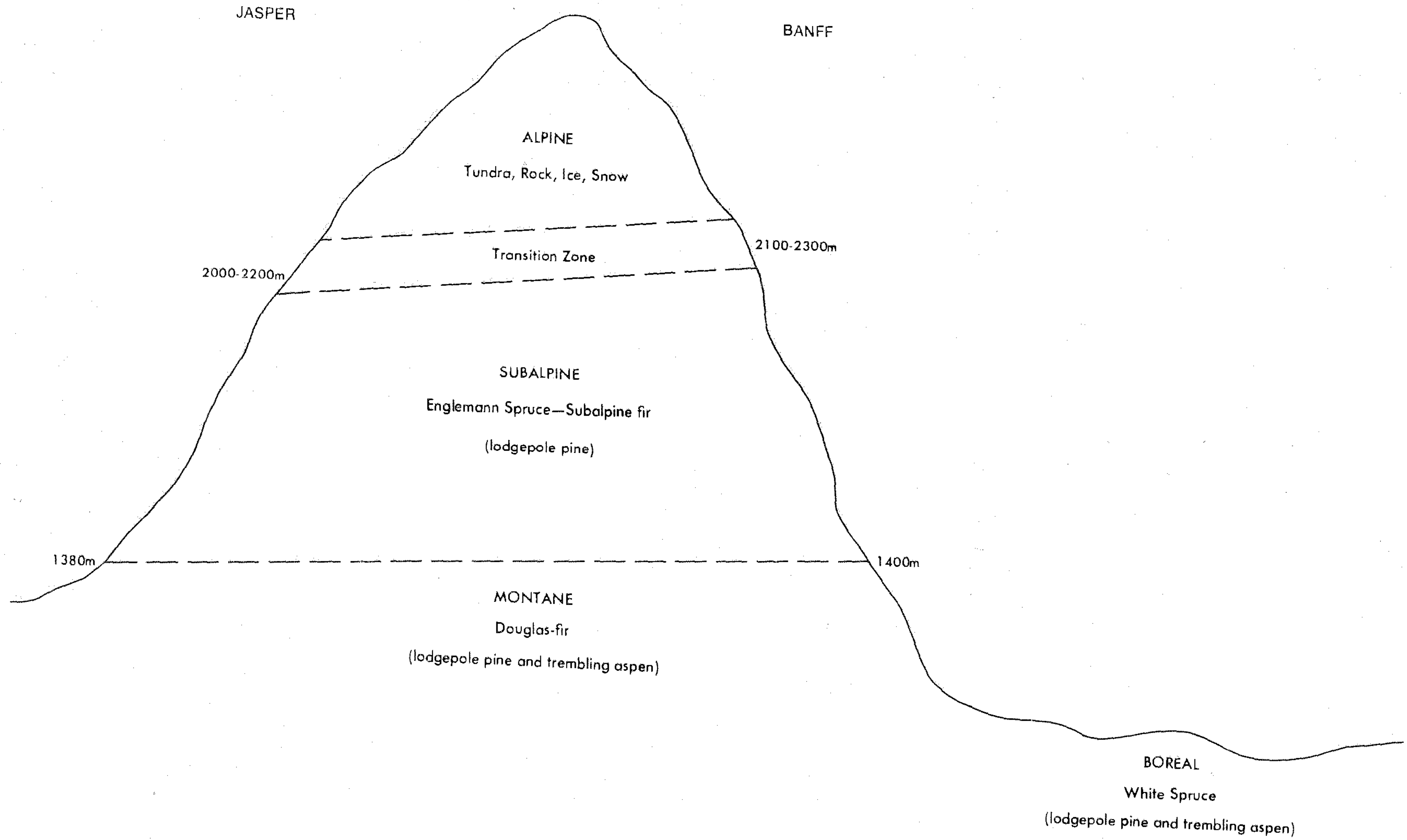


FIG. 13 BIOCLIMATIC ZONES OF BANFF AND JASPER NATIONAL PARKS

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.

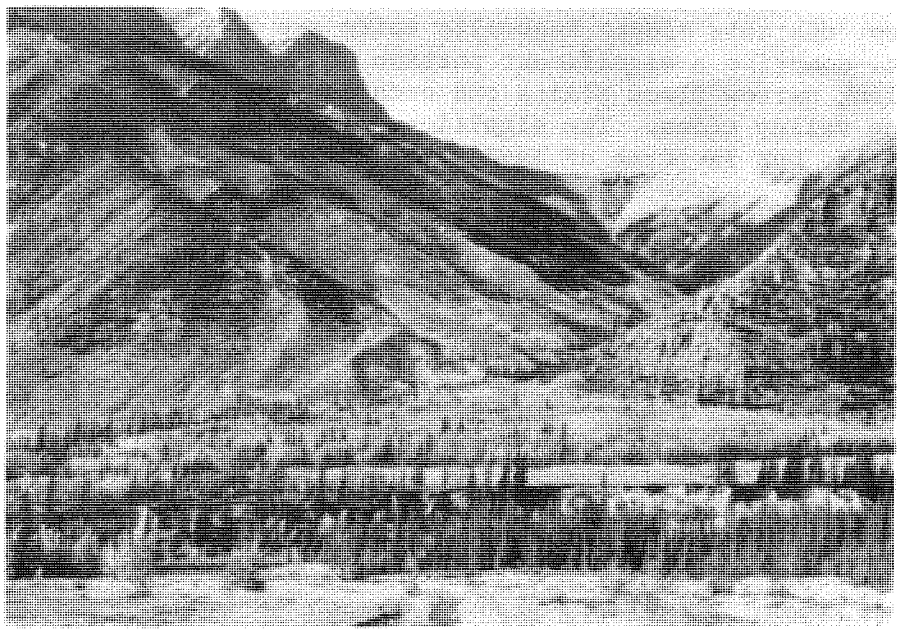
On steep, unstable slopes Regosolic soils are dominant, and in terms of areal extent, comprise a significant portion of the total. Gleysolic soils are found along narrow flood plains and occasionally are associated with seepage along valley sides. The significance of these soils is not in terms of areal 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-subalpine fir-Vaccinium types. There is a gradual transition from the dominantly Luvisolic soils below 1,700 m in Banff and about 1,500 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).



Photograph by B. Walker

FIG. 14 Montane zone trembling aspen-white spruce stand on a fluvial fan in the Bow Valley.

Photograph by B. Walker

FIG. 15 Subalpine zone at Lake Louise made up of subalpine fir—Engelmann spruce forest.

Photograph by L. Knapik

FIG. 16 The Sunshine alpine area along the Continental Divide west of Banff is one of the larger alpine landscapes in the Canadian Rockies.

DAY 1: EDMONTON TO BANFF

The tour travels south from Edmonton, approximately 270 km, on Highway 2 to Calgary along the western fringe of the plains (Figure 17). The route traverses prime agricultural land on Black Chernozemic soils. Landscapes include glaciolacustrine basins, sand dunes, and morainal plains. From the city of Calgary, the route follows the Trans Canada Highway westward, quickly climbing into the foothills and the mountains. Land use in this section of the tour includes ranching, forage production, timber production, and recreation and wildlands values of the national parks. A soil pit, nature walk, and barbeque will be featured at the Kananaskis Forest Research Station at the edge of the mountains.

Road Log No. 1: Edmonton to Calgary

Km (Mile)

0 (0) ELLERSLIE CORNER. Fine clayey textured Black Chernozemic soils on a level glaciolacustrine plain (Figure 18). Agricultural capability class 1.

1.6 (1) BLACK CHERNOZEMICS. Loamy textured Black Chernozemic soils on a level to undulating morainal plain. Agricultural capability class 1.

4.8 (3) BLACK SOLODIZED SOLONETZ. Primarily loamy textured Solonetzic soils on a level to undulating soft rock plain. Agricultural capability class 2 to 4, depending on depth of Ah.

5.1 (3.2) BLACKMUD CREEK. Exposure of soft rock Cretaceous shales on right side along creek bank. Note thin strata of coal.

10.2 (6.4) NISKU, the name of this hamlet means wild goose in Cree.

11.2 (7) SILTY BLACK CHERNOZEMIC SOILS. Developed on a level to undulating glaciolacustrine plain. Agricultural capability class 1.

13.4 (8.4) EDMONTON INTERNATIONAL AIRPORT to the right. Primarily loamy textured Black Solodized Solonetz soils on a level to undulating soft rock plain, with intermittent areas of loamy textured Black Chernozemic soils on till. The Solonetzic areas are agricultural capability class 2 to 4, depending on depth of Ah, while the Chernozemic areas are agricultural capability class 1. The yields of wheat, oats, and barley grown on the Solonetzic soils (soil capability class 4) for the years 1967-74 inclusive are:

Crop	Yield	
	kg/ha	bu/ac
Wheat	1,880	27.9
Oats	1,610	42.3
Barley	1,790	33.3

Due to the proximity of the hard Bnt to the surface the crops grown on these soils will suffer during dry seasons but if moisture comes at the right time they will produce fairly good crops.

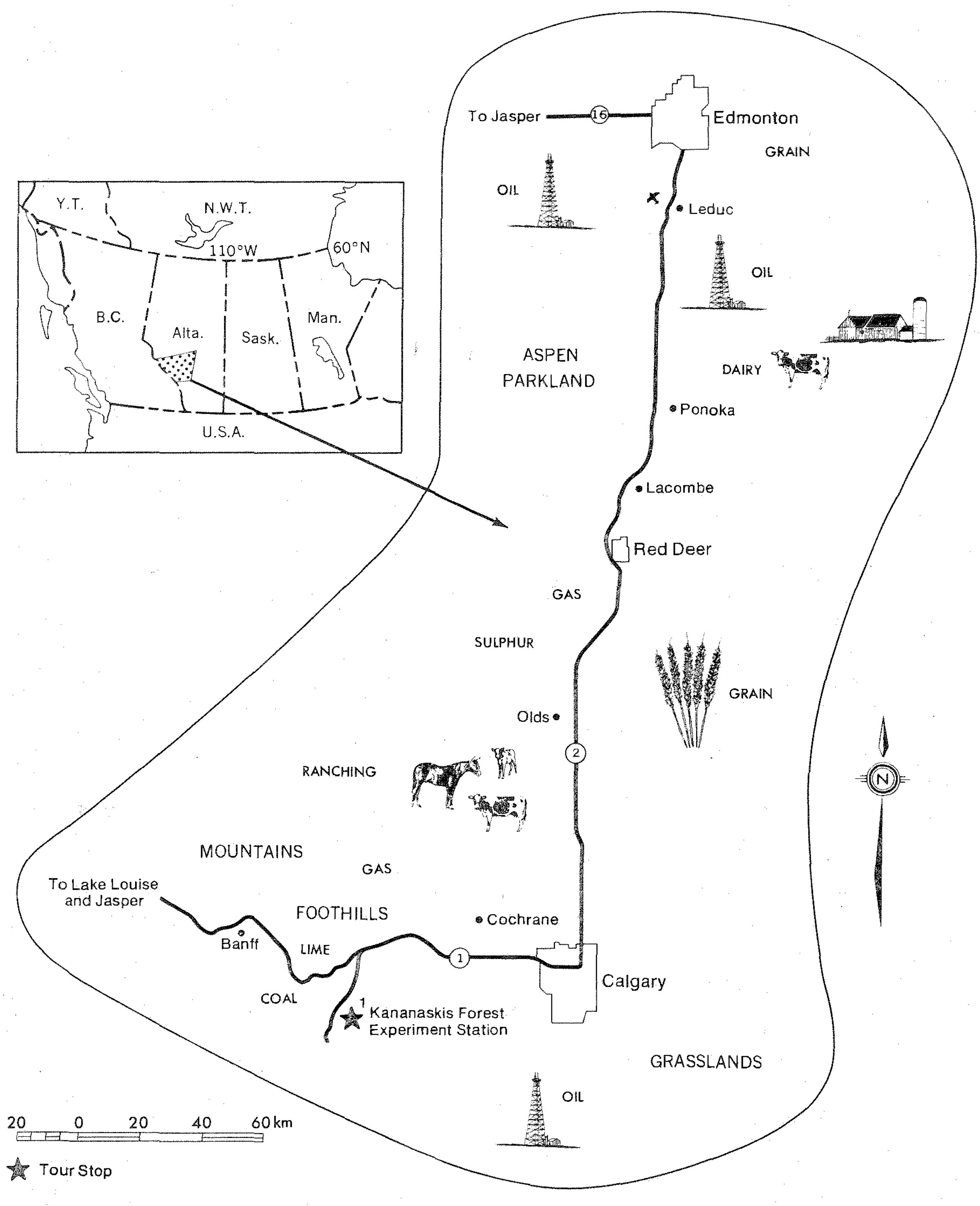


FIG. 17 EDMONTON TO BANFF ROUTE MAP

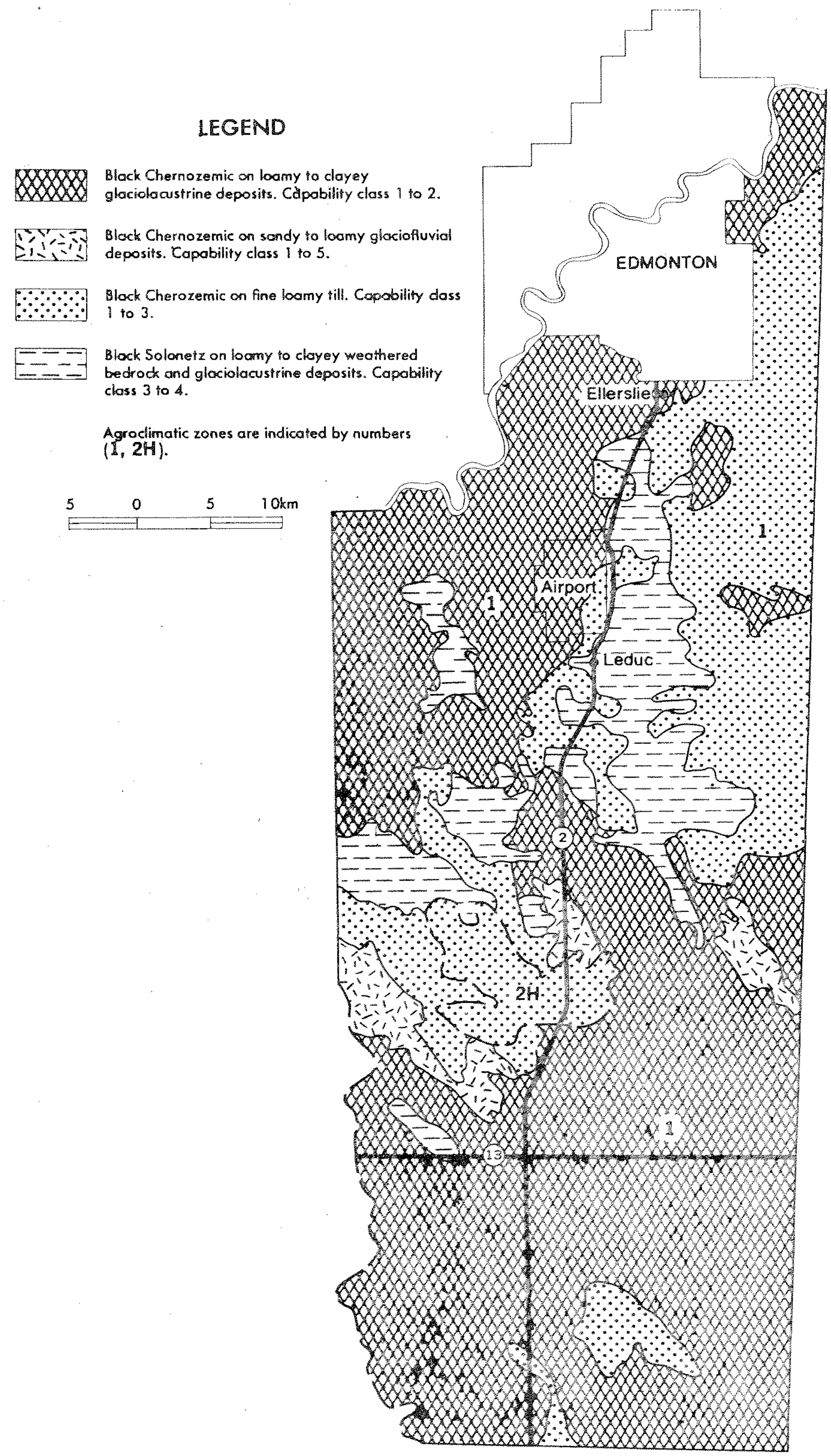


FIG. 18 GENERALIZED SOIL MAP—EDMONTON TO NORTH OF PONOKA

18.1 (11.3) LEDUC, with a population of about 8,000, is one of Edmonton's "bedroom communities". Before the oil strike of 1947, it was a quiet little town of a few hundred people. Leduc No. 1 blew in on February 13, 1947, 9 km west of Leduc, thus marking the advent of increased exploration followed by further discoveries. Today, Alberta is one of North America's largest oil producers.

25.6 (16) BLACK CHERNOZEMICS. These loamy textured soils were developed on a level to undulating lacustrine plain. There are some inclusions of sandy textured materials. Agricultural capability classes 1 and 2.

35.2 (22) BLACK CHERNOZEMICS. These loamy textured soils were developed on an undulating morainal plain dissected by numerous channels or spillways of Pleistocence age. Agricultural capability classes 1 and 2.

41.6 (26) BLACK CHERNOZEMICS. These soils were developed in loamy textured glaciofluvial veneers and blankets overlying till. Agricultural capability classes 1 and 2.

53.1 (33.2) JUNCTION HIGHWAY 13.

55.4 (34.6) MORAINAL PLAIN. These loamy textured Black Chernozemic soils were developed on an undulating and rolling morainal plain. Agricultural capability classes 1, 2 and 3.

84.3 (52.7) JUNCTION HIGHWAY 53 TO PONOKA. (Blackfoot name for Wapiti) These sandy and loamy textured Black Chernozemic soils were developed on an undulating and rolling glaciofluvial plain with fequent longitudinal ridges (Figure 19). The agricultural capability rating of these soils varies from class 2 to class 5.

85.9 (53.7) BATTLE RIVER. This river begins about 80 km to the northwest and flows 700 km eastward to join the North Saskatchewan River at North Battleford, Saskatchewan.

95.0 (59.4) MORNINGSIDE is a hamlet named after a suburb of Edinburgh, Scotland.

105.8 (66.1) JUNIPER LODGE. Visitor service area.

107.7 (67.3) FEEDLOT on the ridge to the right.

111.4 (69.6) LACOMBE with a population of approximately 3,500, is to the left. The Agriculture Canada Research Station is located south of town. Lacombe was named after Father Lacombe, a Roman Catholic missionary, who spent the greater part of his life here in evangelical work among the Indians.

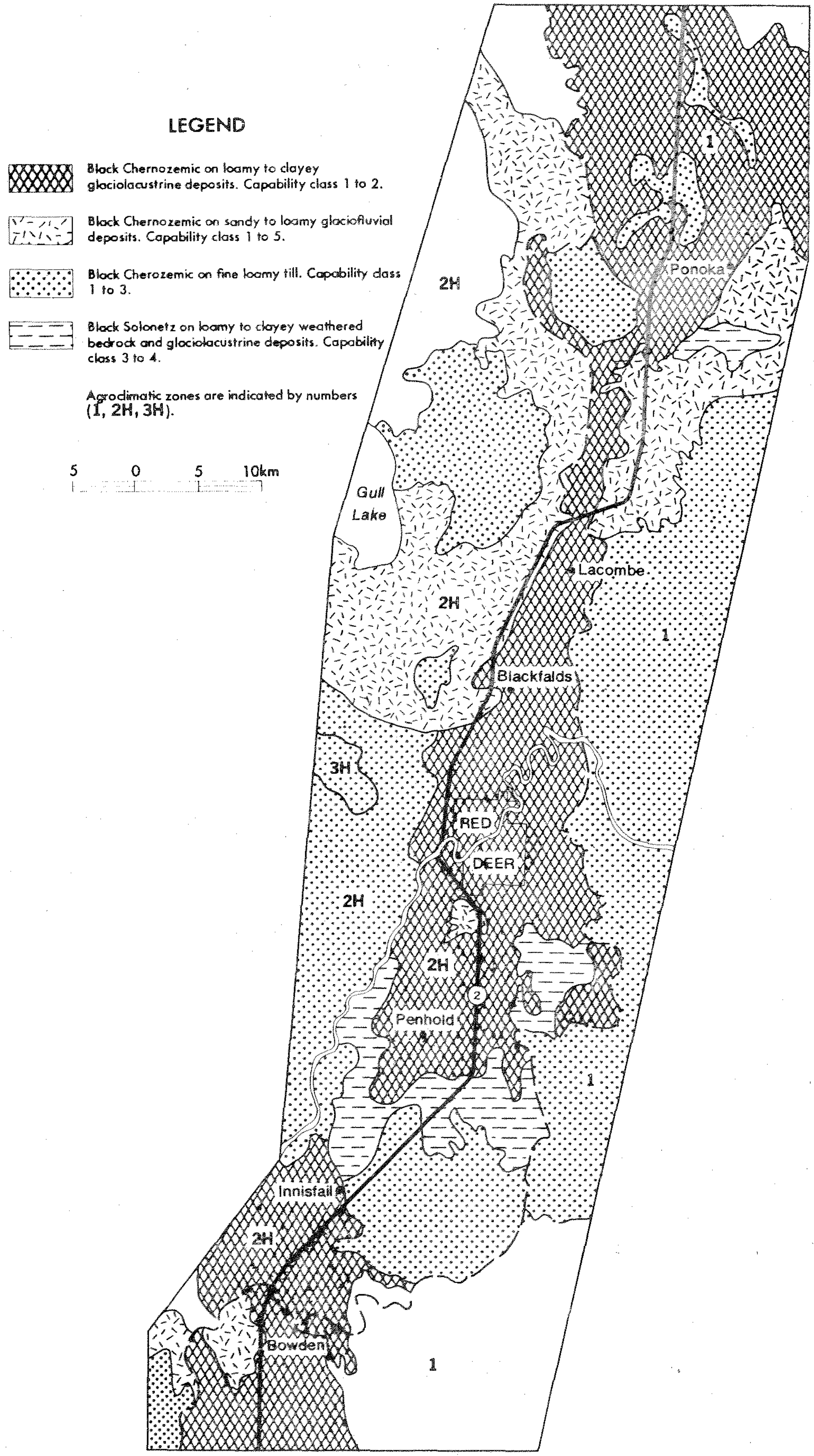


FIG. 19 GENERALIZED SOIL MAP—NORTH OF PONOKA TO BOWDEN

The Lacombe Research Station

The Lacombe Research Station was founded in 1907, the seventh in a network of experimental farms then being established across the country by the Canada Department of Agriculture. Its original objective was to assist the increasing population of settlers in developing their farms in the newly settled areas of central Alberta. In the early days emphasis was placed on the testing and demonstration of farm practices, livestock breeds, grain, forage, vegetable and fruit varieties, which had been developed in other parts of Canada and the United States. As the years passed it was recognized that varieties and practices developed elsewhere were not always suitable for the soil and climatic conditions of this region, so new programs of research, breeding, and development were initiated to develop crop varieties and farming practices to meet the specific needs of the short growing season in central Alberta.

Climate

A summary of meteorological data collected at the Lacombe Research Station during a period of 68 years is presented in Table 3. These data show that the major limitation to crop production is the short growing season. On an average, there are only 90 frost-free days, and only 120 days between spring and fall killing frosts. In addition the mean minimum temperature throughout the growing season is less than 9 C. Unlike much of western Canada, Lacombe does not have a climate suitable for the production of wheat. The growing season is sufficiently long for the production of barley, but short-duration varieties are necessary to escape the risk of frost.

The amount of precipitation is the next limitation to crop production, although the distribution of precipitation during the growing season is very favourable with the largest amounts falling during the months of June, July, and August.

In addition to these two major limitations to production, there is the risk of partial or complete loss of crops, especially grain crops, due to hail. Lacombe is situated in the hail belt of central Alberta and risk of hail damage is prevalent during the months of June, July, and part of August.

Land Use

Because of the short growing season, farming systems based on wheat production have not developed in the Lacombe area, as has been the case in much of the rest of western Canada. Barley, with a shorter growing season requirement, has been the main grain crop, and considerable amounts of forage crops are also produced. This has resulted in the development of "mixed farming" systems with large productions of livestock (especially beef cattle and swine) on most farms to utilize the feed grains and forage produced. Approximately 45% of the cultivated land in the region is seeded to barley and 25% to cultivated forage crops. Only about 12% of the land is fallowed in any year. Wheat occupies less than 3% of the cultivated land, oats slightly more than 5%, and rapeseed has recently developed as a crop in the region to the extent that it occupies almost 10%.

Table 3. Meteorological Data, Lacombe Research Station

	Mean Temperatures, C, 68 year means			Total Precipitation	Sunshine	Wind		Evaporation	
	Maximum	Minimum	Daily	mm	hrs	No. of years	km	No. of years	mm
January	-7.9	-20.7	-14.3	19	84.4	29	6801		
February	-3.9	-17.7	-10.8	18	118.4	30	6236		
March	1.3	-12.3	-5.5	20	161.9	30	7228		
April	10.3	-3.5	3.4	30	201.7	30	8296	14	28
May	17.3	2.2	9.8	48	243.4	30	9166	28	86
June	20.6	6.1	13.4	84	251.4	32	7472	42	88
July	23.9	8.7	16.3	74	296.7	30	6761	44	100
August	22.7	7.0	14.8	61	261.7	28	6703	30	86
September	17.7	2.3	9.9	38	183.2	29	7208	30	52
October	12.1	-3.1	4.5	20	150.9	30	7710		
November	2.1	-10.5	-4.2	16	98.8	30	6811		
December	-4.6	-16.9	-10.7	17	77.6	30	6771		
Annual				445	2130.1		87164		
Mean	9.3	-4.9	2.2						

Growing season precipitation (April-July inclusive) (mm)	236
Growing season evaporation (April-July inclusive) (mm)	302
Last killing spring frost (-2.2 C)	May 18
First killing fall frost (-2.2 C)	September 15
Number of killing frost-free days (-2.2 C)	120

Typical yields of the various crops grown in the region are as follows:

Crop	Yield		
	kg/ha	bu/ac	lbs/ac
Barley	2,500	46	
Oats	2,200	60	
Wheat	2,200	32	
Rapeseed	1,000	18	
Forage	3,700		3,300

Barley, oats and rapeseed are generally responsive to applications of both N and P fertilizers. Typically, about 40 to 50 kg/ha N and 10 to 20 kg/ha P are applied. These crops do not generally respond to K, although isolated responses to K have been observed in some experiments in the region. Manganese deficiency occurs in oats (Grey-speck disease) in most years but is not considered to be a serious problem. Boron deficiency has been noted on alfalfa, but only during very dry years and in extremely rare instances. Alfalfa is not grown for seed in the region so boron deficiency is not considered a major problem.

Forage crops, especially the brome-alfalfa mixture commonly grown in the region, do not appear to be as responsive to fertilization as is barley, hence farmers are reluctant to apply more fertilizer. Typical fertilizer applications, if made, would be 20 to 30 kg/ha N and 10 to 15 kg/ha P.

The N fertilizer applied to barley, oats and rapeseed is applied in the form of anhydrous ammonia, urea or ammonium nitrate. The availability of ammonium nitrate is decreasing while more and more urea is becoming available, and will soon be the dominant source of N fertilizer. These fertilizers are applied either during the fall cultivation or prior to spring seeding. Phosphorus is placed in the drill row along with the seed.

Current Soils Research.

Soil fertility research currently underway at the Lacombe Research Station is aimed at more effective use of N, P, and K fertilizers for the economic production of barley, rapeseed and forage crops. Fertilizer responses of these crops are being correlated with the results of soil analyses as a means of improving fertilizer recommendations and increasing the efficiency of fertilizer use.

The response of grasses and legumes to fertilizers are being studied in pure stands, rather than in mixtures, the objective being a better understanding of the growth requirements of the individual species for higher yields.

Relationships between soil fertility and the effectiveness of certain herbicides in controlling weeds are being investigated, with most of this work being done on wild oats, the most troublesome and costly weed in Western Canada. Work is also being done on the use of urea fertilizer as a carrier for the soil-applied herbicides triallate and trifluralin.

121.6 (76.0) BLACKFALDS. The soils in this area are Orthic Blacks on coarse loamy glaciofluvial materials (Bowser, Peters and Newton 1951).

123.8 (77.4) BLINDMAN RIVER, named because a Cree war party hunting in the area became snow blind.

128.6 (80.4) JUNCTION WITH HIGHWAY 11 - THE DAVID THOMPSON HIGHWAY.

134.1 (83.8) RED DEER RIVER - Note the presence of white spruce and tamarack on the floodplain.

Red Deer City

Red Deer is located in the heart of some of Alberta's best farm land. It derives its name from the Cree Indians, who named the river "Waskasioo Seepee", meaning Red Deer, because of the abundance of deer. Legend has it that Napia, the Indian deity and creator of all beautiful things, decided to form a final resting place for himself. He created the beautiful Red Deer valley, and content with his handiwork, slept forever.

The first settlers arrived in 1884. Soon after, in 1891, the railway arrived bringing with it a great influx of settlers. Growth was steady, and Red Deer became incorporated; as a town in 1901, and as Alberta's fifth city in 1913. In 1905, when Alberta became a province, Red Deer, because of its central location, argued that it should become the provincial capital. Free land for government buildings was offered by a leading citizen, Edward Mitchener, whose son later became Canada's Governor General. However, the politicians of the day, in their wisdom, decided that Edmonton was a better location. Despite this setback, Red Deer continued to grow and today has a population in excess of 30,000.

Of interest to tour participants is Red Deer's annual International Folk Festival involving every ethnic group in Central Alberta. This cultural extravaganza emphasizes the preservation of traditional values and encourages further development of cultural heritage in Alberta.

138.6 (86.6) TREED SAND DUNES.

140.3 (87.7) JUNCTION HIGHWAY 2A. Visitor service area at south end of Red Deer. Southern limit of naturally-occurring white spruce on the Alberta Plains.

PENHOLD, the site of a former airforce base, is now the Red Deer airport. The Alberta Research Council centre for hail suppression studies is located here.

159.8 (99.9) POINT OF INTEREST SIGN. Anthony Henday, the first white man to view the Rocky Mountains, saw them from about this point in 1754.

164.3 (102.7) INNISFAIL. Town named after Innisfail, Ireland. A lamb processing plant and the Hereford test centre are located here.

174.1 (108.8) NATURAL GAS PROCESSING PLANT.

176.3 (110.2) BOWDEN. Village named after Bowden near Manchester, England.

The mounds and strings of soil in the ditches of the highway are the result of pocket gopher burrowing activities.

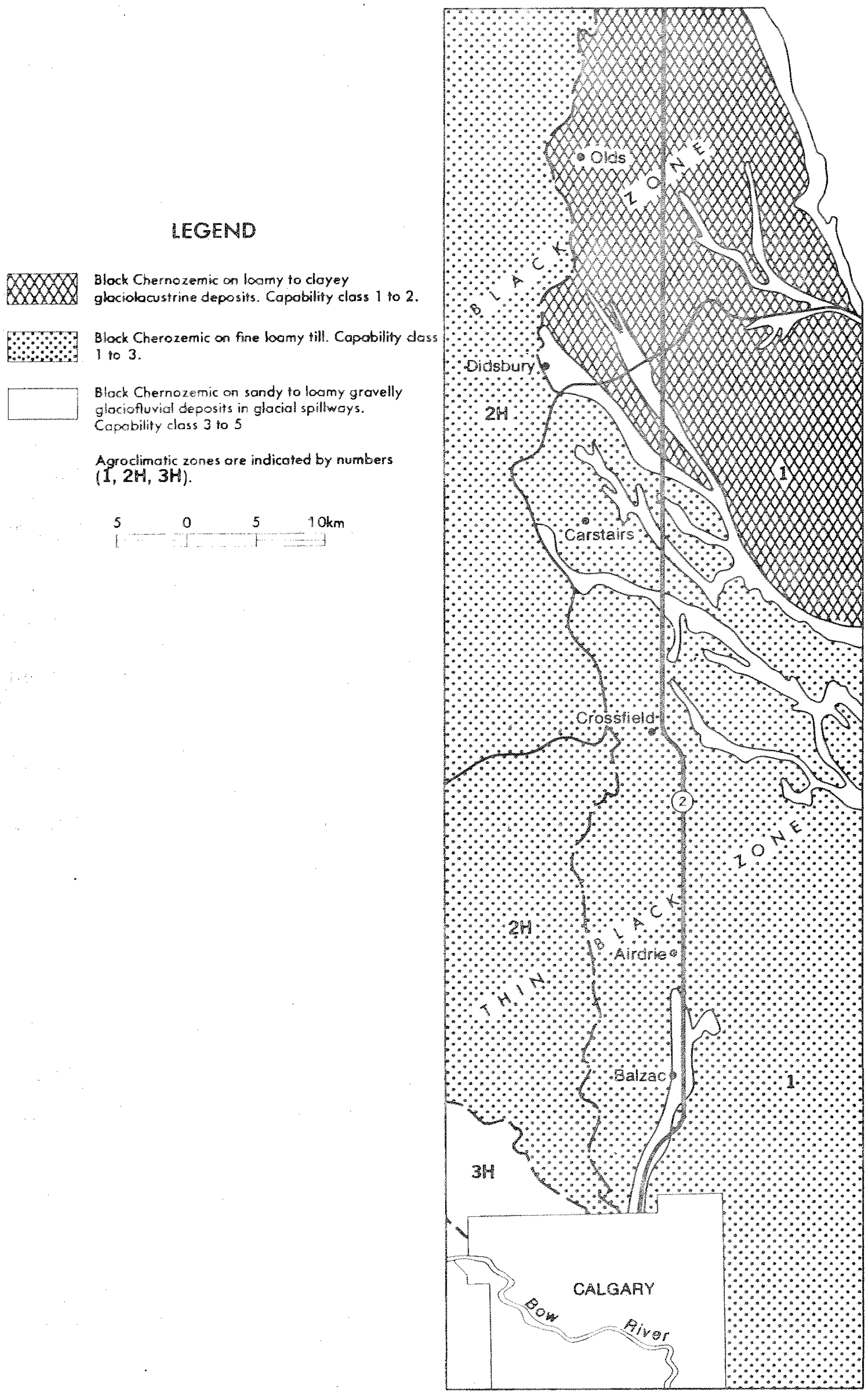


FIG. 20 GENERALIZED SOIL MAP—BOWDEN TO CALGARY

This is an area of mixed farming and dairying with beef cattle, and cereal grains produced. Average farm size is 200-320 ha (500-800 acres). Soils are Orthic Black Chernozemics (Figure 20), with an Agricultural capability rating of 1. This is the highest yielding area for cereals in Alberta. The average yield of wheat, oats, and barley obtained on these soils are:

Crop	Yield	
	kg/ha	Bu/ac
Wheat	2,900	43.1
Oats	2,650	69.6
Barley	2,680	49.8

192 (119.9) JUNCTION with Highway 27 to Olds, a town named after George Olds, a Canadian Pacific Railway traffic manager. Olds College is noted for its agricultural and vocational training. This is an area of mixed farming. The soils are Black Chernozemics developed in a thin loamy lacustrine blanket overlying till (Figure 20, Wyatt et al. 1943). These are friable, moderately calcareous soils that are very productive and have an Agricultural Capability rating of 1. The area is prone to severe hail storms.

213.3 (133.3) ROSEBUD RIVER.

217.3 (135.8) JUNCTION with road to Carstairs to the west.

221.9 (138.7) GRAVEL PITS. Sorted glaciofluvial materials were deposited in interglacial stream courses in this area.

224.6 (140.4) FERTILIZER DEMONSTRATION PLOTS set up by Western Co-operative Fertilizer Co. to demonstrate effects of fertilizer on forage crops.

233 (145.7) JUNCTION with road to Crossfield, a village to the west named after the chief surveyor of the Canadian Pacific Railway.

234 (146.2) POINT OF INTEREST SIGN. Millions of bison (commonly called buffalo) roamed the plains of North America until the white men killed them off in the late 1800's. The bison were a source of food, clothing, and shelter to the Plains Indians.

246.5 (154) AIRDRIE is a village named after Airdrie, Scotland.

256 (160) BALZAC is a hamlet named after Honore de Balzac, a noted French novelist. It is in the Nose Creek valley which was eroded into Tertiary-aged sandstones and shales. Although mixed farming is the main land use several people who work in Calgary have built country residences in this area. The soils of the general area are "Thin" Black Chernozemics (less than 15 cm Ah). They are rated as Agricultural Capability Class 1 soils. The average crop yields for 1966-74 are:

Crop	Yield	
	kg/ha	Bu/ac
Wheat	2,290	34.0
Oats	2,370	62.4
Barley	2,670	49.6

269 (168) CITY OF CALGARY (450,000 population)

Calgary ... a city with a wealth of history dating back over 100 years to 1875 ... the year when the first detachment of the Mounted Police 'F' Troop under Inspector Brisbois arrived at the junction of the Bow and Elbow Rivers. A year later, Colonel James Macleod named the small settlement Calgary, translated to mean 'preserved pasture of the harbour'.

Just prior to the winter of 1875-76, the I.G. Baker Company of Fort Benton, Montana, completed the Mounties' first fort here, and that, in effect was the beginning of today's city.

The 'Town' in 1881 consisted of the fort, two stores, the Commanding Officer's residence, one or two small churches and some tents. The population was 75. Spurred by the advent of the railway in 1883, thus establishing a permanent and reliable east/west trade link, Calgary's population reached 1,000 by 1884. The town of Calgary was incorporated November 17, 1884 and George Murdock, a harness maker, was elected as the first mayor.

Between 1875 and 1900, the population struggled to reach 4,000 residents. However, the early years of the Twentieth Century witnessed dramatic changes in Calgary. A million new settlers poured into Western Canada and finally, a large percentage of them were finding their way west as far as Calgary. A period of progress and expansion followed as oil and real estate reached a peak. The growth of city boundaries and the increase in population necessitated the installation of essential services.

1912 was the year of the first Calgary Stampede. A fast talking rodeo promoter, Guy Weadick, talked four of the district's leading cattlemen, A.E. Cross, Pat Burns, George Lane and A.J. McLean into backing an annual 'stampede' that has grown in size and stature to be known today as the 'World's Greatest Outdoor Show'.

Calgary surged forward in the next 50 years to become a vibrant community boasting of a population of nearly a half-million people with a total area reaching to 158 square miles. This growth can be attributed not only to the expansion in the oil, gas & cattle industry but also to the increasing diversification in Calgary's industrial growth.

This is Calgary -- a unique city combining friendliness, hospitality and a forecast of a bright future. A city with a history - young but full of dignity (Trudy Cotterall, City of Calgary Public Information).

Road Log No. 2: Calgary to Banff

Km (Mile)

0 (0) BOW RIVER near western edge of Calgary.

4.8 (3) JUNCTION with Happy Valley road. To the north lies the Bow Valley and the Pleistocene gravel terraces. Glaciolacustrine sediments of Glacial Lake Calgary blanket the low areas.

11.4 (7.1) ROCKY MOUNTAINS may be seen to the southwest. This is a prime forage production area. The soils are thin Black Chernozemics, mostly on glacial till.

Soils - Calgary to Kananaskis

Proceeding west from Calgary, the soils grade from Black Chernozemics to Gray Luvisols (Figure 21), elevation and tree cover increase, and the climate becomes cooler and more moist.

The Black Chernozemics in the Calgary-Cochrane area have Ah horizons of 5 to 15 cm thickness and are often called thin Blacks in contrast to the Blacks in the Edmonton-Lacombe area where Ah horizons are as much as 50 cm thick.

The trend to Dark Gray Chernozemic, Dark Gray Luvisol, and Gray Luvisol is indicative of increasing eluviation associated with forest vegetation and increasing net downward movement of moisture.

The soils of the area were mapped at a reconnaissance level in the 1940's (Blackfoot-Calgary and Rosebud-Banff sheets).

The Cochrane Ranch

The Cochrane Ranch, one of the first in Alberta, belonged to the large ranch era of the late 1800's. Senator Matthew Henry Cochrane of Compton, Quebec, headed the Cochrane Ranche Company incorporated May 14, 1881, which received a land grant of 43,600 ha in the Bow Valley area between Calgary and Cochrane. The ranch headquarters were established 2 km west of Cochrane. That fall 4,000 head of cattle were purchased in Montana and driven in haste to Calgary to arrive before the snow. About 60% of the cattle survived the drive. By the fall of 1882 the herds had been increased to 12,000 head but a very severe winter, with deep snow and cold temperatures, reduced the herd to 4,000 in the spring. Poor management, due to a lack of understanding by the absentee owners and poor communication between Cochrane and Quebec, continued to cause problems. The ranch split its holdings, attempting sheep and then horse ranching, but failed. By 1894 the ranch ceased to exist.

20.1 (12.5) COCHRANE is a small town to the north servicing the farming and ranching area.

23.2 (14.5) ROCKY MOUNTAIN FOOTHILLS geological province begins here. Notice the northwest-southeast trending bedrock ridges formed by west-dipping thrust plates of Cretaceous-aged sandstone. Note the prairie Grasslands give way to Montane Parkland. Shrubby cinquefoil, willow, and dwarf aspen are common with occasional white spruce and a few limber pine on the ridges.

25.4 (15.9) BRIDGE OVER JUMPING POUND CREEK. The name of the creek was derived from the former Indian practice of hunting Buffalo by chasing them over steep banks.

29.1 (18.2) SANDSTONE RIDGE with meteorological station on west side to monitor chinook winds (warm, dry Pacific air that crosses the mountains periodically).

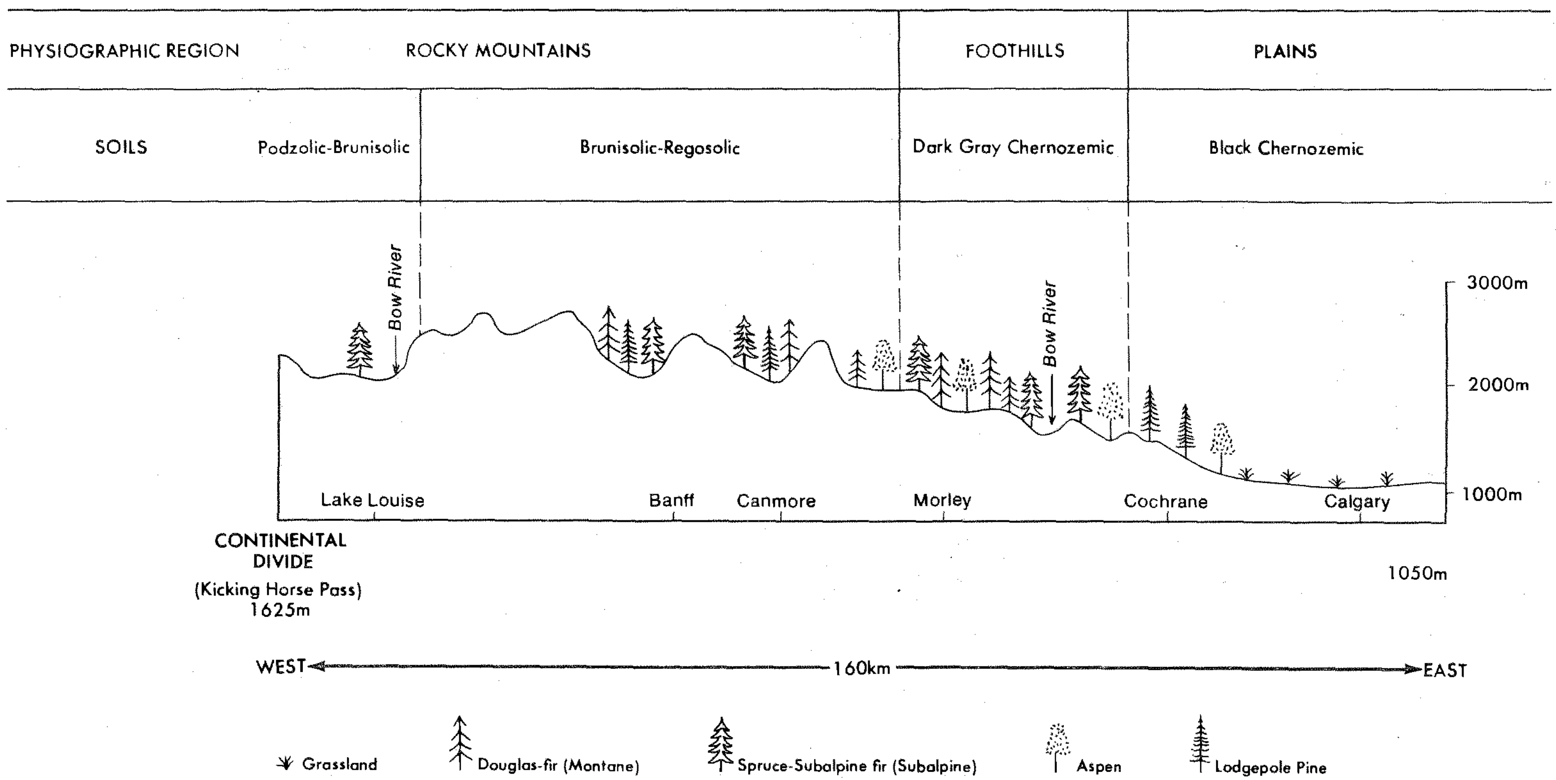


FIG. 21 CONCEPTUAL CROSS-SECTION SHOWING GENERALIZED PHYSIOGRAPHY AND SOILS FROM THE CONTINENTAL DIVIDE TO CALGARY

30.6 (19.1) JUMPING POUND GASFIELD and gasplant to the north. This field was discovered by the Shell Oil Company in 1944. Gas is trapped at 1,650-2,100 m below sea level in Mississippian-aged strata.

39.4 (24.6) LIVINGSTONE RIDGE service station.

40.2 (25.1) STONY INDIAN RESERVE. The Stony, or Mountain Assiniboine Indians live on this reserve which was established in 1879.

45.1 (28.2) DRUMLINS. The ridges on both sides of the highway are drumlins, partially buried by glaciofluvial gravels. Notice the gently graded up-valley slope of the cigar-shaped drumlin (the direction the glacier came from) and the steeply graded lee slope. The effect of aspect on vegetation is evident; white spruce grows on the shaded north-facing slopes while grasses and juniper occupy the warmer, drier south-facing slopes.

48.4 (30.2) JUNCTION with Chinequay Lakes - Morley road. George McDougall, a Methodist Missionary, established a mission in 1872 on the north side of the Bow River near Morley. The church built in 1875 was used until 1921 and has recently been restored. Reverend George McDougall froze to death in a blizzard in 1876 but the mission was continued by his son.

57.8 (36.1) POINT OF INTEREST SIGN. Peagan Post, later called Old Bow Fort, was built in 1832 by the Hudson's Bay Company on the Bow River north of here to lure fur trade away from the American Fur Company. Difficulties with the Indians forced its closure in 1834.

61.3 (38.3) JUNCTION with Kananaskis road. The tour leaves the Trans Canada Highway for a 6 km trip south to the Kananaskis Forest Experiment Station, and the first soil pit.

Kananaskis Site: Orthic Eutric Brunisol

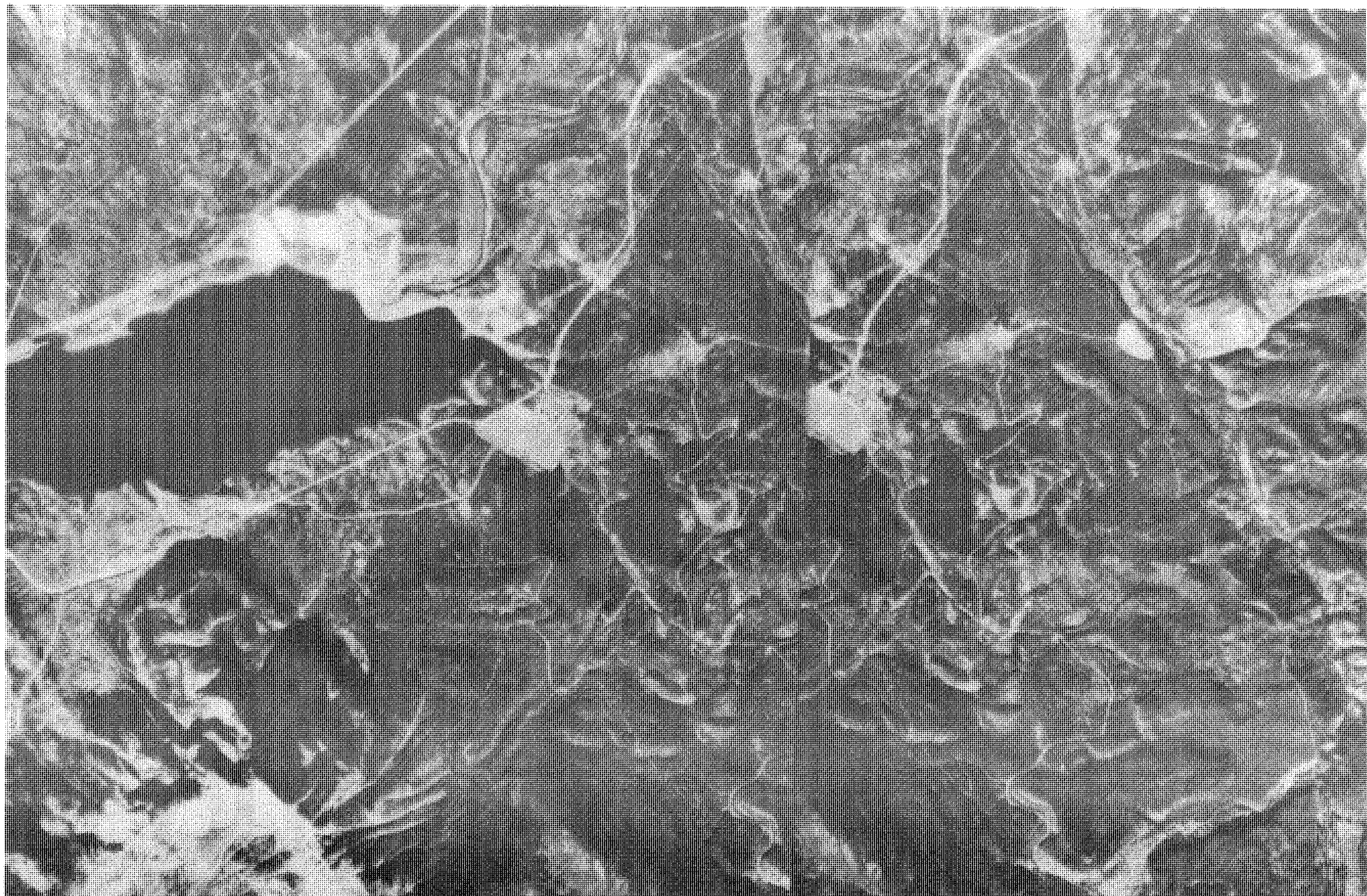
This soil is developed in a blanket of glaciofluvial sediments overlying morainal deposits (Figure 22). The soil pit is a feature stop on the nature trail built and maintained by the Canadian Forestry Service. For site specific data concerning the soil, vegetation, and climate refer to Appendix C.

There will be a barbeque dinner at the Forest Experiment Station at approximately 1700 hours. Returning to the Trans Canada Highway the Log continues.

61.3 (38.3) JUNCTION of Kananaskis Road and Trans Canada Highway.

64.5 (40.3) BRIDGE over Kananaskis River. The river was named by Captain John Palliser in 1858. This is the western boundary of the Stony Indian Reserve. A group of Hudson's Bay Company fur traders led by James Gaddy were probably the first white men in this area. They wintered at the junction of the Kananaskis and Bow Rivers in 1787-88.

65.3 (40.8) JUNCTION with Bow Valley Provincial Park - Seebe road is located on the terminal moraine of a readvance of the valley glacier. There are several kames, eskers, and crevasse fillings between the highway and the Bow River to the north (Rutter 1972). A thin veneer of loess covers much of the area.



Courtesy of Alberta Government

FIG. 22 Stereogram of the Kananaskis area. Soil pit location marked with *. (Alberta Govt. Photos AS831, 157-158)

Orthic Regosols are common on the very gravelly materials, with Ck (free lime) horizons to the surface. Weak Brunisolic profiles, with thin Ah and Bm horizons, have developed in the loess veneers and sands.

69.0 (43.1) MCCONNELL THRUST FAULT - marks the division of the mountains to the west and the foothills to the east. Paleozoic limestones have been thrust over the Mesozoic sandstones and shales. The horizontal displacement in this area is in excess of 8 km. The fault is named after R.G. McConnell, a geologist of the Geological Survey of Canada, who identified and mapped the fault in 1887 (McConnell 1887). This fault zone can be traced continuously for 320 km.

Mount Yamnuska, across the Bow Valley, is made up of Cambrian carbonates carried on the McConnell thrust fault over Cretaceous sandstones.

69.5 (43.5) POINT OF INTEREST SIGN. Fossil Reefs. Devonian-aged coral reefs, such as the one exposed in the mountain opposite, are the source of most of Alberta's oil and natural gas.

74.2 (46.4) LAC DES ARCS - The road is built on a fill across the lake.

75.8 (47.4) POINT OF INTEREST SIGN. Mountain of Limestone. Limestone mining supports two industries at Exshaw. Canada Cement has quarried nearly pure (98.8% $CaCO_3$) limestone from Exshaw Mountain since 1912, to use in production of cement. High silica - low aluminum sandstone from east of here is another constituent of the cement. Loder's Lime Plant, just down the valley, also quarries lime to produce pulverized lime, chicken grits, hydrated lime (drilling mud), and hot lime (steel flux).

81.1 (50.7) JUNCTION - access to service centre.

Glaciation

Most of Canada was glaciated during Pleistocene times, with the last major ice masses disappearing about 10,000 years ago. Several alpine glaciers still exist at high elevations in the Cordilleran region, some of which will be seen on this tour.

Glaciers erode, transport and redeposit materials. Unsorted material deposited directly by the ice, either beneath or marginal to the glacier, is called till. Running water, associated with glacier melt, deposits sorted materials (such as sands and gravels) beneath, within, and beyond the glacier; these are called glaciofluvial deposits. Much of the Bow Valley is partially filled with gravelly glaciofluvial material, deposited as outwash from the valley glacier.

Much of the present morphology of the Rocky Mountains is attributable to glacial action (Figure 23). Mountain peaks and ridges are sculpted by glacial erosion and the valleys are deepened, rounded, and partially filled by glacial erosion and deposits.

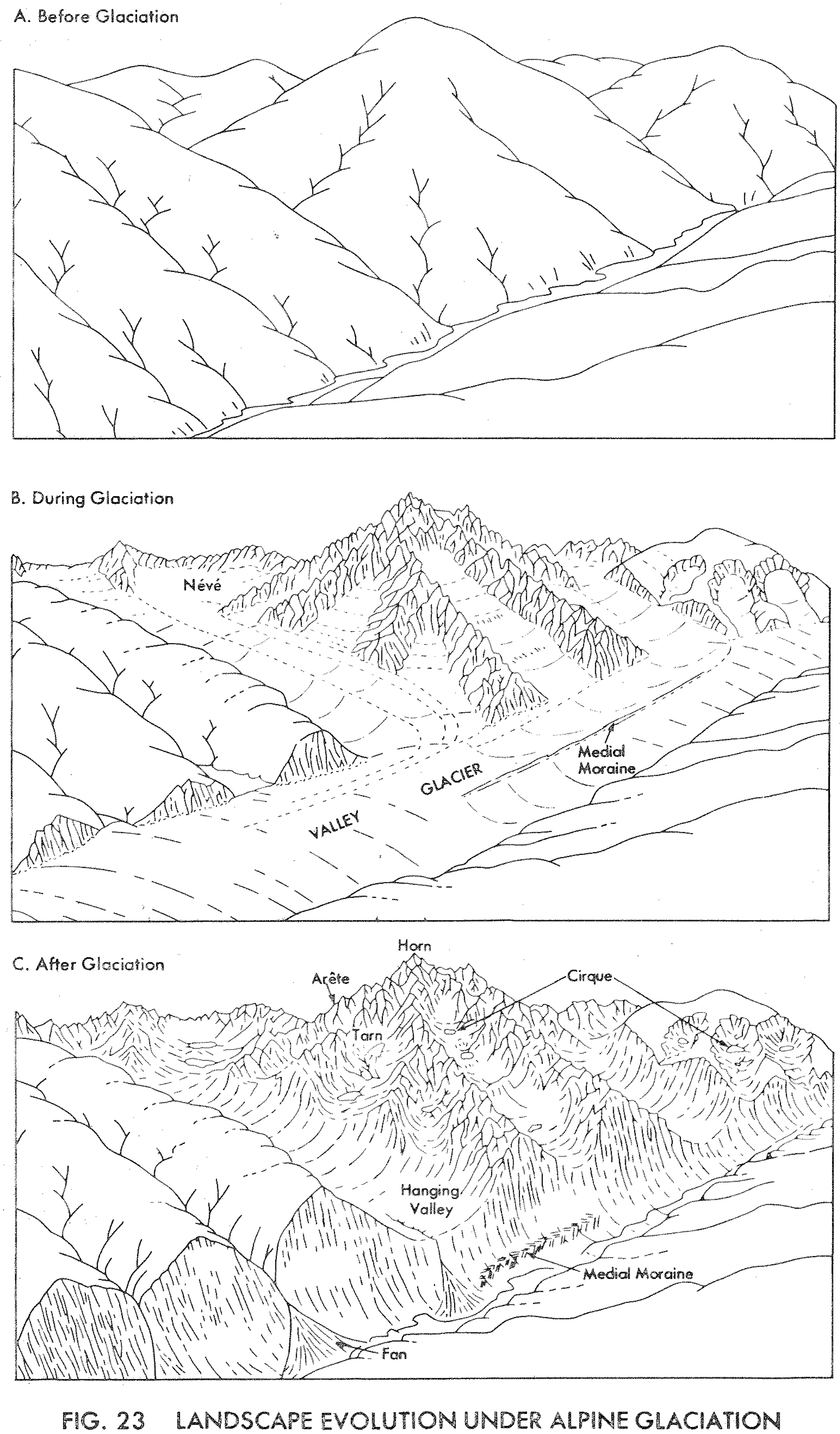


FIG. 23 LANDSCAPE EVOLUTION UNDER ALPINE GLACIATION
(Adapted from Strahler, A.N. (1960) Physical Geography
J. Wiley & Sons, New York)

85.6 (53.6) CANMORE MINES (established 1886) extend to the north west. Lower Cretaceous and Jurassic coal is mined by underground and surface operations.

86.6 (54.2) BOW RIVER. The Bow Valley at this point runs parallel to the strike of the bedrock and is eroded into the soft Cretaceous and Jurassic sandstones and shales. The valley was partially filled with glacial till and outwash, much of which has since eroded as the stream incised (Figure 24). Regosolic and Gleysolic soils are found under white spruce, dwarf birch, lodgepole pine and willow communities on the fluvial floodplain, and fans in the valley bottom. Orthic Eutric Brunisols developed under open Douglas-fir and lodgepole pine associations on the slopes and terraces along the southwest-facing valley sides. Orthic Gray Luvisols are found under white spruce and lodgepole pine communities on the cooler, more moist northeast-facing valley sides (Figure 23).

91.4 (57.1) JUNCTION with access road to Canmore. The town of Canmore was originally a coal mining community but is developing recently as a visitor service centre and residential suburb of Banff.

94.3 (59.0) JUNCTION with access to Harvie Heights, a residential development.

96.4 (60.2) BANFF NATIONAL PARK east gate.
Note: Collecting of soils, rocks, plants and animals is not permitted in national parks without a permit. Wapiti, black bear, coyote and mule deer are common animals in this area.

98.8 (61.7) CARROT CREEK. A large, gravelly, fluvial fan has formed where the steeply-graded Carrot Creek meets the Bow Valley.

104.3 (65.1) "HOODOOS" - Columns resulting from differential erosion of, in this case, glaciofluvial materials occur to the right.

105.7 (66.0) JUNCTION with Lake Minnewanka road

106.2 (66.4) CASCADE HYDRO PLANT. This is a Calgary Power Hydro electric plant with a head of 110 m and an output of 46,000 horsepower.

108.5 (67.8) CASCADE RIVER. Cascade Mountain ahead.

109.1 (68.3) TRAFFIC CIRCLE

111.0 (69.4) BISON PADDOCK

113.3 (70.7) JUNCTION with access road to Banff. Turn into the town of Banff.

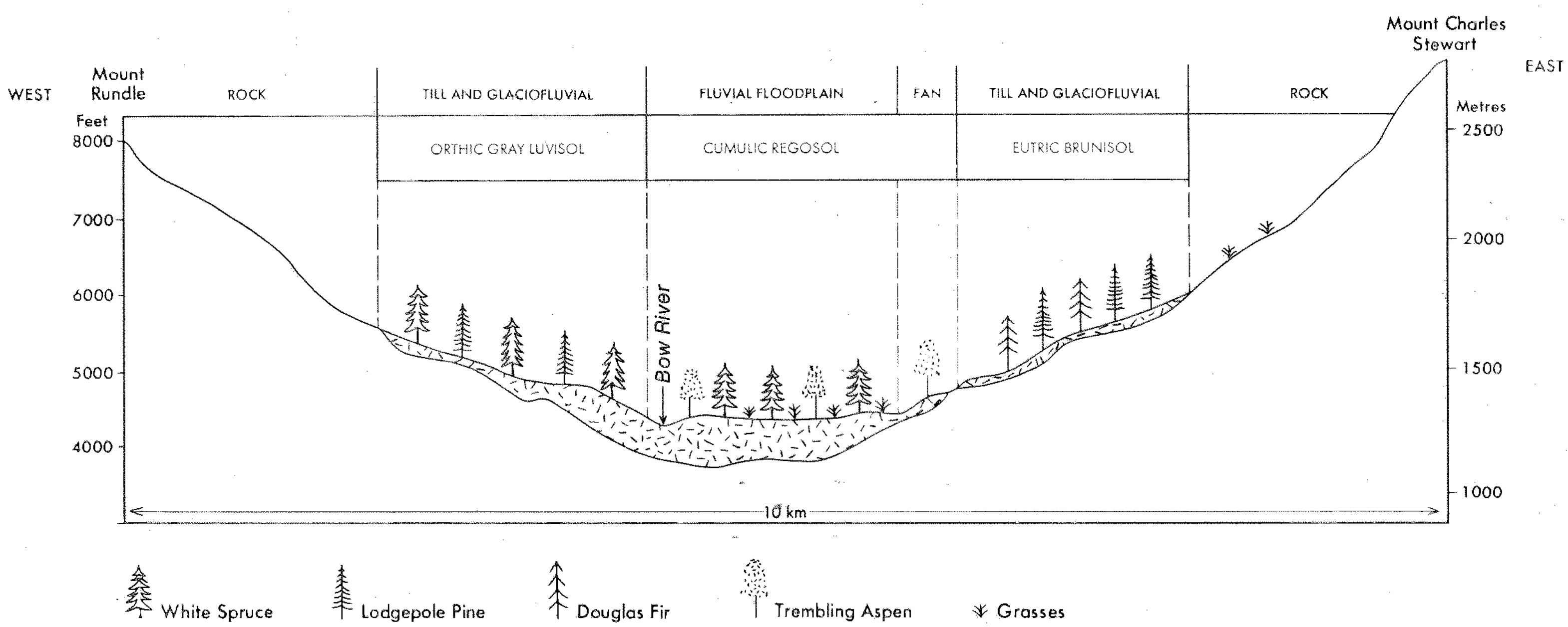


FIG. 24 CONCEPTUAL CROSS-SECTION OF THE GENERALIZED LANDFORMS AND SOILS OF THE BOW VALLEY AT CANMORE

Canada's National Parks

There are 28 national parks in Canada, covering approximately 130,000 km^2 (Figure 25). These parks represent sea shores, prairies, boreal forests, arctic islands, and mountains. Banff and Jasper National Parks are two of five parks in the Rocky Mountains.

Banff National Park covers an area of 6,500 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 Icefield, Maligne Lake, and several waterfalls.

Section 4 of the National Parks Act of 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 and public pressure is being directed to encourage non-facility oriented recreation.

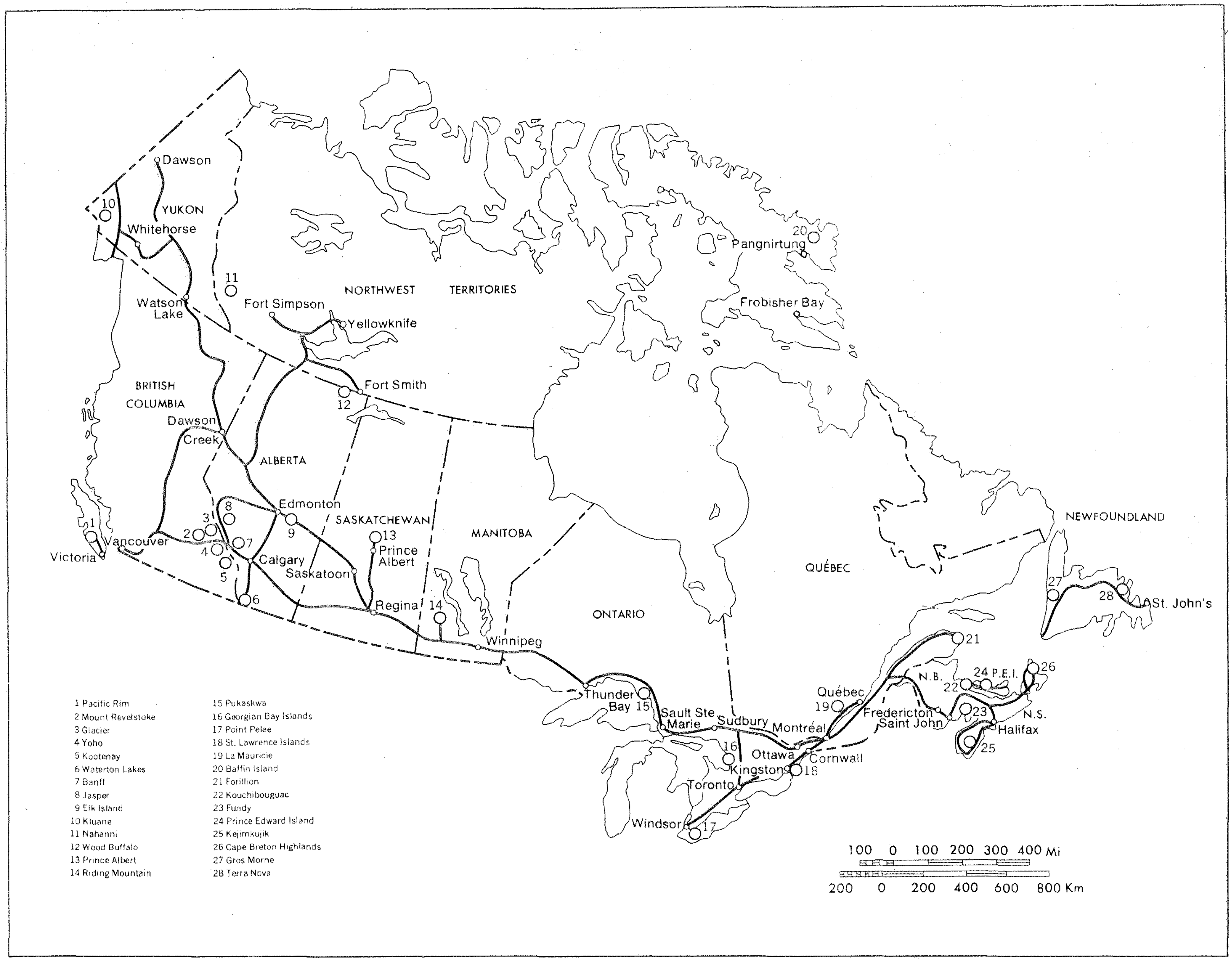


FIG. 25 CANADA'S NATIONAL PARKS

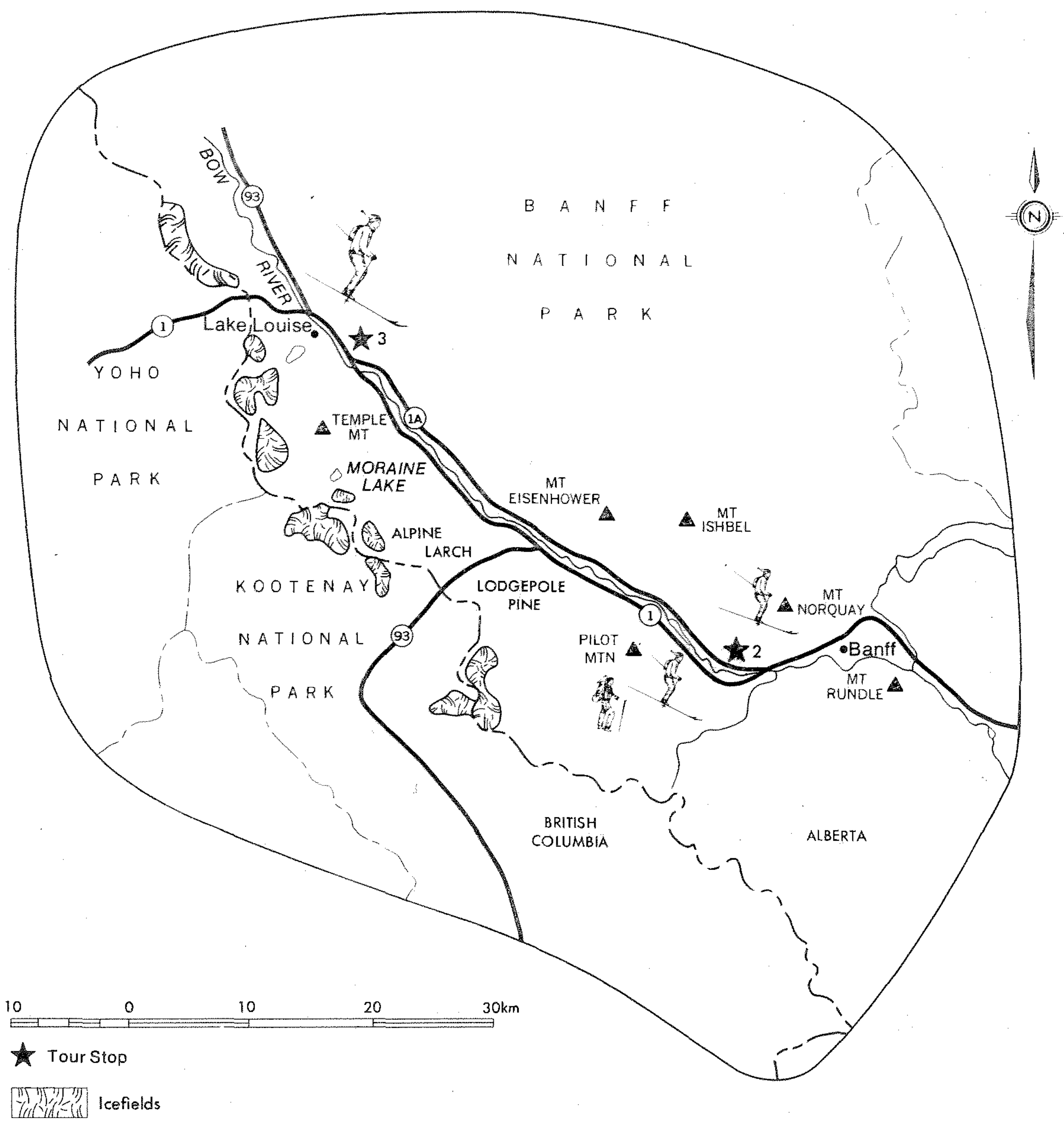
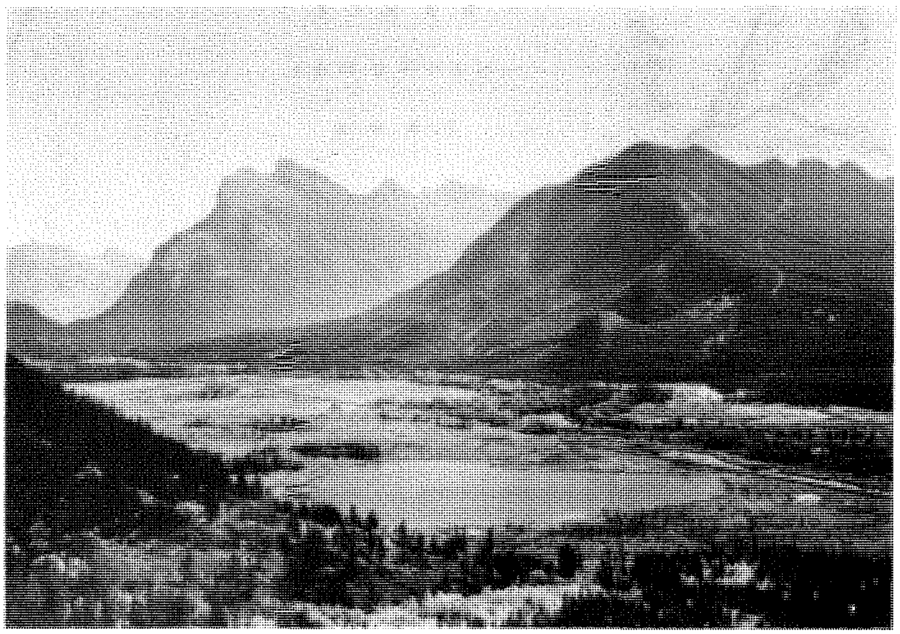


FIG. 26 BANFF TO LAKE LOUISE ROUTE MAP



Photograph by B. Walker

FIG. 27 Montane zone aspen and meadow communities occur in the Bow Valley immediately above Banff. Organic and Gleysolic soils occur on the floodplain of the Bow River. Subalpine fir and spruce stands can be seen on Sulphur Mountain (right) and Rundle Mountain (center)

DAY 2: BANFF AND LAKE LOUISE

The tour heads west, up the Bow Valley along Highway 1A, stopping for two soil pits (Figure 26). The soils are representative of the Brunisolic and Luvisolic soils of the Bow Valley. The tour includes visits to Lake Louise and Moraine Lake to examine the aesthetic qualities of these famous areas before returning to Banff.

Road Log No. 3: Banff to Lake Louise and Return

Km (Mile)

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

1.8 (1.1) 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 95 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.

3.0 (1.9) VERMILION LAKES LOOKOUT. To the left, on the flood-plain of the Bow River, is an area of Organic soils (Figure 27). There are few areas of Organic soils in the front and main ranges of the Rockies, and these are usually quite small. The example here is one of the largest in Banff Park (Figure 27).

5.6 (3.5) JUNCTION with Highway 1A. Leave Trans-Canada Highway and turn north onto Highway 1A.

For the next 30 km the tour route will be traversing the lower slopes of the Sawback Range. 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 Regosolic.

6.4 (4.0) GLEYSOLS. To the left 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 limited areal extent. Note as well to the left, road cuts displaying the shallow profile development typical of much of this part of the Park.

Muleshoe Site: Eluviated Eutric Brunisol

11.0 (6.9) This weakly developed soil is located on a medium textured fluvial fan derived from highly calcareous bedrock (Figure 29). 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. Refer to Appendix C for site data.

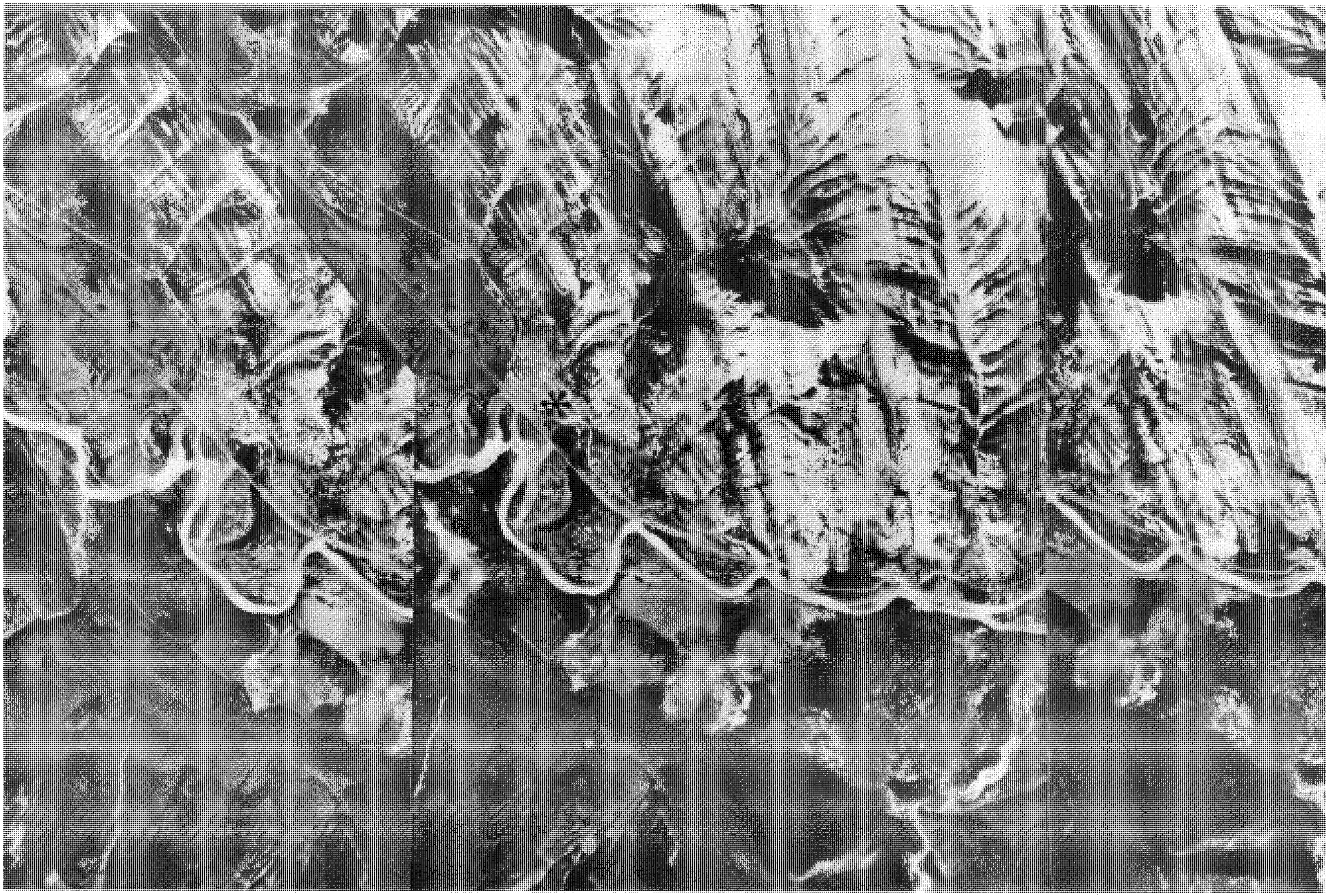


FIG. 28 Stereogram of the Muleshoe area. Soil pit location marked with *. (Alberta Govt. Photos AS167, 159-161)

14.8 (9.3) EXPERIMENTAL RANGE PLOT on the left. This exclosure shows the marked increased growth in trees and shrubs when they are protected from browsing ungulates.

16.5 (10.3) 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.

17.5 (10.9) SPRUCE in middle of road. When the road was widened in the 1930's this majestic white spruce was saved. It provides an example of the kind of vegetation that might flourish if the area was protected from fire for a long period.

18.5 (11.5) TRANSITION from Montane to Subalpine vegetation zones. Elevation is about 1,410 m. We have just passed through several km of Douglas-fir (on the dry exposed sites) and trembling aspen. We will progress into spruce-subalpine fir stands as we approach Lake Louise. Lodgepole pine is very common throughout both zones.

19.0 (11.9) LANDSLIDE. The hummocky terrain over which we are driving 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 slump can be seen with better perspective between km 100 and 103 on the way back to Banff.

23.5 (14.7) 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. 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.

24.5 (15.3) WILDLIFE EXCLOSURE to the left 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. 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 high levels of oxygen in the water prevent reducing conditions.

28.7 (17.9) SILVER CITY. Between 1883 and 1885 up to 2,000 residents lived in a shanty town on this location. They came to get rich by mining copper and lead (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.

29.8 (18.6) 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 apart by horseback.

29.9 (18.7) EISENHOWER JUNCTION. The castellate peaks of Mount Eisenhower (2,770 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 north-west.

For the next several km we will be traversing fluted moraines. The till deposits at the base of the valley walls are wider and thicker. Here the Bow Valley turns to run parallel to the main ranges rather than cutting through them.

38.0 (23.8) TILL. An exposure on the right reveals the calcareous, stony, silt loam till characteristic of the Bow Valley.
On the left is a panoramic view of the Bow Valley showing the floodplain, terraces, dissected fluted moraines, fluvial fans and inclined moraines as depicted in Figure 29.

41.2 (25.8) PROTECTION MOUNTAIN FAN. An example of a large gently sloping calcareous fluvial fan. The central part of this fan is characterized by Regosols and the margins by Brunisols.

42.8 (26.8) 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).

44.9 (28.0) TERRACE. For the next few km we will be travelling over fluvial terrace materials deposited during the waning of the last glaciation. The weakly developed Brunisolic soils have an intermittent Ae (Albic) horizon. Well rounded gravels and cobbles constitute a major portion of the solum.

51.8 (32.4) MOUNT TEMPLE (3,540 m) to the left, the third highest peak in Banff Park. It is a popular climb for hiking enthusiasts.

Corral Creek Site: Brunisolic Gray Luvisol

53.6 (33.5) This soil is developed in calcareous, medium textured till and in the overlying silty deposit. These soils cover an extensive portion of the Bow Valley (Figure 30). Refer to Appendix C for site data.

54.1 (33.9) PROTEROZOIC ROCKS exposed here are some of the oldest in the park and were deposited as sediments about 600 million years ago.

54.6 (34.2) JUNCTION of Highway 1A and the Trans-Canada Highway near Lake Louise.

55.0 (34.4) JUNCTION. Leave Trans-Canada Highway and travel to Lake Louise via Highway 1A.

57.1 (35.7) VILLAGE OF LAKE LOUISE to the right provides accommodation for tourists in the summer and skiers in the winter. The ski slopes are located to the east. The steep bank along the road is cut in the dense calcareous tills associated with the Bow Valley. Groundwater recharge near the treeline and discharge in the lower slopes makes slopes similar to the one on which we are

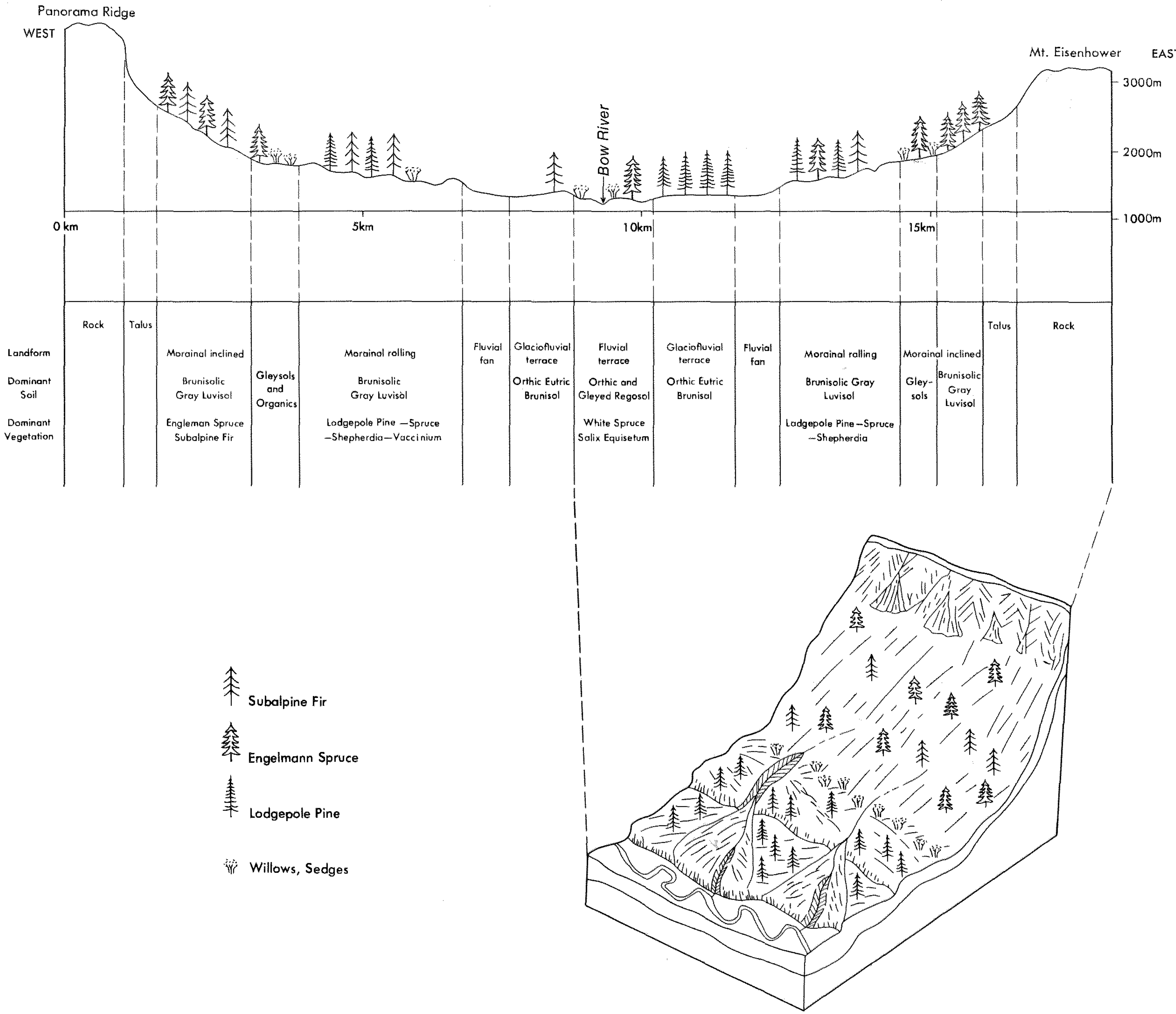


FIG. 29 CONCEPTUAL CROSS-SECTION OF THE GENERALIZED LANDFORMS AND SOILS OF THE BOW VALLEY AT BAKER CREEK.

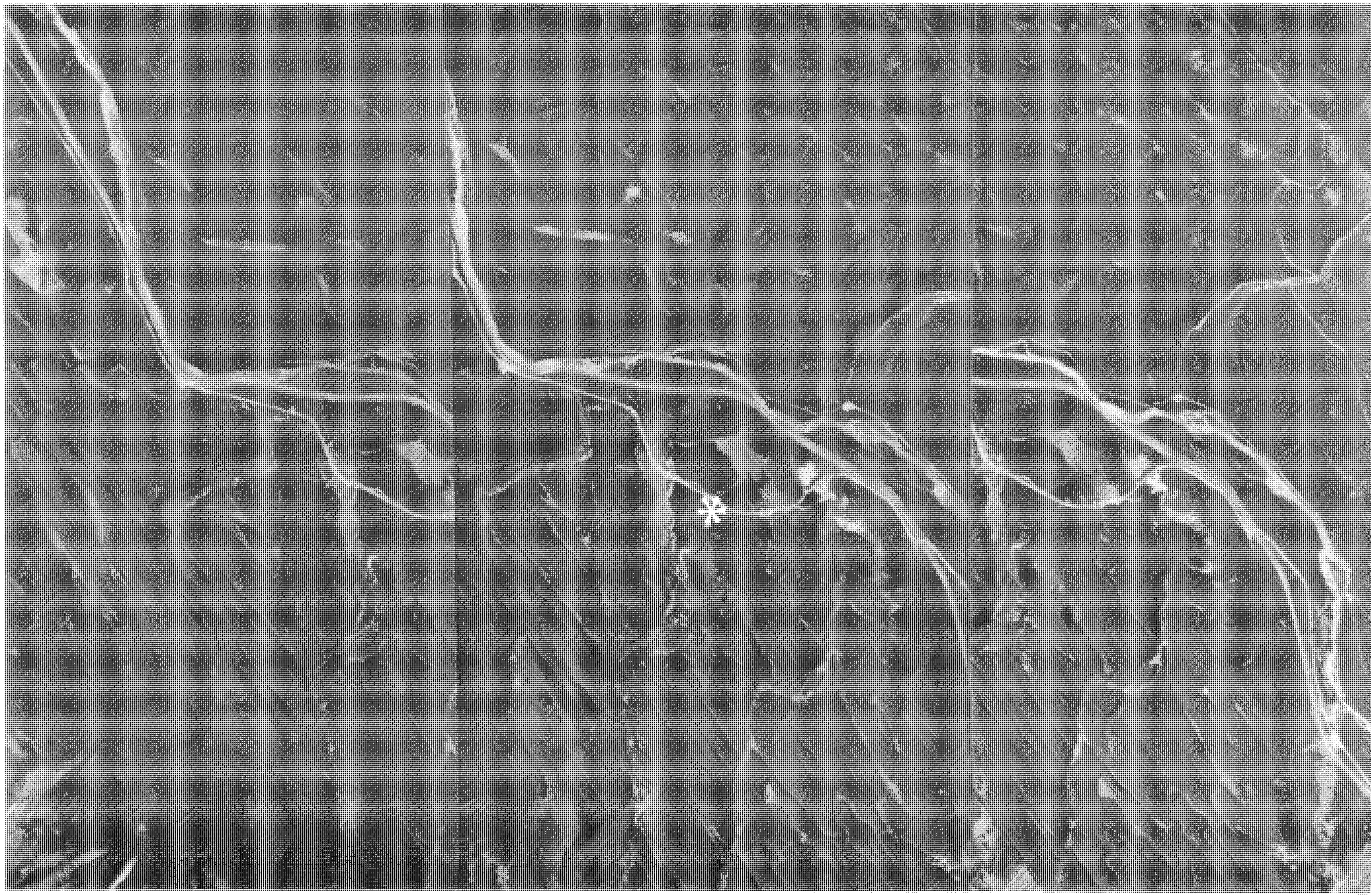


FIG. 30 Stereogram of the Corral Creek area. Soil pit location is marked with *. (Alberta Govt. Photos AS165, 228-230)

driving unstable. Healed scars of small slumps and earth flows provide evidence of instability. Care and constant maintenance is required when these slopes are oversteepened to construct a road. In their resource inventory program the Parks hope to be able to identify these potential problem areas and plan future developments wisely.

60.5 (37.8) JUNCTION. Leave Highway 1A for a short drive to Lake Louise. Here the pine forest, typical of much of the valley bottom, gives way to spruce-subalpine fir forest. Elevation is about 1,700 m.

61.1 (38.3) LAKE LOUISE - Elevation 1,730 m.

63.2 (39.5) MORAINE LAKE (a round trip of about 25 km to the southwest) is a spectacular small mountain lake set before a backdrop of glaciated summits called The Wenkchemna Peaks (Wenkchemna is the Stony Indian word for ten, hence the Valley of the Ten Peaks). Hiking trails starting at the lake provide access to alpine meadows, glaciers, and high mountain passes.

Km

67.6 (42.3) TRANS CANADA HIGHWAY. We have returned to the Trans Canada Highway and will follow it to Banff. After crossing the Bow River we will be driving along the margin of the same fluvial terrace mentioned at km 44.9. — 54.4

74.0 (46.3) MORAINE CREEK. — 48.0

76.9 (48.0) ROCKSLIDES. To the east, on the lower slopes of Mount Eisenhower, can be seen examples of rockslides. Between the two visible scars is an older slide that is now revegetated. — 45.1

82.6 (51.6) TAYLOR CREEK. — 39.4

91.4 (57.0) JUNCTION with Highway 93 which proceeds southwest through Kootenay National Park for 100 km to Radium Hot Springs. — 30.6

92.4 (57.7) COPPER LAKE to the right is a small lake in a kettle within a hummocky moraine landform. — 29.6

93.8 (58.6) CASTLE MOUNTAIN FAULT. The valley between the castellate peaks of Mount Eisenhower and the jagged assymetric peaks of the Sawback Range separates the Main Ranges from the Front Ranges. — 28.2

94.9 (59.3) ICE CONTACT STRATIFIED DRIFT deposits such as the glaciofluvial gravels exposed in this cut are common occurrences, generally of limited areal extent, in the bottoms of the mountain valleys. — 27.1

100.4 (62.5) MOUNT EISENHOWER VIEWPOINT. The large boulder upon which the plaque is displayed is similar to many of the boulders which occur as strongly weathered remnants exposed in the road bank near km 19. You can see where the slump has been undercut by the Bow River leaving erosion banks. There is similar material on the west side of the river indicating that some slump material flowed across it. When the glacial ice occupied the Bow Valley it oversteepened many of the valley walls. When the lateral support for these steep faces was removed as the ice melted, weaker rocks, such as on the face above this slide, crumbled and flowed downslope (see Dishaw 1967 and Cruden 1976 for discussion of slides). — 21.6

		Km
101.4 (63.2)	REDEARTH CREEK. On this side of the valley the transition between subalpine and montane takes place over the next 10 km.	20.6
109.4 (68.3)	WOLVERINE CREEK. For the next 0.5 km or so there is a good view of the Sawback Range to the east. These parallel bedded layers of Mississippian and Upper Devonian rocks were uplifted and tilted to a high angle during the creation of the Rocky Mountains about 70 million years ago. Weathering of the nearly vertical strata resulted in a distinctive sawtooth-shaped mountain range.	12.6
110.9 (69.2)	SULPHUR MOUNTAIN is to the east, just south of Banff townsite. The observatory at the top of the switchback road was built in 1902 to record weather statistics and other high altitude phenomena. The building is now operated by the University of Calgary as a geophysical research station.	11.1
113.1 (70.6)	JUNCTION with road to the Sunshine area where excellent skiing is provided for about 6 months of the year.	8.9
116.0 (72.4)	BRIDGE over the Bow River and the Canadian Pacific Railway.	6.0
120.9 (75.5)	BANFF SPRINGS HOTEL can be seen on the far side of Banff townsite. It was built in 1888 by the Canadian Pacific Railway and enlarged on several occasions, the last addition being in 1928. This hotel was part of a program to promote the use of the recently completed railway. The Canadian Pacific Railway Company built several such hotels in the mountains as luxury accommodation for the use of people experiencing "the beautiful mountains and unclimbed peaks".	1.1
122.0 (76.2)	JUNCTION. Leave the Trans Canada Highway and proceed to accommodation in Banff.	0

DAY 3: BANFF TO JASPER

The first 55 km of Day 3 will be along the Trans-Canada Highway from Banff to Lake Louise (Figure 31). The last part of Road Log 3 can be read in the opposite direction (distances on the right) for this portion of the trip. 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. 4: Lake Louise to Jasper

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 Canadian Pacific Railway and the Trans-Canada Highway pass. The crest of the pass at 1,625 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 pass 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. This Range is the remnant of the west limb of the Bow River anticline. The centre of the anticline is approximately coincidental with the road for the first 25 km of the Icefields Parkway.

17.2 (10.7) HECTOR LAKE (1,740 m) and Mt. Hector (3,400 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 subalpine fir.

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

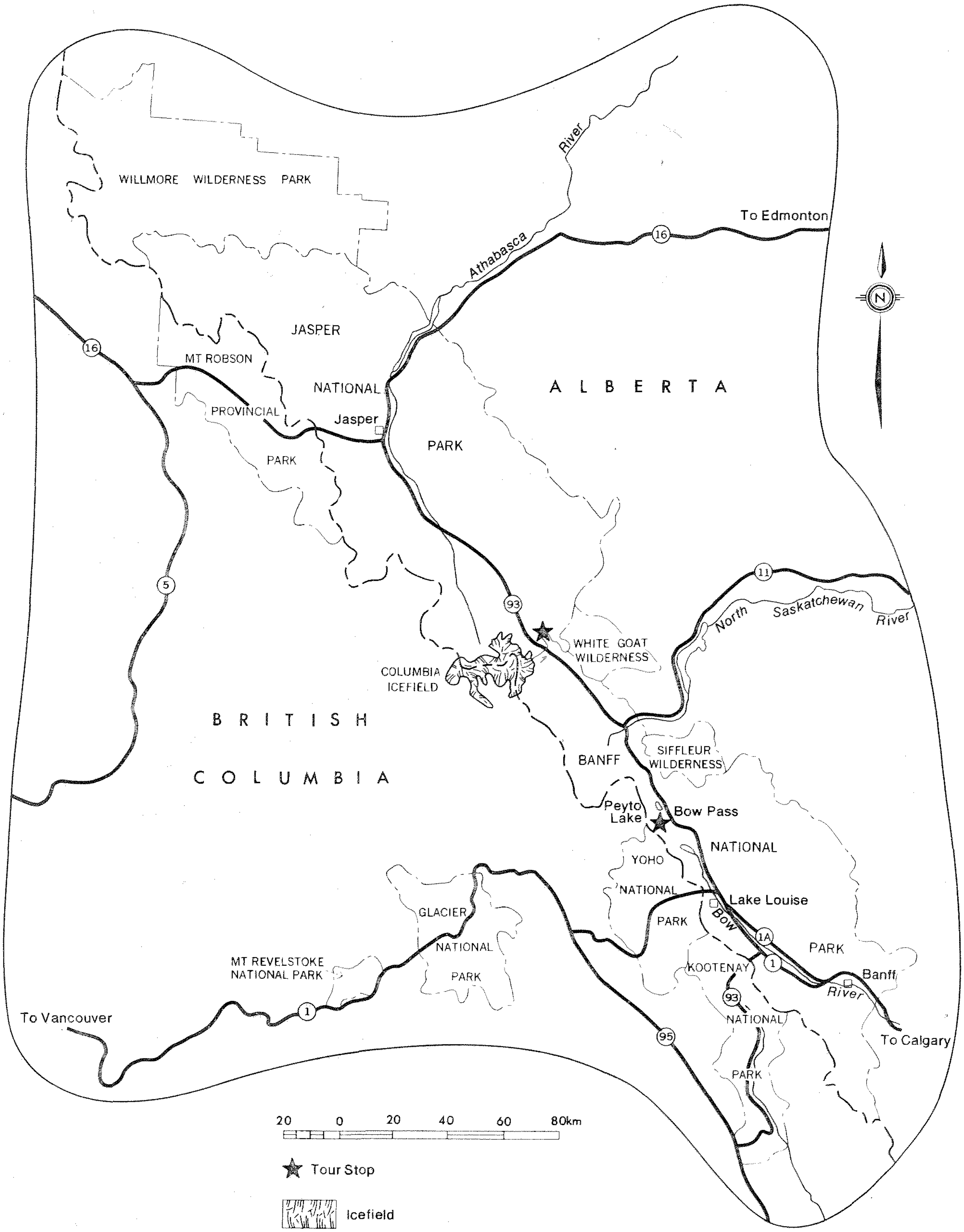


FIG. 31 BANFF TO JASPER ROUTE MAP

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 1,940 m. Vegetation is characterized by Engelmann spruce, subalpine fir and grouseberry (*Vaccinium scoparium*). 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 rational 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 (1,980 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 (2,070 m) (Figure 32).

Bow Pass Site: Humo-Ferric Podzol

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 33). If the snow has melted, an opportunity will be provided to examine a Podzolic (Spodosol) soil developed on calcareous till at 2,130 m. The few trees in the vicinity are mainly subalpine fir, while the main shrubs are white and pink heathers. Refer to Appendix C for site data.

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.

52.5 (32.8) SILVERHORN CREEK.

53.1 (33.2) BARBETTE GLACIER to the southwest.

56.8 (35.5) UPPER WATERFOWL LAKE (1,650 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) NOYSE CREEK.

58.7 (36.7) LOWER WATERFOWL LAKE. Mount Chephren (3,265 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 1970; 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.

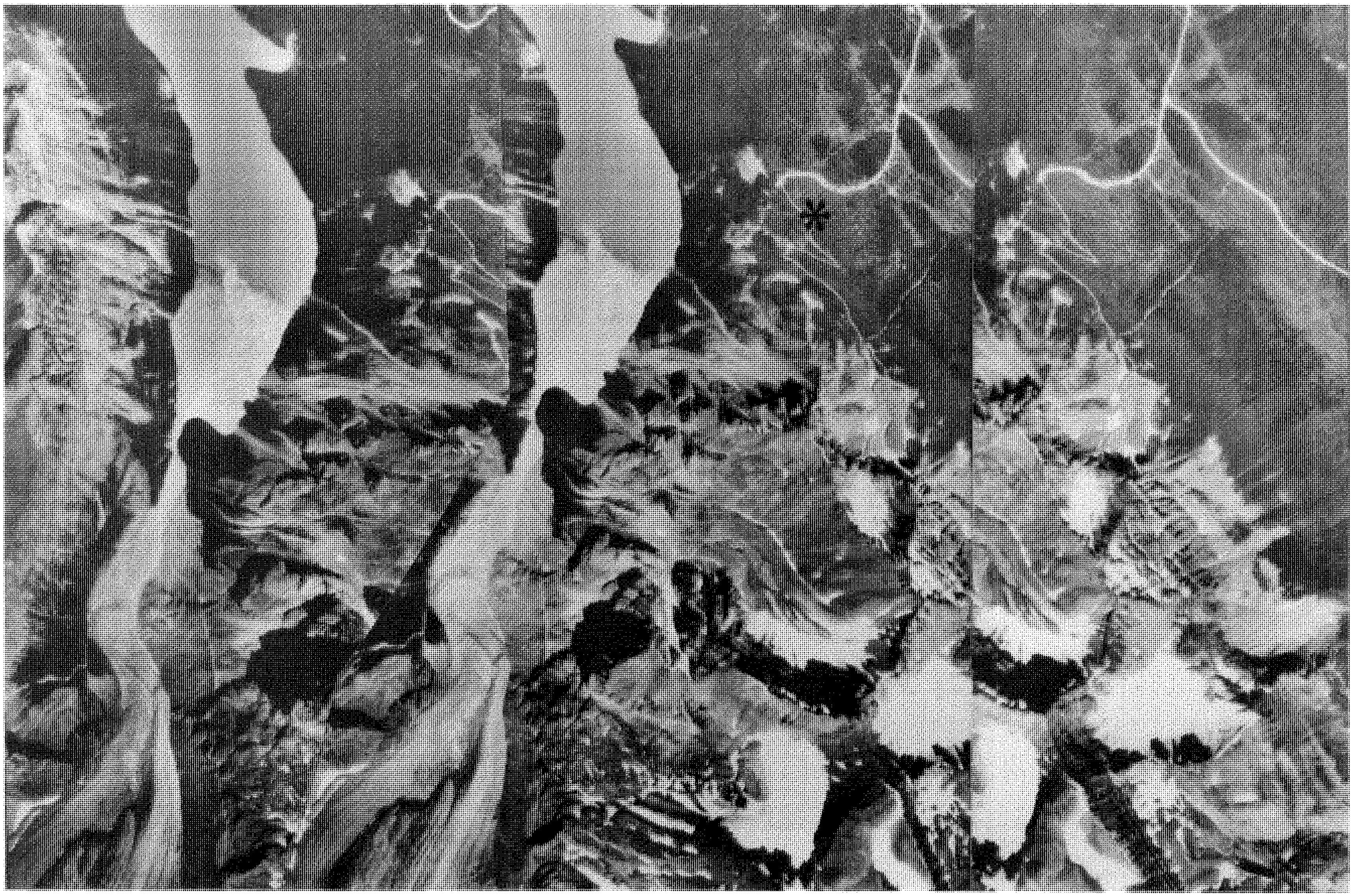
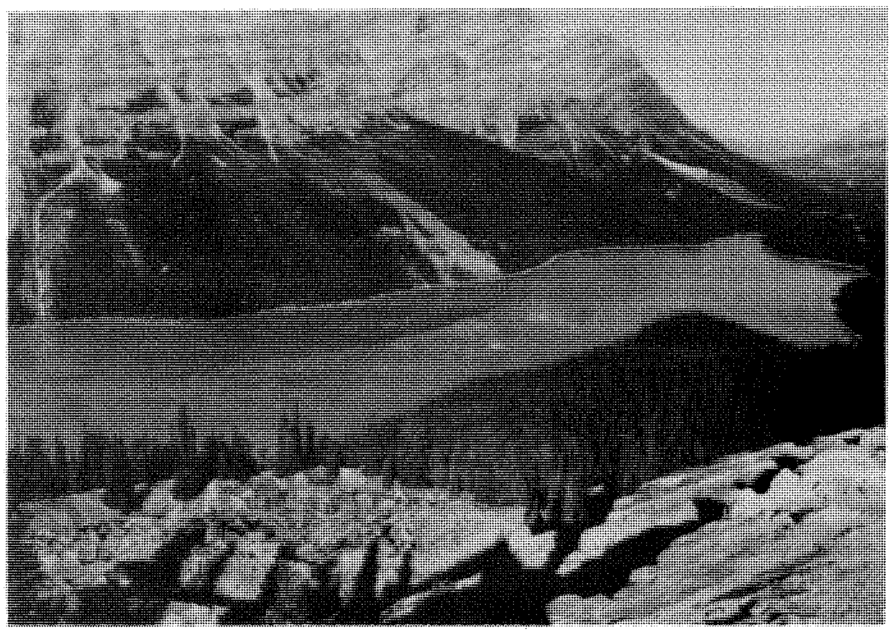


FIG. 32 Stereogram of the Bow Pass area. Soil pit location marked with *. (Alberta Govt. Photos AS162, 165-167)



Photography by G. Coen

FIG. 33 Peyto Lake was named after Bill Peyto, who guided and outfitted in the Banff area around 1900 Melt water from the Peyto Glacier is dammed by morainal deposits

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 spruce or fir 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 dryad communities. Warm sunny days, perhaps combined with thundershowers on the glaciers, periodically cause abrupt and large changes in the streamflow levels sweeping away the dryad 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.

Km (Mile)

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 (Entisols). Where there are abundant willows and deciduous shrubs, and avalanches are frequent enough to prevent subalpine 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 1,800 m, where infrequent avalanching allows the regeneration of subalpine 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 (2,000 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.

Columbia Icefield and Athabasca Glacier

The Columbia Icefield (Figure 34) which straddles the continental divide, has an average elevation of about 3,000 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

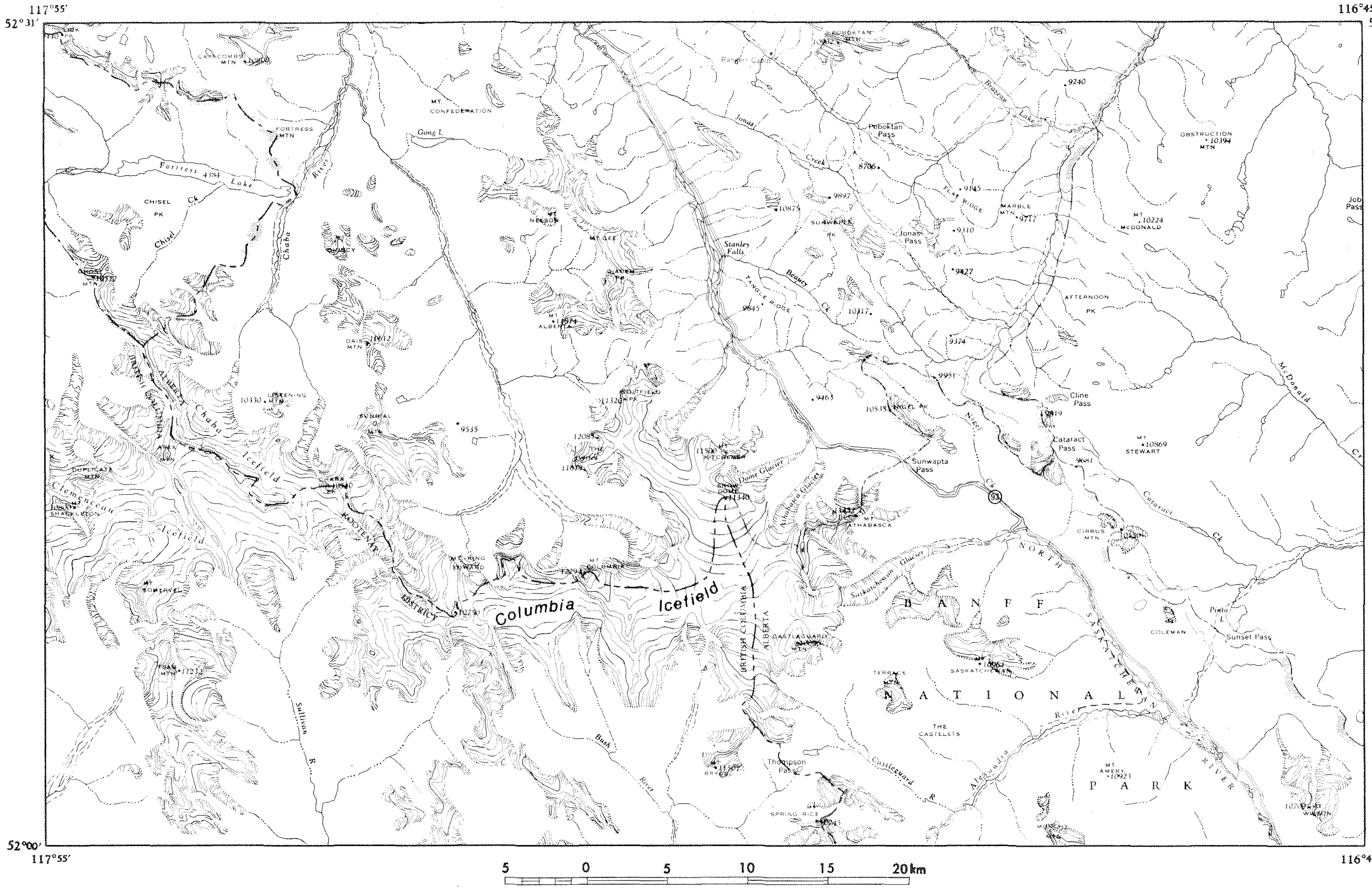


FIG. 34 The Columbia Icefield situated along the Continental Divide is a large snow and ice field with several outlet glaciers. There are several other icefields in the area

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 34).

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 2,600 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 (1,920 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 35). 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.

124.1 (77.6) SUNWAPTA PASS (2,030 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 36).

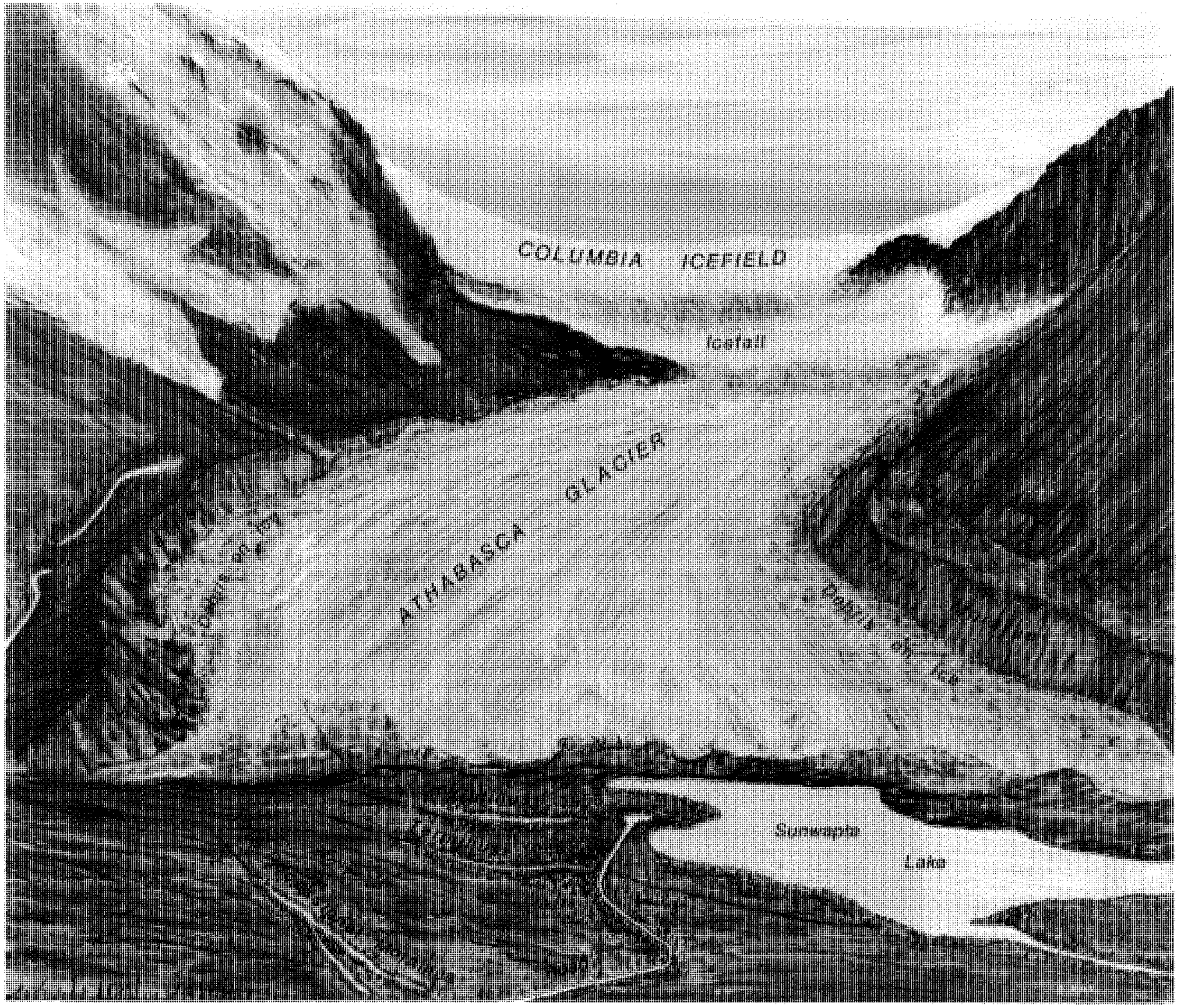


FIG. 35 Athabasca Glacier, located beside the Banff-Jasper highway, drops approximately 670m over its 7.3km length. The glacier front has a net retreat of 13m per year

Courtesy of Alberta Government

FIG. 36 Athabasca Glacier and the Icefields Chalet.

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

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 assymetric 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.

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 landform.

182.5 (114.0) HONEYMOON LAKE Road.

183.3 (114.5) ATHABASCA VALLEY VIEWPOINT. On the east-facing slopes 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.

DAY 4: JASPER LOCAL

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 3,000.

The elevation of Jasper townsite is about 1,000 m and the summit of Yellowhead pass to the west is 1,130 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. 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.

Examples of typical soils and vegetation communities will be examined in the Jasper vicinity.

Two soil sites in the Jasper vicinity are featured on Day 4 (Figure 37). A short bus ride is required to reach each site, located on opposite sides of the Athabasca Valley. Road Log 5 describes the route to the Portal Creek site 9 km south of Jasper, and Road Log 6 describes the route to the Signal Mountain site 10 km east of tour. Some free time will be given in the afternoon for individual activities.

Road Log No. 5: Jasper to Portal Creek

Km (Mile)

0 (0) JUNCTION of Highways 16 and 93 west of Jasper. Our route will follow the Icefields Parkway (Highway 93) southward for about 7 km and then take 93A for a short distance (Figure 37).

0.8 (0.5) MIETTE RIVER

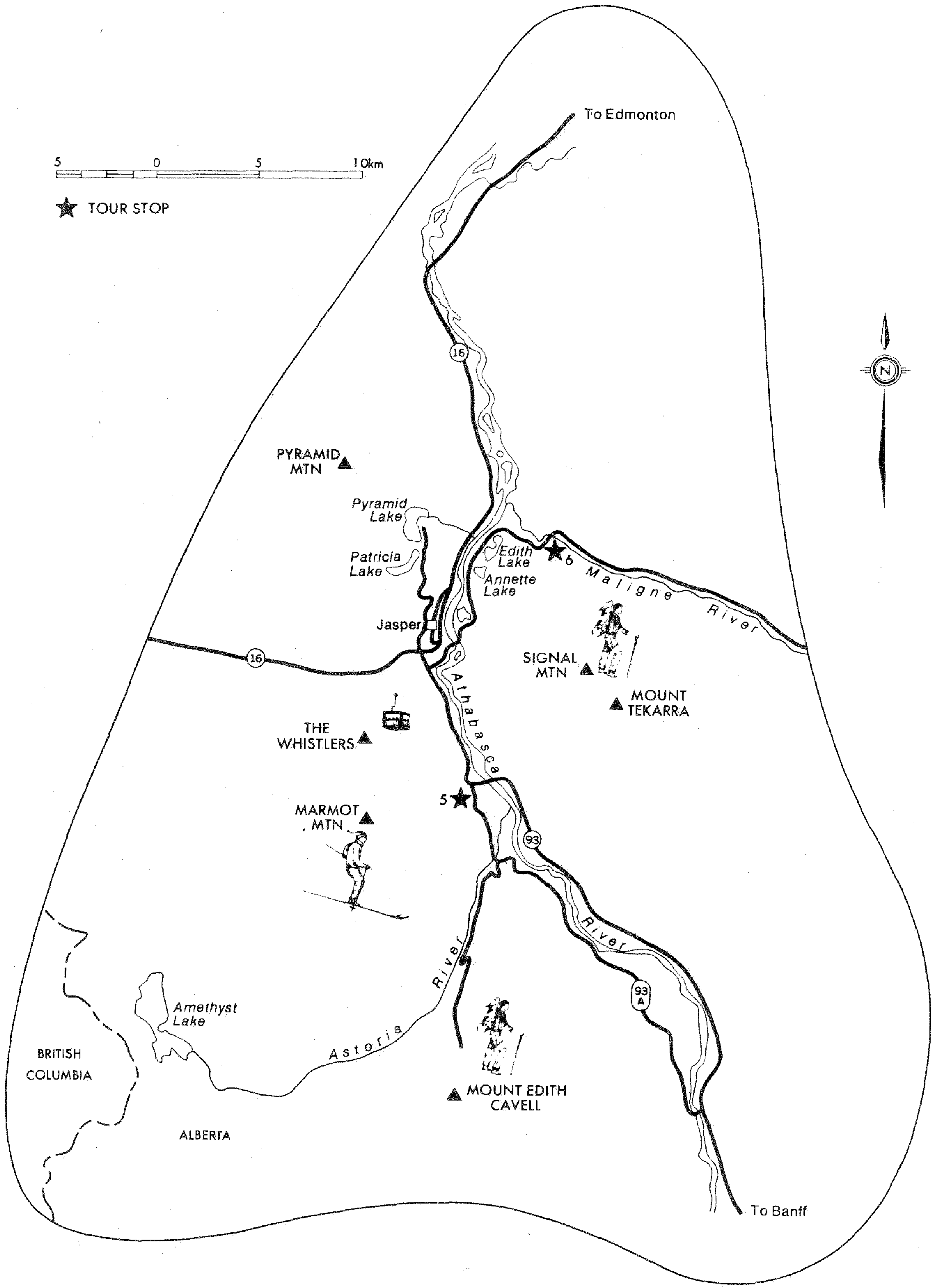


FIG. 37 JASPER LOCAL ROUTE MAP

1.9 (1.2) WHISTLERS ROAD to Youth Hostel and Sky Tram. The lower terminal of the Sky Tram at 1,790 m provides an interesting view of the Athabasca Valley. The top terminal, at 2,285 m offers an impressive panorama of Jasper townsite and area, and also provides access to an alpine environment.

The soils on the glaciofluvial landform over which we will be travelling for the next 5 km are very similar to those along the west side of the Bow River downstream from Lake Louise. They differ in that their climate and environment are characterized by the montane zone near Jasper and the subalpine zone near Lake Louise.

6.9 (4.3) JUNCTION. Leave the Icefields Parkway via Highway 93A. As we climb above the valley bottom the steep road cuts give a view of the glacial deposits which will be examined at the Portal Creek site. These till materials are quite heterogeneous having gravelly pockets and slightly stratified zones.

A good view of the Athabasca Valley is also provided as we leave the valley floor.

Portal Creek Site: Eluviated Eutric Brunisol

9.0 (5.6) This pedon and the one at the Signal Mountain site differ mainly in degree of genetic horizon development. After examining the pit and site (Figure 38) we will return to Jasper townsite. Refer to Appendix C for site data.

Road Log No. 6: Jasper to Signal Mountain Area

Km (Mile)

0 (0) JUNCTION of Highways 16 and 93 west of Jasper. Our route will head eastward on Highway 16.

4.3 (2.7) JUNCTION of east entrance to Jasper townsite with Highway 16. To the left can be seen the steep faces of the glaciofluvial benches upon which the town sits. Kettle lakes can be seen on these benches on either side of the Athabasca River (Figure 39). There are occasional local silty deposits exposed on the steep faces. These are typically dry and grass covered, with an occasional Douglas-fir, and characterized by either weak Brunisolic or Regosolic soils.

6.2 (3.9) JUNCTION. Leave Highway 16, cross the Athabasca River and proceed on the Maligne Lake road. For the next 3 km the road is built on cobbly glaciofluvial materials that can be seen along the road cuts. Weakly developed Brunisolic soils characterize the area.

7.4 (4.6) JUNCTION with road to Edith and Annette lakes. These shallow kettle lakes provide swimming and other water-based recreation to park residents and visitors.

8.5 (5.3) JUNCTION. The road to the left leads to the abandoned fish hatchery. Until a few years ago lakes within the Park were routinely stocked with fish to provide good angling. However, the hatchery, and the stream used

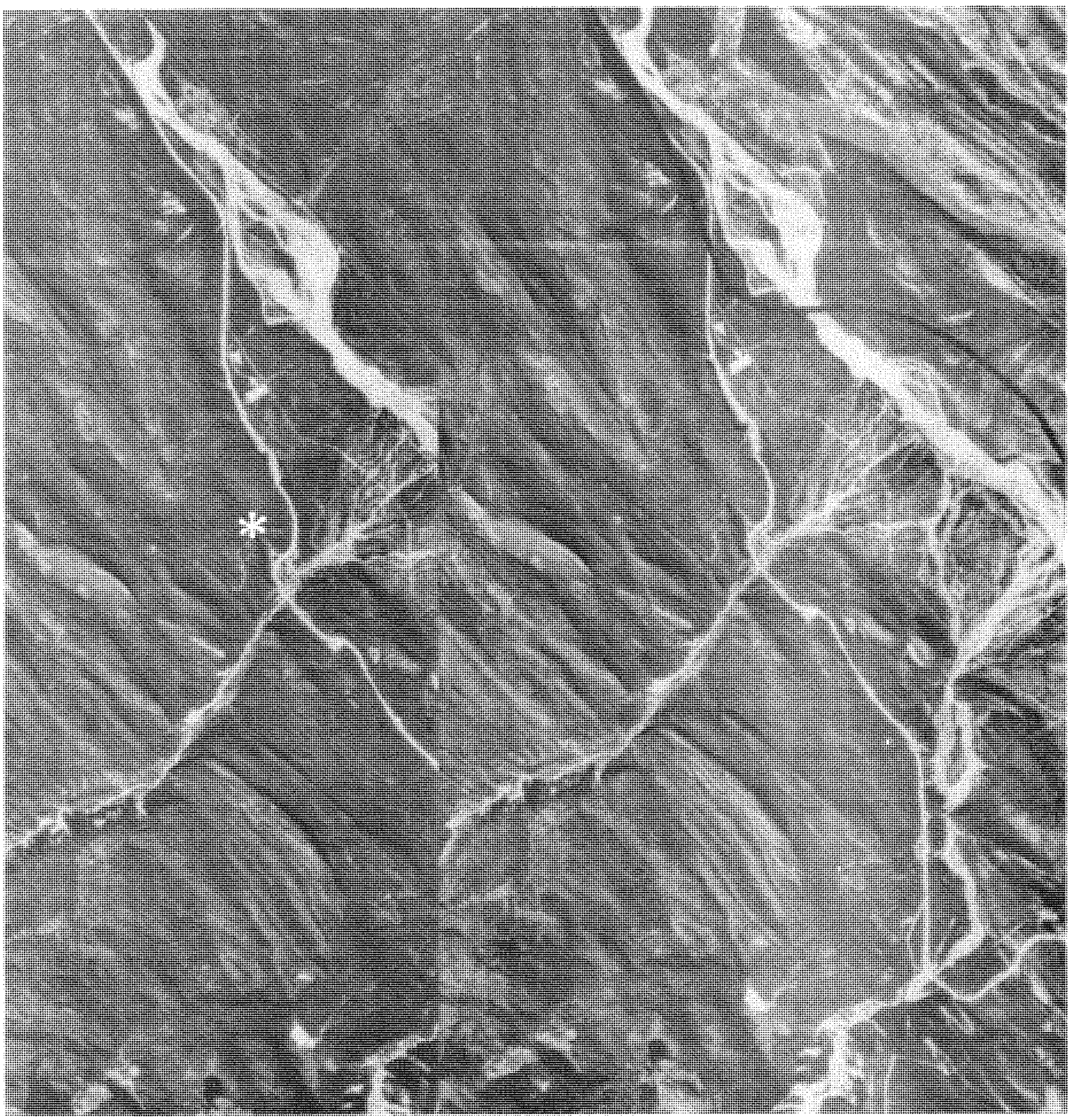


FIG. 38 Stereogram of the Portal Creek area. Soil pit location marked with *
(Alberta Govt. Photos AS147, 156-157)

as a water source, became contaminated with Pancreatic Necrosus virus which devastatingly reduced the viability of fish fry. The Parks, at least temporarily, have abandoned raising fish for stocking lakes.

9.4 (5.9) TILL. The gravelly and cobbly glaciofluvial material changes to calcareous, medium-textured tills typical of much of this part of the Athabasca Valley.

Signal Mountain Site: Orthic Gray Luvisol

11.7 (7.3) This pedon is developed in calcareous till materials in a low rainfall environment. Refer to Appendix C for site data and to Figure 39 for stereogram of site.

After examining the pit and site, we will return to Jasper.

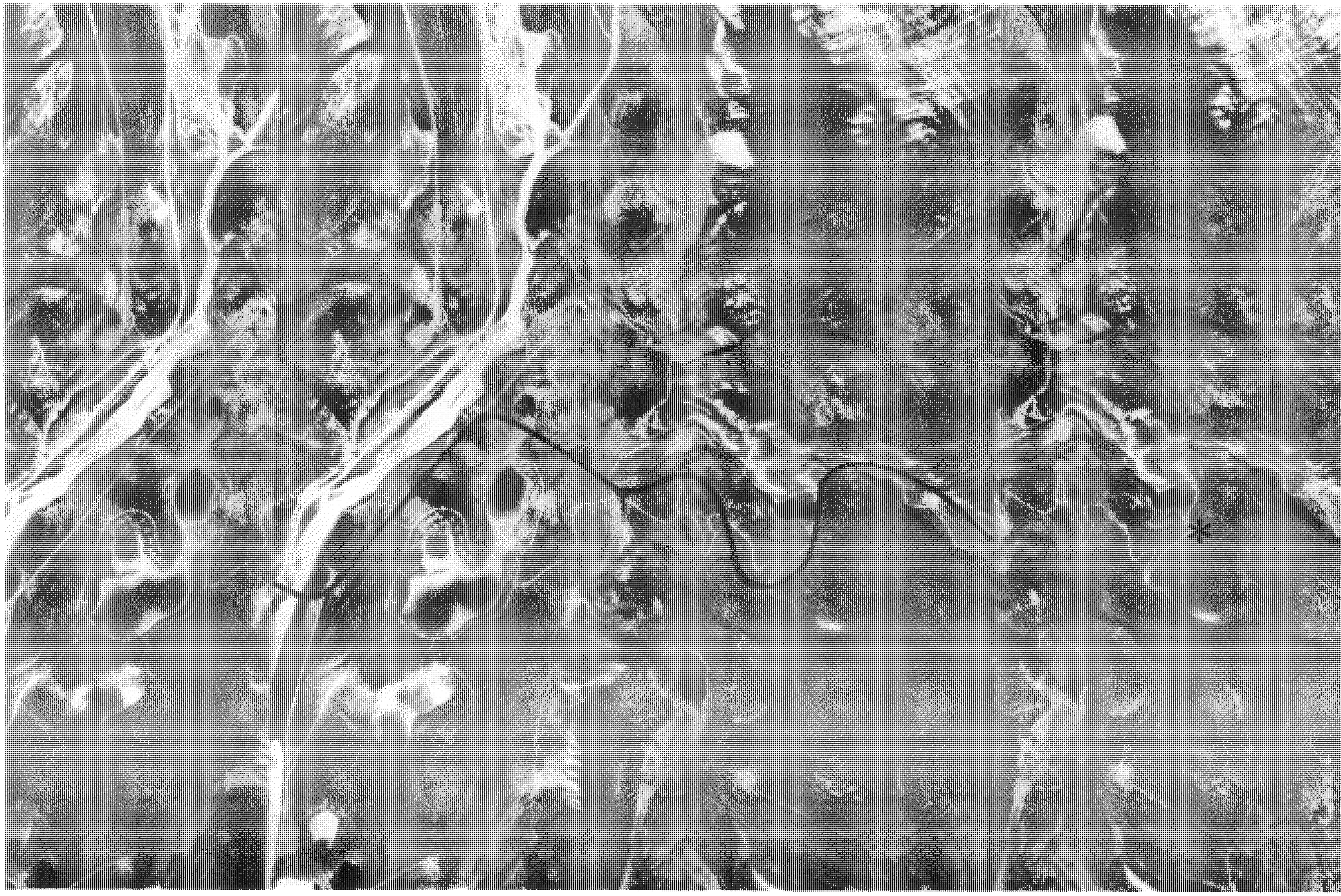


FIG. 39 Stereogram of the Signal Mountain area. Soil pit location marked with *. (Alberta Govt. Photos AS145, 51-53)

DAY 5: JASPER TO EDMONTON

The route follows Highway 16 east from Jasper to the park gates where we stop at a soil pit to examine a Brunisolic soil on loess. We then continue eastward across the foothills and western plains to return to Edmonton (Figure 40).

From the park gates to Hinton the Brunisolic soils on loess are the dominant soils in the Athabasca Valley (Figure 41). Luvisolic soils on till, and organic (bog) soils are most common from east of Hinton to Wabamun Lake (Figure 42, 43, 44). 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 (Figure 44).

Road Log No. 7: Jasper to Edmonton

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 left (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 Center. 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 1,020 m.

14.1 (8.8) LOESS. The overhanging calcareous loess "cap" on the left (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.

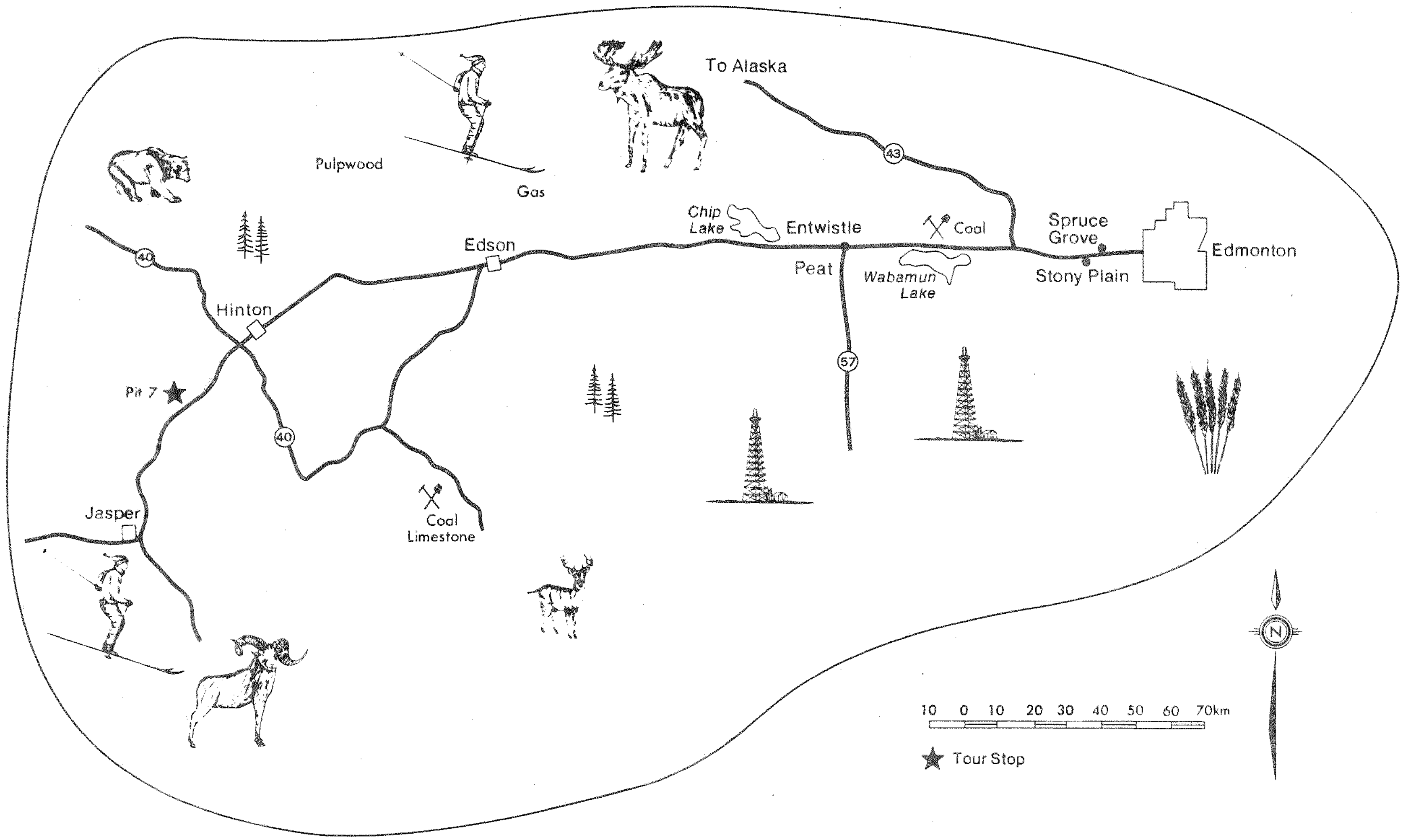


FIG. 40 JASPER TO EDMONTON ROUTE MAP

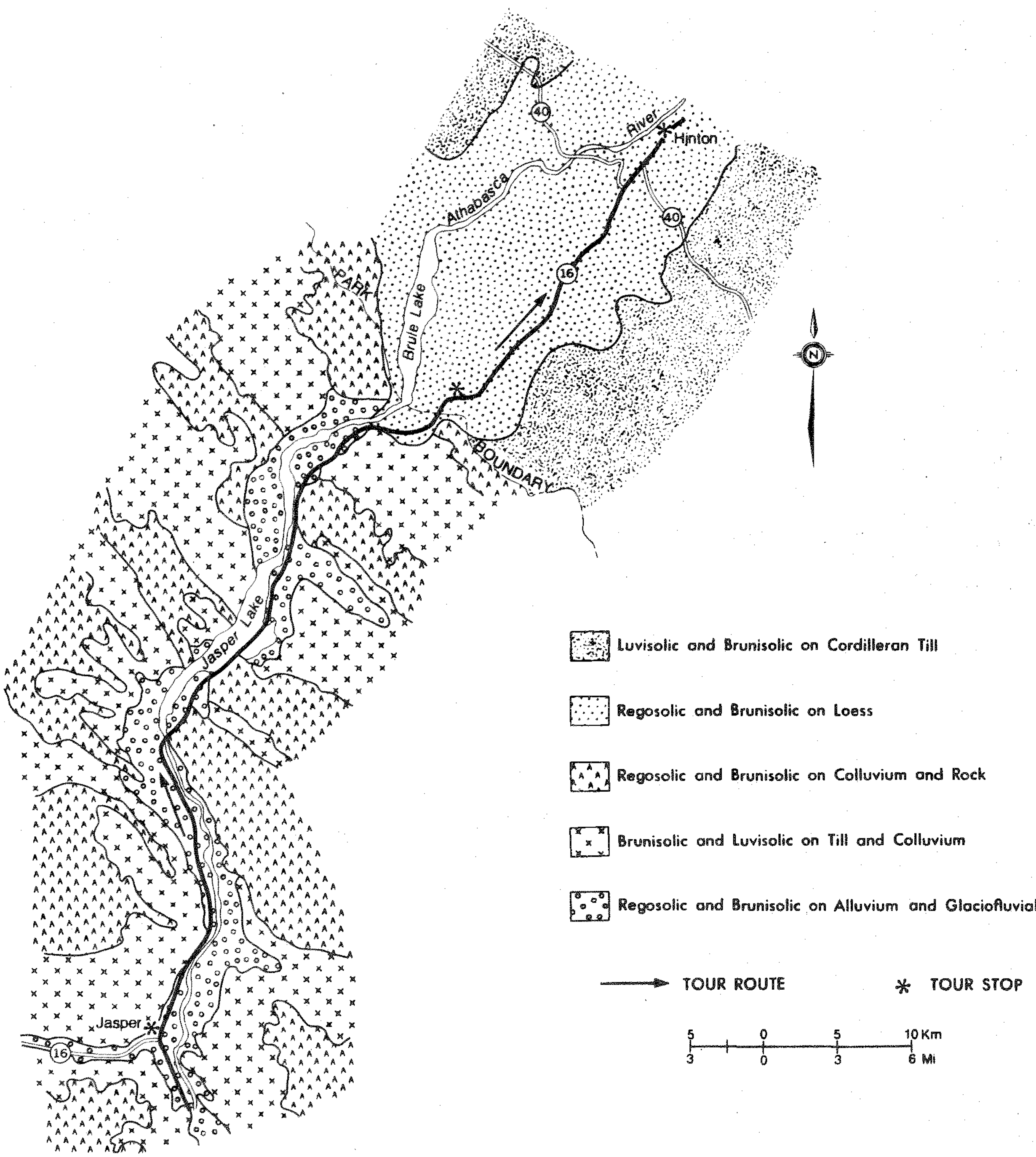


FIG. 41 GENERALIZED SOIL MAP—JASPER TO HINTON

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

18.6 (11.6) COLD SULPHUR SPRING. Water from rain and snow flow 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.

Overlander Site: Orthic Melanic Brunisol

51.6 (32.3) OVERLANDER LODGE. This is a cumulic Brunisolic soil developed in the calcareous loess that blankets the landscape (Figure 42). Refer to Appendix C for site data.

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

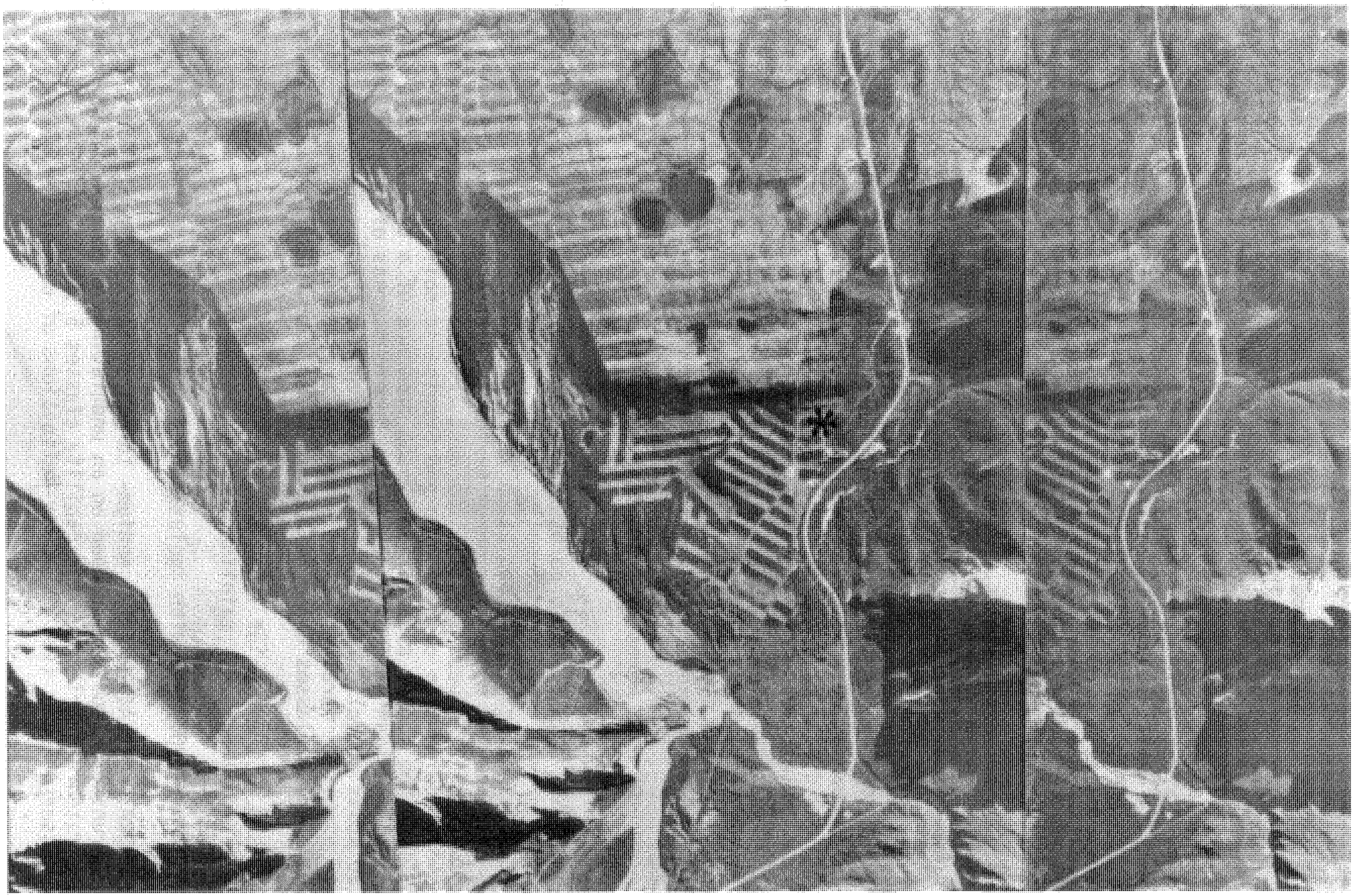


FIG. 42 Stereogram of the Brûlé Lake area. Overlander site is marked with *. (Alberta Govt. Photos AS2872, 9-11)

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 6,000. 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 43). 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 <u>et al</u>. 1973). The landform is primarily a rolling morainal upland. Agricultural capability classes 5 and 6. Forest capability classes 4 and 5 (see p. 14 for definitions of capability classes).

115 (72) OBED. Elevation of 1,086 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 (see p. 14 for definitions of capability classes).

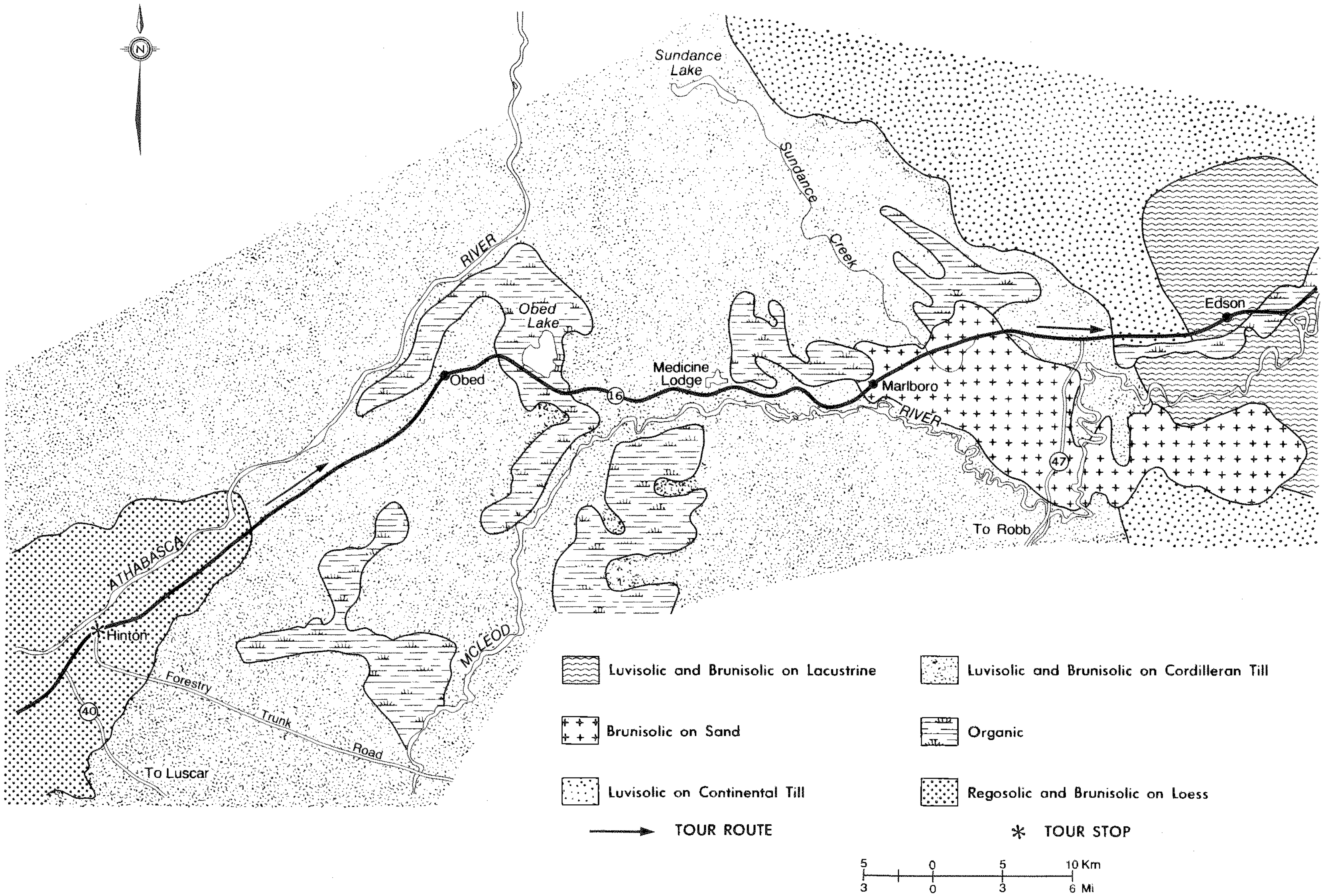


FIG. 43 GENERALIZED SOIL MAP–HINTON TO McLEOD RIVER

126 (79) MEDICINE LODGE. The flowing well that is located here is a popular stopping point for travellers. There is a minimum security detention center on the hill. Inmates from this institution work nearby cleaning and thinning forested areas, and 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 (see p. 14).

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 ostracods. The marl has been dated by radiocarbon method at 1,830 ± 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. This is the first major indication of an agricultural endeavor since DAY 1 of the tour. 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 (see p. 14).

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.

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 homestead. The tortuous, mud-choked trail was used until the railway reached Grande Prairie in 1916.

166 (104) EDSON corporate limits. Population 3,500. 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 44).

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

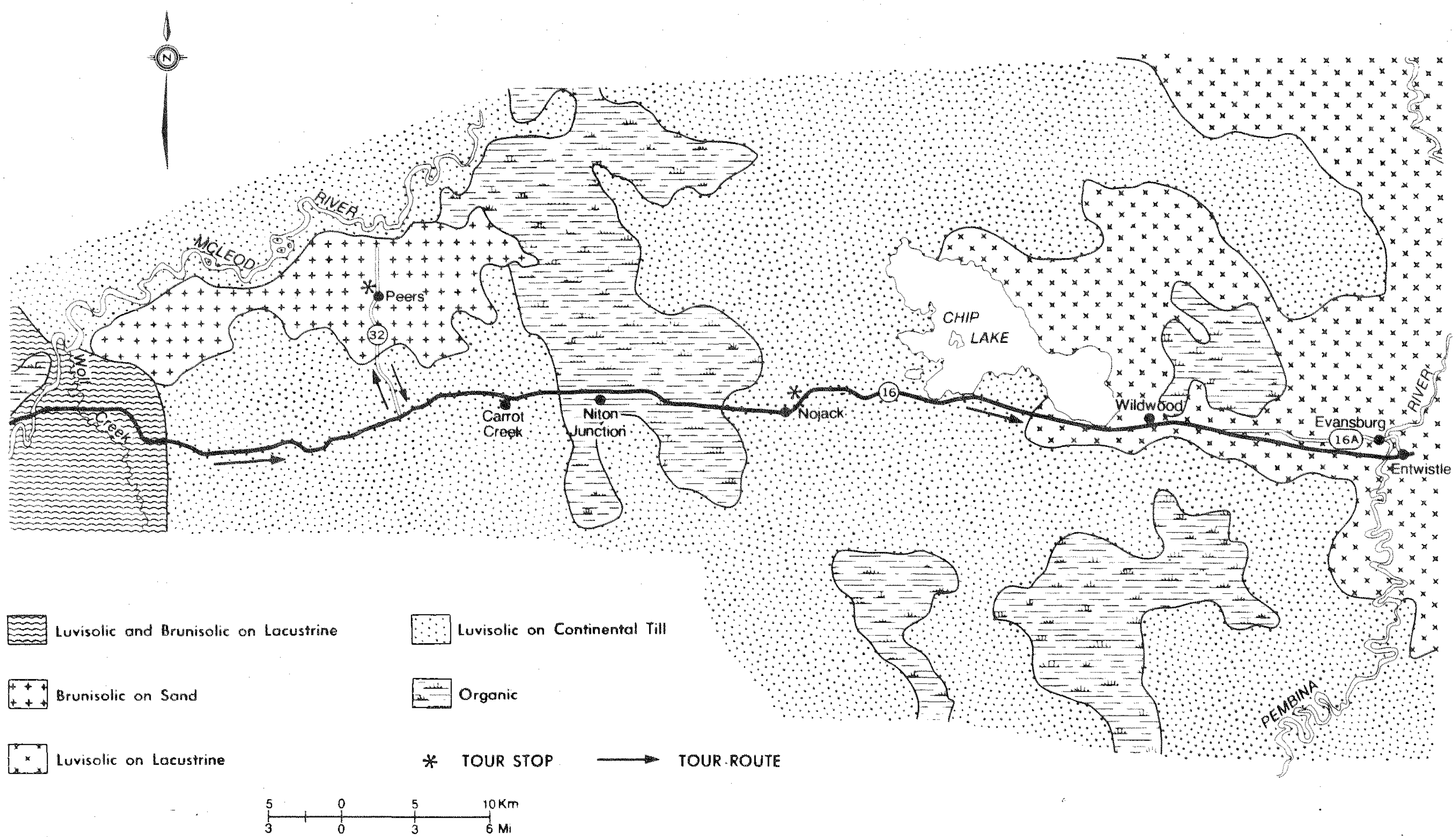


FIG. 44 GENERALIZED SOIL MAP—McLEOD RIVER TO PEMBINA RIVER

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. (Fig. 7)

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 45; 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 right (south side of highway). Proximity to large population centers 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

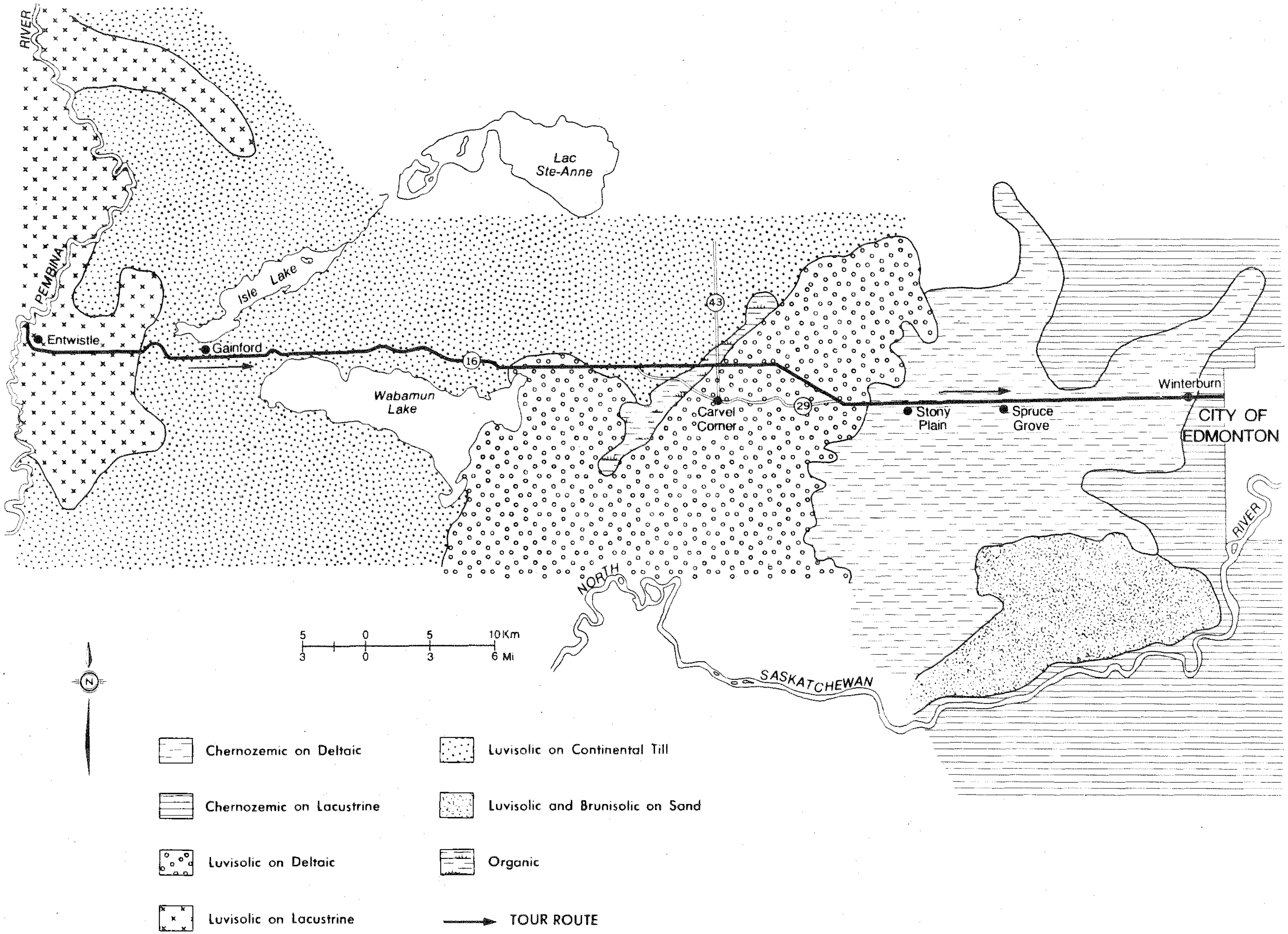


FIG. 45 GENERALIZED SOIL MAP—PEMBINA RIVER TO EDMONTON

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.

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 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 suggests 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 2,500. This community lies in Agro-Climatic area 1.

347 (217) SPRUCE GROVE. Population 5,500. The size and population of centers 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	US	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

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.

<u>Illumination</u> 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

<u>Magnifications used for descriptions</u>
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 porus 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

APPENDIX C: SITE, PEDON AND MICROMORPHOLOGICAL DESCRIPTIONS AND ANALYTICAL DATA

Description of an Orthic Eutric Brunisol at the Kananaskis Site.

Location:	UTM IIU 3860 5510 Soil pit on Kananaskis Forestry Research Station Interpretive Trail
Elevation:	1,425 m a.s.l.
Landform:	Hummocky glaciofluvial
Slope:	5 to 8%, mid slope bench, north
Estimated drainage:	Rapidly drained
Surface runoff:	Moderate
Parent Material:	Calcareous coarse loamy fluvial sediments
Vegetation:	Representative species include lodgepole pine and buffalo berry (see stand description Table 5)
Climate:	Continental with long cold winters and cool summers Annual precipitation is in the range of 500 to 700 mm
Classification:	Canada - Orthic Eutric Brunisol U.S.A. - Typic Cryochrept F.A.O. - Calcic Cambisol
Notes:	The soil temperature at 50 cm was 6 C. At least two large boulders were removed from the pit during excavation. The surface of the landform was nonstony. Microtopography - slightly mounded.

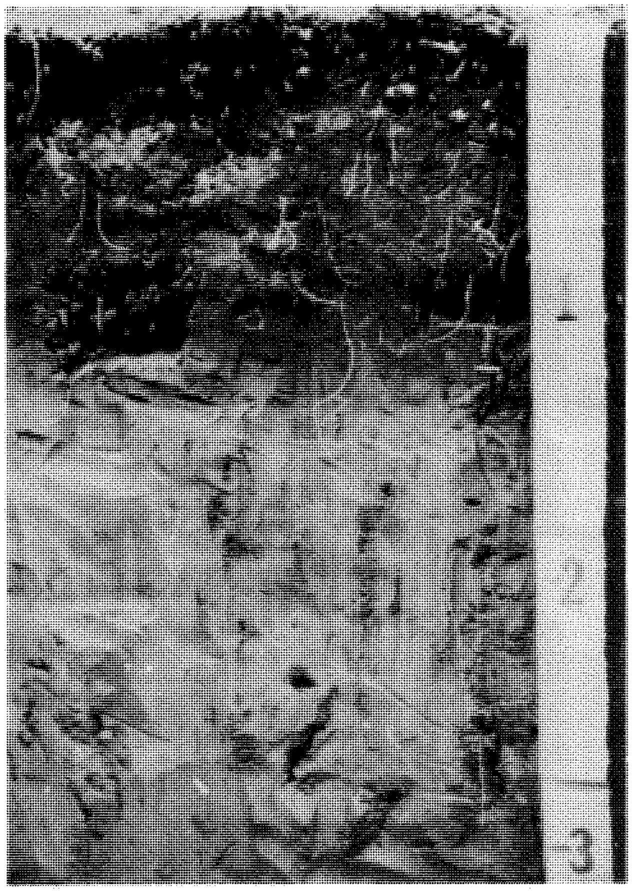
Horizon	Depth (cm)	Description
L	1-0	Slightly decomposed needles and leaves; abundant fine and medium oblique roots; abrupt wavy boundary; 0 to 2 cm thick
Ae	0-0	Brown (10YR 5/3 m) sandy loam; very weak, very fine to fine platy; friable; plentiful fine roots; few very fine pores; no clay films; no effervescence; clear broken boundary; 0 to 5 cm thick
Bm	0-18	Strong brown (7.5YR 5/6 m) and occasionally yellowish red (5YR 4/6 m) sandy loam; structureless to very weak fine to medium subangular blocky; friable; abundant medium roots; few fine pores; no clay films; no effervescence; clear wavy boundary; 8 to 23 cm thick
Ck1	18-30	Brown (10YR 4/3 m) sandy loam; structureless, friable; plentiful fine roots; very few very fine pores; no clay films; strong effervescence with 10% HCl; clear wavy boundary; 7 to 12 cm thick
Ck2	30-55	Grayish brown (10YR 5/2 m) sandy loam; structureless; friable; few medium roots; few very fine pores; no clay films; strong effervescence with 10% HCl; diffuse wavy boundary; 23 to 26 cm thick
Ck3	55-85	Grayish brown (10YR 5/2 m) sandy loam; structureless; friable; few medium roots; very few fine pores; no clay films; strong effervescence with 10% HCl; diffuse wavy boundary; 28 to 32 cm thick
Ck4	85-100+	Grayish brown (10YR 5/2 m) sandy loam; structureless; friable; few medium roots; very few very fine pores; no clay films; strong effervescence with 10% HCl

TABLE 4. ANALYTICAL DATA FOR AN ORTHIC EUTRIC BRUNISOL AT THE KANANASKIS SITE
DONNEES ANALYTIQUES DU BRUNISOL EUTRIQUE ORTHIQUE A SITE KANANASKIS

Horizon	pH H_2O	pH $CaCl_2$	C Total	$CaCO_3$ Equ.	N Total	C/N	Exch. Cations / Cations Ech. Buffered / Tamponée Total	NH4OAc (pH7) Ca	Mg	Na	K	Dithionite Fe	Dithionite Al	Dithionite Mn	Oxalate Fe	Oxalate Al	Pyrophos. Fe	Pyrophos. Al	Moisture / Humiditie 1/3 atm	Moisture / Humiditie 15 atm
			%	%	%		me/100 g	me/100 g	me/100 g	me/100 g	me/100 g	%	%	%	%	%	%	%	%	%
L																				
Ae																				
Bm	7.7	7.0	0.76	0.60	0.04	17	12.8	8.94	3.18	0.03	0.23	0.98	0.08	0.03	0.36	0.07	0.05	0.02		5.8
Ck1	8.0	7.4		39.2															9.1	3.5
Ck2	8.1	7.5		50.0																
Ck3	8.1	7.6		48.4																
Ck4	8.2	7.7		50.2																

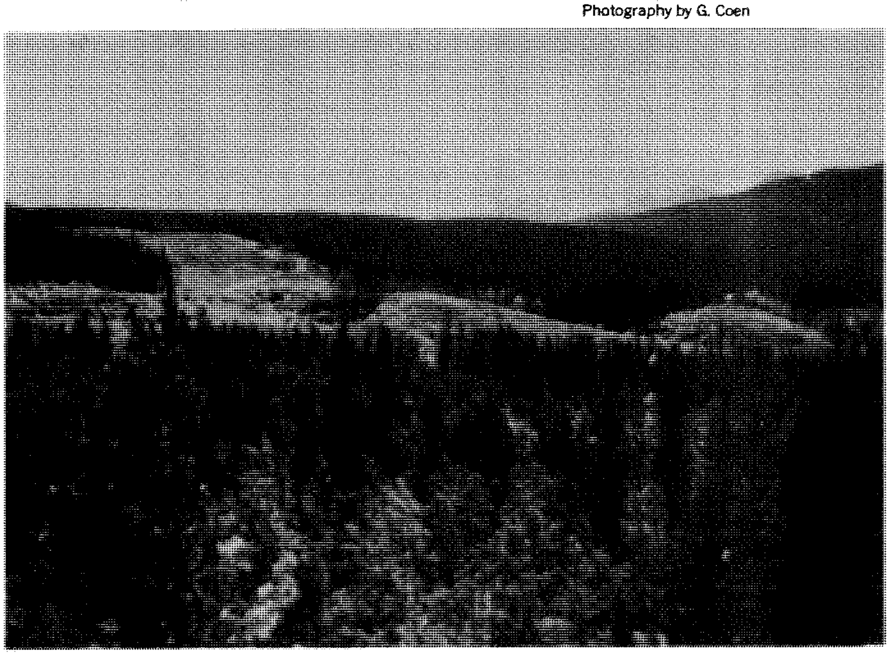
Horizon	Org. mat. / mat. org. Extracted / Extrait C	Extracted / Extrait N	Cha/Cfa	FA E4/E6	HA E4/E6	Mineralogy / Mineralogie (<2μm[1]) Mica	Chlor	Kaolin	Smect.	Verm.	Quartz	Felds.	Part Size Dist. / anal. gran. (<2 mm) Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile Fine	Bulk D. / dens. app.
	%	%											%	%	%	%	g/cc
L																	
Ae																	
Bm	47.3	48.3	0.42	9.6	4.3	1	tr	tr	tr	1	1	0	61	27	12	5	1.1
Ck1						1	tr	0	0	0	1	0	69	27	4	1	1.2
Ck2													66	28	6	2	
Ck3													60	34	6	2	
Ck4													71	23	6	2	

[1]Amount estimated from x-ray diffractograms: tr= trace, 1= 2-20%, 2= 20-40%, 3= 40-60%, 4= 60-80%, 5= 80-100%



a

Photography by G. Coen

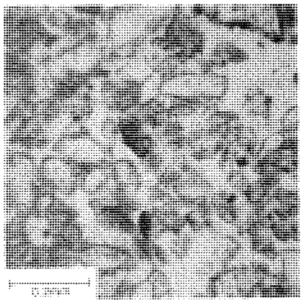


b

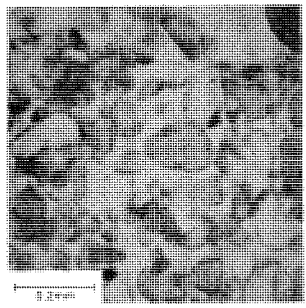
Photography by G. Coen

FIG. 46 Rolling morainal topography with a fluvial veneer (a) and Orthic Eutric Brunisol profile (b) at the Kananaskis site.

Figure 47. Micromorphology of the Orthic Eutric Brunisol at the Kananaskis site.



a. plane light



b. plane light

Bm This horizon is loosely packed grayish brown material consisting of medium to fine sand and almost isotropic matrix material which occurs as thin (<20μm) complete matrans on almost all grains and small aggregates (<150μm) (that contain volcanic ash) as loose to incomplete intergranular fillings (Fig. 47a). Dark brown to black well humified organic material is (0) and most of it is fragmented. Some of the matrans are weakly sepic.
-1- agglomeroplasmic
-2- matriplectic

Ck This horizon is moderately packed grayish material consisting of medium to fine sand with some (20%) silt (Fig. 47b). There are some loosely packed areas. The majority (70%) of the sand and silt are carbonates with the rest silicates (mostly quartz). Thin (<20μm) partial carbonate matrans occur on 75% of the silicate grains and 30% of the carbonate grains. Dark brown well humified organic material is (0) and usually fragmented.
-1- granular with thin partial matrans
-2- orthogranic-gefuric

Table 5. Vegetation structure of the Kananaskis site

		Cover Class*
Tree Layer: A		
A1:	*Pinus contorta*	3
	Picea glauca	1
	Populus tremuloides	1
A2:	*Picea glauca*	2
	Pinus contorta	1
Shrub Layer: B		
B1:	*Picea glauca*	2
	Salix scouleriana	1
B2:	*Shepherdia canadensis*	2
	Juniperus communis	1
	Rosa acicularis	1
	Spiraea lucida	1
	Picea glauca	1
	Juniperus horizontalis	+
	Symphoricarpos occidentalis	+
Herb Layer: C		
Cw:	*Linnaea borealis*	3
	Arctostaphylos uva-ursi	1
	Vaccinium caespitosum	1
C1:	*Calamagrostis rubescens*	3
	Elymus innovatus	2
	Epilobium angustifolium	1
	Aster conspicuus	1
	Pyrola virens	1
	Fragaria virginiana	1
	Aster ciliolatus	1
	Carex concinna	1
	Lathyrus ochroleucus	1
	Oxytropis deflexa	1
	Clematis verticellaris	+
	Disporum trachycarpum	+
	Galium boreale	+
	Gentianella amarella	+
	Habenaria sp.	+

	Cover Class*
Herb Layer: (cont'd)	
Hedysarum mackenzii	+
Orellis rotundifolia	+
Pyrola secunda	+
Stenanthium occidentale	+
Vicia sp. *(probably americana)*	+
Zygadenus sp.	+
Moss & Lichen Layer:	
Hylocomium splendens	3
Drepanocladus uncinatus	1
Pleurozium schreberi	1
Polytrichum juniperinum	1
Thuidium recognitum	1
Dicranum sp.	+
Polytrichum commune	+
Tortula princeps	+
Peltigera aphthosa	1
Peltigera canina	1
Cladonia sp.	+
Parmelia sp.	+

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 6. Long-term Meteorological data for Kananaskis Lat. 51° 02' N Long. 115° 03' W Elevation 1,390 a.s.l.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Daily Temp C	-9.7	-6.1	-4.2	1.8	7.1	10.7	14.1	13.1	9.2	5.0	-2.3	-6.1	2.7
Mean Daily Max Temp C	-3.3	0.6	2.4	8.2	13.8	17.4	22.1	20.7	16.3	11.3	3.6	-0.3	9.4
Mean Daily Min Temp C	-16.0	-12.7	-10.8	-4.5	0.28	3.8	6.1	5.5	2.1	-1.4	-8.2	11.9	-3.9
Extreme Max Temp C	17.2	16.1	17.8	23.9	27.8	31.1	33.9	33.3	30.0	27.2	18.9	16.1	33.9
Extreme Min Temp C	-45.6	-41.1	-40.6	-31.1	-21.7	-5.6	-1.1	-2.2	-9.4	-22.2	-35.6	-42.2	-45.6
No. of days with Frost	30	27	29	25	17	4	1	2	10	19	27	29	220
Mean Rainfall mm	0.51	0.25	1.02	8.13	61.0	111.3	64.3	69.9	42.7	13.7	5.3	1.5	376
Mean Snowfall mm	279.4	345.4	370.8	535.9	205.7	7.6	0	5.1	94.0	256.5	269.2	287.0	2657
Mean Total Pptn. mm	28.5	34.8	38.1	63.0	81.5	115.6	64.3	70.1	52.0	39.9	29.5	30.2	648

Description of an Eluviated Eutric Brunisol at the Muleshoe site.

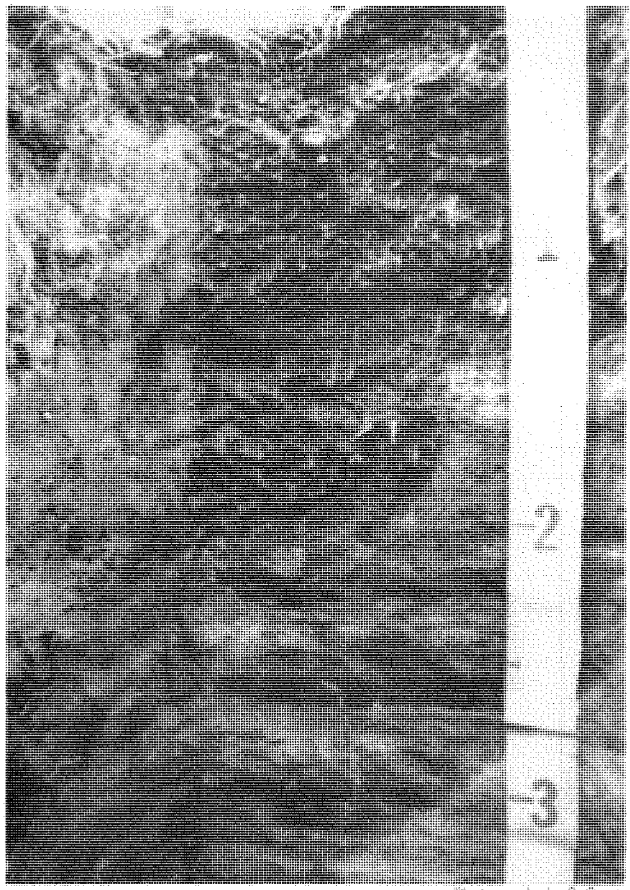
Location:	UTM 11U NG 8980 7020 Along Highway 1A west of Banff and to the east of the Muleshoe picnic site
Elevation:	1400 m a.s.l.
Landform:	12% simple slope, mid slope, southeast
Estimated drainage:	Well drained
Surface runoff:	Moderate
Parent Material:	Calcareous fine loamy to fine silty fluvial sediments
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 effervescence; few coarse fragments

TABLE 7. ANALYTICAL DATA FOR AN ELUVIATED EUTRIC BRUNISOL AT THE MULESHOE SITE
DONNEES ANALYTIQUES DU BRUNISOL EUTRIQUE ELUVIEE A SITE MULESHOE

Horizon	pH		C Total	$CaCO_3$ Equ.	N Total	C/N	Exch. Cations / Cations Ech. — Neutral Salt / Sel Neutre					Buffered / Tamponée	NH_4OAc (pH7)				Dithionite			Oxalate		Pyrophos.	
	H_2O	$CaCl_2$					K	Ca	Mg	Al	Total	Total	Ca	Mg	Na	K	Fe	Al	Mn	Fe	Al	Fe	Al
			%				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				Org. mat. / mat. org. — Extracted / Extrait		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.
	N	P-Bray	K	S	C	N								
	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	



a

Photography by G. Coen

b

Photography by G. Coen

FIG. 48 Trembling aspen community (a) and Eluviated Eutric Brunisol on fluvial sediments (b) at the Muleshoe Site.

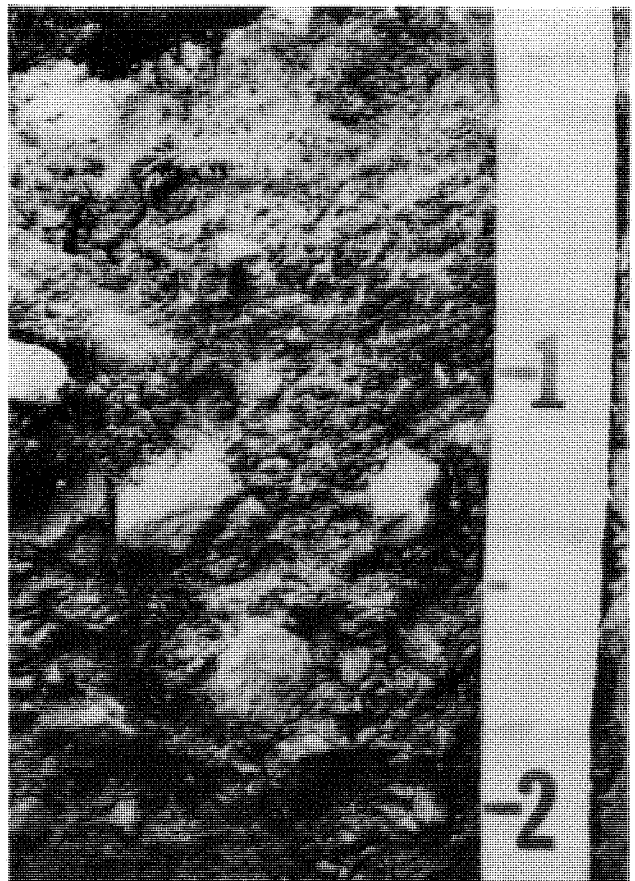
Table 8. Vegetation structure at the Muleshoe Site

Layer		Species	Cover Class*
Tree Layer: A			
	A1:	*Populus tremuloides*	5
Shrub Layer: B			
	B1:	*Populus tremuloides*	+
		Rosa acicularis	2
	B2:	*Populus tremuloides*	1
Herb Layer: C			
	Ch:	*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 9. Long-term meteorological data for Banff Lat. 51° 11' N Long. 115° 34' W Elevation 1,397 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



a

Photography by G. Coen

b

Photography by G. Coen

FIG. 49 Lodgepole pine community (a) and Brunisolic Gray Luvisol on till (b) at the Corral Creek Site.

DA4083
82O 1975 350

Description of a Brunisolic Gray Luvisol at the Corral Creek site.

Location:	UTM 11U 5940 9520 About 0.8 km east of the junction of Highway 1A and the Trans Canada Highway north of the Bow River and south of Lake Louise townsite
Elevation of Site:	1690 m a.s.l.
Landform:	Ridged (fluted) moraine
Slope:	5%, crest, west-southwest
Estimated drainage:	Well drained
Surface runoff:	Rapid
Parent Material:	Silt loam surficial deposit over fine loamy to fine silty calcareous dense till
Vegetation:	Represented by lodgepole pine and buffalo berry (see stand description, Table 11)
Climate:	Continental, with long cold winters and cool summers. Annual precipitation is in the range of 500 to 700 mm
Classification:	Canada - Brunisolic Gray Luvisol U.S.A. - Typic Cryoboralf F.A.O. - Albic Luvisol
Notes:	This pedon is developed in silty surficial material for the top 17 cm. This material was probably deposited by winds in the immediate post-pleistocene period. Most of the Brunisolic Gray Luvisols in this area have their upper horizons associated with the silty surficial material. Infiltration rate 5 cm/hr, percolation rate 300 min/10 cm

Horizon	Depth (cm)	Description
L-F	3-0	Black (10YR 2/1m) partly decomposed needles; abundant medium and coarse random roots; contains some white mycelia; abrupt wavy boundary; 3 to 4 cm thick
Ae1	0-2	Light gray (10YR 7/1d) silt loam; weak very fine to fine platy; very friable; abundant medium and coarse random roots; few very fine pores; no clay films; no effervescence; estimated coarse fragments 5%; abrupt broken boundary; 0 to 5 cm thick
Bm	2-12	Light yellowish brown (10YR 6/4d) silt loam; weak very fine subangular blocky; very friable; plentiful medium and coarse oblique roots; few very fine pores; no clay films; no effervescence; estimated coarse fragments 10%; abrupt wavy boundary; 7 to 12 cm thick
Ae2	12-17	Light gray to white (10YR 7.5/2d) loam; weak fine platy and weak medium subangular blocky friable; few very fine random roots; common very fine and fine pores; few thin clay films on ped faces; no effervescence; estimated coarse fragments 20%; abrupt wavy boundary; 3 to 6 cm thick
IIBt	17-31	Pale brown (10YR 6/3d) clay loam to gravelly clay loam; weak medium subangular blocky; firm; few micro roots; few very fine random pores; many thin clay films on ped faces; no effervescence; estimated coarse fragments 20%; clear wavy boundary; 11 to 15 cm thick
IICk1	31-40	Light gray (10YR 7/2d) gravelly loam; moderate fine to medium subangular pseudo blocky; firm; few micro roots; common very fine pores; few very thin clay films on ped faces; moderate effervescence; estimated coarse fragments 30%; clear wavy boundary; 8 to 10 cm thick
IICk2	40-75+	Light olive brown (2.5YR 5.5/4m) gravelly loam; structureless; firm; very few coarse roots; no pores; no clay films;

TABLE 10. ANALYTICAL DATA FOR A BRUNISOLIC GRAY LUVISOL AT THE CORRAL CREEK SITE
DONNEES ANALYTIQUES DU LUVISOL GRIS BRUNISOLIQUE A SITE CORRAL CREEK

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 NH_4OAc (pH7): Total	Ca	Mg	Na	K	Dithionite: Fe	Al	Mn	Oxalate: Fe	Al	Pyrophos.: Fe	Al
			%	%	%		me/100g										%						
L-F	4.9	4.9	37.1		0.89	42	2.33	34.4	6.66	0.33	43.8	58.5	36.6	7.43	0.11	3.08							
Ae1	5.3	4.6	1.82		0.07	26						8.0	4.41	1.47	0.11	0.11							
Bm	6.2	5.5	1.70		0.08	21	0.38	4.23	1.07		5.68	12.2	4.30	1.34	0.08	0.14	1.43	0.48	0.01	0.87	1.98	0.05	0.12
Ae2	6.0	5.5	0.46		0.03	15	0.11	3.84	1.54		5.49	7.70	4.31	2.20	0.02	0.07							
IIBt	7.0	6.4	0.58	1.5	0.05	8																	
IICk1	7.8	7.3		26.4																			
IICk2	8.1	7.5		26.8																			

Horizon	Avail. Nutrients / Assimilable: N	P-Bray	K	S	Org. mat. / mat. org. Extracted / Extrait: C	N	Mineralogy / Mineralogie ($<2\mu m$[1]): Mica	Chlorite	Kaolin	Smect.	Verm.	Quartz	Felds.	Part Size Dist. / anal. gran. ($<2mm$): Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile Fine	Bulk D. / dens. app.
	ppm				%									%				g/cc
L-F	0	23	187	13	27.7	44.0												
Ae1					44.7	59.9	tr	0	tr	1	1	1	1	30	64	6	1	0.6
Bm	0	0	37	4	54.6	57.5	tr	0	0	tr	1	1	0	21	71	8		1.3
Ae2	0	4	22	2	61.8	33.8	1	tr	0	0	0	1	tr	33	49	18	2	1.4
IIBt					44.6	21.9	2	tr	0	tr	0	1	tr	25	38	37	12	
IICk1														33	41	26	7	
IICk2							2	tr	0	0	0	1	tr	29	45	26	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 11. Vegetation structure of the Corral Creek Site

			Cover Class*
Tree Layer: A			
	A1:	*Pinus contorta*	3
	A2:	*Pinus contorta*	2
		Picea glauca	+
Shrub Layer: B			
	B1:	*Picea glauca*	+
	B2:	*Shepherdia canadensis*	3
		Rosa acicularis	1
		Salix glauca	1
		Abies lasiocarpa	+
		Juniperus communis	+
		Lonicera involucrata	+
		Picea glauca	+
		Pinus contorta	+
		Potentilla fruticosa	+
Herb Layer: C			
	Cw:	*Vaccinium scoparium*	2
		Arctostaphylos uva-ursi	2
		Vaccinium caespitosum	2
	Ch:	*Linnaea borealis*	2
		Elymus innovatus	2
		Fragaria virginiana	2
		Aster conspicuus	1
		Cornus canadensis	1
		Aster ciliolatus	1
		Pyrola secunda	1
		Achillea millefolium	+
		Arnica cordifolia	+
		Carex scirpoidea	+
		Epilobium angustifolium	+
		Hedysarum sulphurescens	+
		Pyrola virens	+
		Senecio indecorus	+
		Solidago multiradiata	+

			Cover Class*
Moss and Lichen Layer: D**			
	Db:	*Barbilophozia hatcheri*	
		Campylium or Brachythecium sp.	
		Dicranum fuscescens	
		Drepanocladus uncinatus	
		Pleurozium schreberi	
		Ptilium crista-castrensis	
	Dl:	*Cladonia sp.*	
		Peltigera aphthosa	
		Steriocaulon sp.	
Epiphyte Layer: E			
		Alectoria sp.	
		Parmelia sp.	
		Parmeliopsis sp.	

*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%

** Cover class was not recorded on the mosses and lichens, but values are probably all less than 1%.

Table 12: Long-term meteorological data for Lake Louise Lat. 51° 25' N Long. 116° 10' W Elevation 1,534 a.s.l.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Daily Temp C	-14.6	-9.6	-6.4	0.17	5.9	9.6	12.4	11.4	7.3	1.8	-7.1	-12.4	0.11
Mean Daily Max Temp C	-7.6	-1.5	1.6	7.0	13.6	17.3	21.4	20.0	15.1	8.3	-8.3	-6.2	7.3
Mean Daily Min Temp C	-21.4	-17.7	-14.4	-6.8	-1.8	1.9	3.4	2.7	-0.6	-4.7	-13.3	-18.6	-7.6
Extreme Max Temp C	7.8	13.9	15.6	23.3	31.7	31.1	34.4	32.2	28.3	26.1	18.3	12.2	34.4
Extreme Min Temp C	-52.8	50.6	-44.4	-33.9	-27.8	-10.0	-5.6	-7.2	-25.0	-25.0	-43.3	-49.4	-52.8
No. of Days with Frost	31	28	31	29	23	9	5	8	19	27	30	31	271
Mean Rainfall mm	0.51	1.02	0.25	7.1	32.3	60.7	58.9	58.7	45.0	18.5	1.8	0.25	285
Mean Snowfall mm	823.0	622.3	447.0	457.2	175.3	12.7	T	2.54	43.2	411.5	843.3	980.4	4818
Mean Total Pptn. mm	82.8	63.3	44.9	52.8	50.8	62.0	59.2	58.7	50.0	59.9	85.1	98.0	767

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 Peyt Lake Lookout parking area
Elevation:	2130 m a.s.l.
Landform:	Inclined morainal
Slope:	10% simple solpe, 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 (see stand description, Table 14)
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

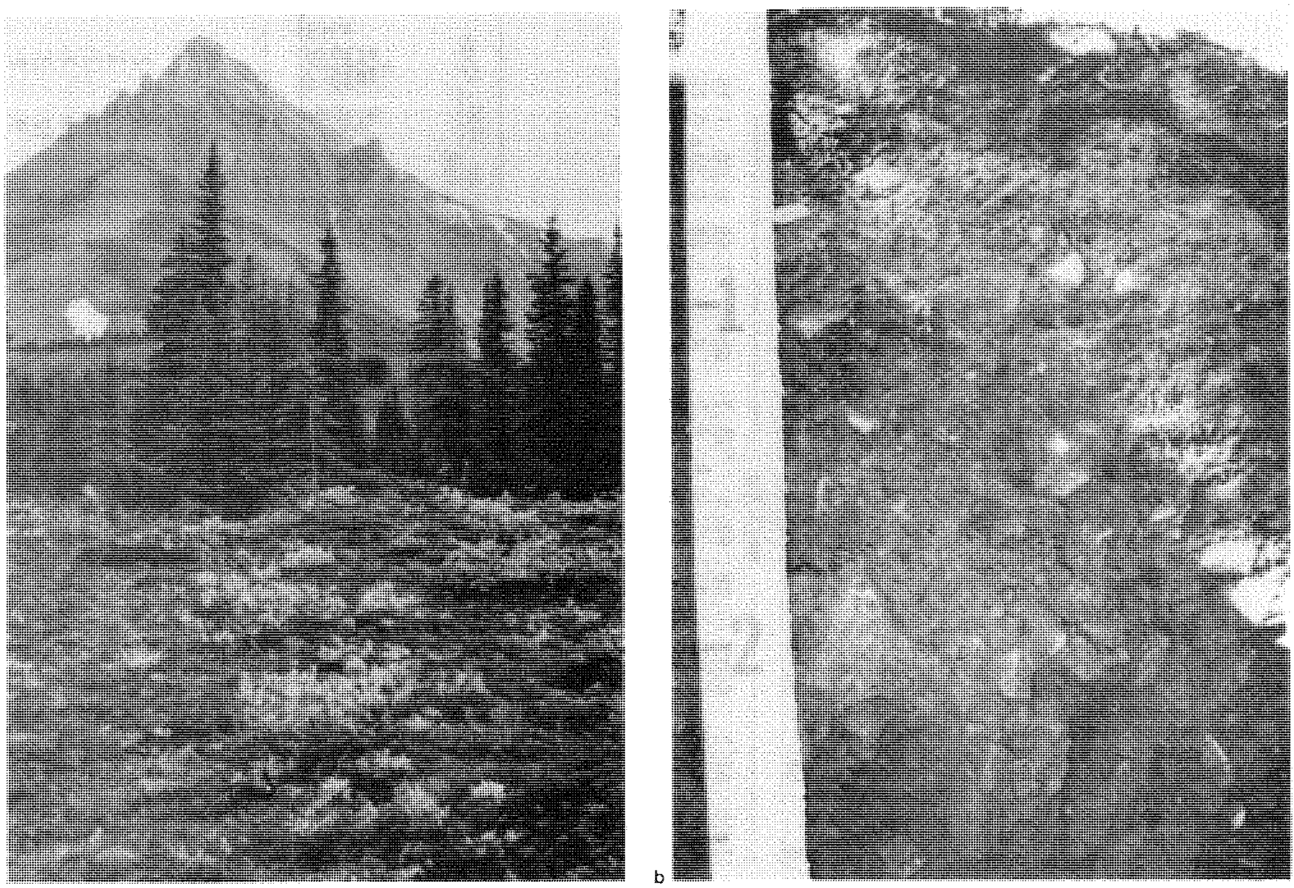
Horizon	Depth (cm)	Description
F-H	2-0	Dark reddish brown (5YR 3/2m) well decomposed organic litter; plentiful micro and very fine roots; few white mycella; abrupt smoooth boundary; 0 to 4 cm thick
Ae	0-6	Pale brown (10YR 6/3m) silt loam; weak to moderate fine to medium platy; very friable; very fine 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 13. 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 H_2O	pH $CaCl_2$	C Total	$CaCO_3$ Equ.	N Total	C/N	Exch. Cations / Cations Ech. — Neutral Salt / Sel Neutre K	Neutral Salt Ca	Neutral Salt Mg	Neutral Salt Al	Neutral Salt Total	Buffered / Tamponée Total	NH_4OAc (pH7) Ca	NH_4OAc (pH7) Mg	NH_4OAc (pH7) Na	NH_4OAc (pH7) K	Dithionite Fe	Dithionite Al	Dithionite Mn	Oxalate Fe	Oxalate Al	Pyrophos. Fe	Pyrophos. Al
			%	%	%		me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	me/100g	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 Ca + Mg	Na	K	SAR	Avail. Nutrients / Assimilable N	P-Bray	K	S	Mica	Mineralogy / Mineralogie (2µm[1]) Chlorite	Kaolin	Smect.	Verm.	Quartz	Felds.	Part Size Dist. <2mm / anal. gran Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile Fine	Bulk D. / dens. app.	Moisture / Humiditié 1/3 atm	15 atm
	mmhos/cm	%	me/l	me/l	me/l		ppm	ppm	ppm	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%



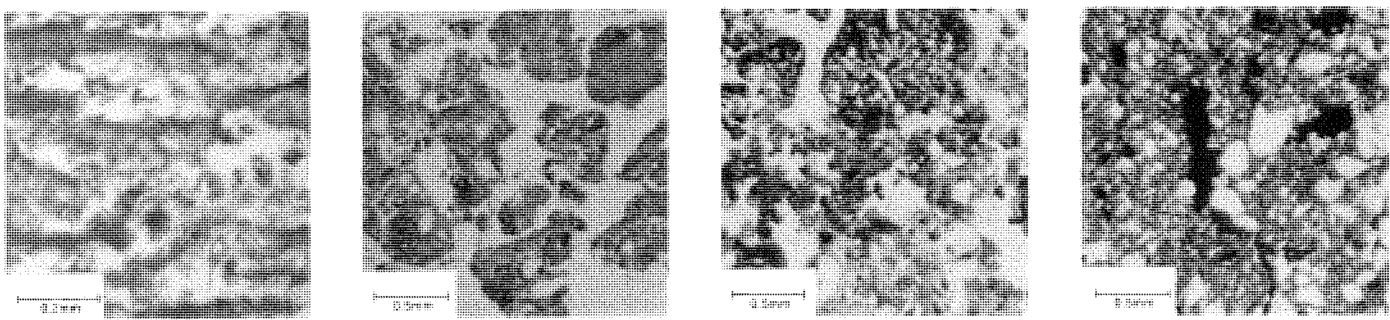
a b

Photograph by L. Knapik

Photography by G. Coen

FIG. 50 Upper Subalpine community (a) and Orthic Humo-Ferric Podsol on till (b) at the Bow Pass Site.

Figure 51. 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. 51a). 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. 51b) 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. 51c). 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. 51d). 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

Table 14. Vegetation structure of the Bow Pass Site

Layer		Species	Cover Class*
Tree Layer: A			
	A1:	*Picea engelmannii*	1
	A2:	*Abies lasiocarpa*	2
		Picea engelmannii	1
Shrub Layer: B			
	B1:	*Abies lasiocarpa*	1
		Picea engelmannii	1
	B2:	*Salix glauca*	2
		Abies lasiocarpa	1
		Picea engelmannii	+
		Pinus contorta	+
Herb Layer: C (including dwarf shrubs)			
	C:	*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%

a

Photography by G. Coen

b

Photography by G. Coen

FIG. 52 Lodgepole pine community (a) and Eluviated Eutric Brunisol on till (b) at the Portal Creek Site.

Description of an Eluviated Eutric Brunisol at the Portal Creek Site.

Location:	UTM 11U MJ 2930 5040 About 300 m along an abandoned roadway north of the Portal Creek picnic area
Elevation of Site:	1030 m a.s.l.
Landform:	Hummocky moraine
Slope:	35% complex slopes, crest of narrow ridge, northeast
Estimated drainage:	Well drained
Surface runoff:	Rapid
Parent material:	Calcareous, dense, coarse loamy till
Vegetation:	Representative species include lodgepole pine, buffalo berry and pine grass (see stand description, Table 16)
Climate:	Continental, with long cold winters and cool summers. Annual precipitation is in the range 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. The tills in this part of the valley have pockets of stratified gravels throughout the landform. Thin section evidence indicates that the cross sectional area of clay films is probably close to the 1% required to identify a Bt.

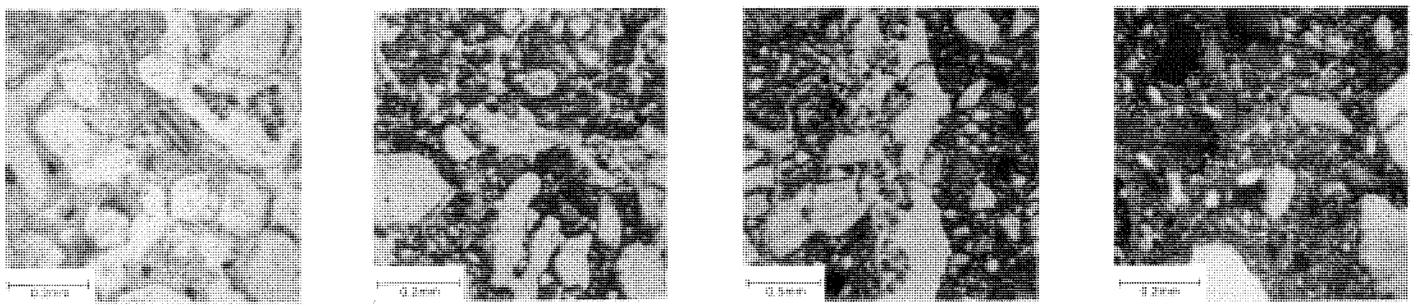
Horizon	Depth (cm)	Description
F-H	2-0	Very dark grayish brown (10YR 3/2m) well decomposed organic litter; plentiful fine and medium random roots; abrupt wavy boundary; 2 to 5 cm thick
Ae	0-14	Pale brown (10YR 6/3m) and very pale brown (10YR 7/3m) sandy loam; weak medium platy; very friable; few fine random roots; many fine random pores; no effervescence; estimated coarse fragments 5% gravels; clear wavy boundary; 12 to 20 cm thick
Bm	14-20	Strong brown (7.5YR 5/6m) loam; weak to moderate medium subangular blocky; friable; plentiful fine random roots; common fine random pores; no effervescence; no clay films; estimated coarse fragments 5% gravels; clear wavy boundary; 4 to 9 cm thick
Cca	20-35	Light yellowish brown (2.5YR 6/4m) sandy loam; structureless with weak, fine, subangular pseudo blocky structure; friable; abundant fine and medium vertical roots; very few fine pores; strong effervescence with common fine irregular white (10YR 8/2m) spots of secondary carbonates; estimated coarse fragments 10% gravels; clear wavy boundary; 9 to 18 cm thick
Ck1	35-50	Light yellowish brown to light olive brown (2.5YR 5.5/4m) sandy loam; structureless; firm; few fine random roots; very few fine random pores; strong effervescence; estimated coarse fragments 10% gravels and 10% cobbles; diffuse wavy boundary; 13 to 17 cm thick
Ck2	50-75	Light olive brown (2.5Y 5/4m) sandy loam; structureless; firm; few fine random exped roots; very few pores; strong effervescence; estimated coarse fragments 10% gravels and 10% cobbles; diffuse wavy boundary; 20 to 30 cm thick
Ck3	75-100	Light olive brown (2.5Y 5/4m) sandy loam; structureless; firm; strong effervescence; estimated coarse fragments 10% gravels and 10% cobbles; diffuse wavy boundary; 20 to 30 cm thick
Ck4	100-150+	Light olive brown (2.5Y 5/4m) sandy loam; structureless; firm; no roots; no pores; strong effervescence; estimated coarse fragments 10% gravels and 10% cobbles

TABLE 15. ANALYTICAL DATA FOR AN ELUVIATED EUTRIC BRUNISOL AT THE PORTAL CREEK SITE
DONNEES ANALYTIQUES DU BRUNISOL EUTRIQUE ELUVIEE A SITE PORTAL CREEK

Horizon	pH H_2O	pH $CaCl_2$	C Total	$CaCO_3$ Equ.	N Total	C/N	Exch. Cations / Cations Ech. — Buffered / Tamponée Total	NH4OAc (pH7) Ca	Mg	Na	K	Dithionite Fe	Dithionite Al	Dithionite Mn	Oxalate Fe	Oxalate Al	Pyrophos. Fe	Pyrophos. Al
			%	%	%		me/100g	me/100g	me/100g	me/100g	me/100g	%	%	%	%	%	%	%
FH	5.5	5.1	29.1		0.99	29	58.5	37.2	6.15	0.01	1.25							
Ae	6.4	5.7	0.56		0.03	19	5.0	5.09	0.92	0.00	0.07							
Bm	7.2	6.7	1.41	2.90	0.06	24	12.8	15.8	2.25	0.04	0.20	1.73	0.12	0.03	0.36	0.06	0.12	0.05
Cca	7.8	7.4		24.1														
Ck1	8.3	7.6		17.5														
Ck2	8.4	7.7		15.4														
Ck3	8.4	7.7		14.1														
Ck4	8.4	7.7		14.6														

Horizon	Avail. Nutrients / Assimilable N	P-Bray	K	S	Org. mat. / mat org. — Extracted / Extrait C	Extracted / Extrait N	Cha/Cfa	FA E4/E6	HA E4/E6	Part Size Dist. / anal. gran. <2mm — Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile fine	Bulk D. / Dens. app.
	ppm	ppm	ppm	ppm	%	%				%	%	%	%	g/cc
FH					26.7	41.8	0.92	8.8	6.1					
Ae	<1	0	23	2	45.9	36.6	0.41	11.2	6.7	58	35	7	1	1.5
Bm	<1	0	75	2	36.4	37.4	0.27	13.3	7.8	49	30	21	10	1.3
Cca										60	31	9	2	1.6
Ck1										59	32	9	1	1.9
Ck2										60	31	9	1	2.0
Ck3										54	36	10	2	1.9
Ck4										60	31	9	1	1.8

Figure 53. Micromorphology of the Eluviated Eutric Brunisol at the Portal Creek site.



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

Ae This horizon is moderately to loosely packed medium to grayish brown material in which most grains have matrans (<100μm) and the matrix material forms some aggregates (<3mm) but mainly occurs as thick bridges between grains (Fig. 53a). The overall appearance is a porous mass with (C) sand and gravel-sized rock fragments (sandstone, siltstone, shale, schist). There are some areas that are enriched with ferruginous clay and diffuse sesquioxidic nodules (<2.5mm) are (R) and occasionally contain some manganiferous material. Moderately oriented ferriargillans are (R-0), usually are thin (<100μm) vugh cutans to fillings, but occasionally are thick (<250μm) coatings on sand and gravel. Large moderately humified organic material (<8mm) is (0).
-1- intertextic
-2- matriplectic

Bm This horizon is moderately to loosely packed orange-brown material with some (20%) grayish brown areas. The former is enriched with ferruginous clay and contains (VR) diffuse sesquioxidic nodules (<300μm) that occasionally include some manganiferous material. Many grains have matrans (<100μm) which extend to form bridges and then to aggregates but most areas appear to consist of aggregates (<3mm) and fused aggregates (Fig. 53b). There are (0) sand and gravel-sized rock fragments, carbonates are (R) as sand and gravel, and calcans (<350μm) capping gravel are (VR). Weakly to moderately oriented ferriargillans are (R-0) and occur on free and embedded grains and occasionally on aggregate surfaces. Moderately humified organic material (<5mm) is (R-0).
-1- intertextic
-2- matriplectic//matrigranic//matriganoidic

Cca This horizon is very dense grayish calcareous material with (C) thick (<3mm) horizontal channels and skew planes which give an overall moderate porosity and a weak banded fabric. In the channels and skew planes are clusters of aggregates (50-300μm) that are occasionally fused (Fig. 53c). Carbonates are very abundant occuring as gravel, sand, coarse silt, a few calcans (<250μm) capping gravel and sand, and very fine matrix material. Ferruginous nodules (<400μm) are (VR) and there is (0) non-calcareous gravel (sandstone, siltstone, shale).
-1- silasepic porphyroskelic with weak banded fabric

Ck1 This horizon is moderately packed gray calcareous material (Fig. 53d) with (R) vughs and (C) skew planes, most of which are aligned subparallel to the surface. This material is quite dense but the abundant planar voids increase the overall porosity. Carbonates are very abundant occuring as gravel, sand, coarse silt, a few calcans (<500μm) capping gravel, (R-0) skew plane calcans (<120μm) and very fine matrix material. Sand and gravel-sized rock fragments (schist, quartzite, shale) are (0) and irregular ferruginous nodules (<200μm) are (VR).
-1- silasepic porphyroskelic

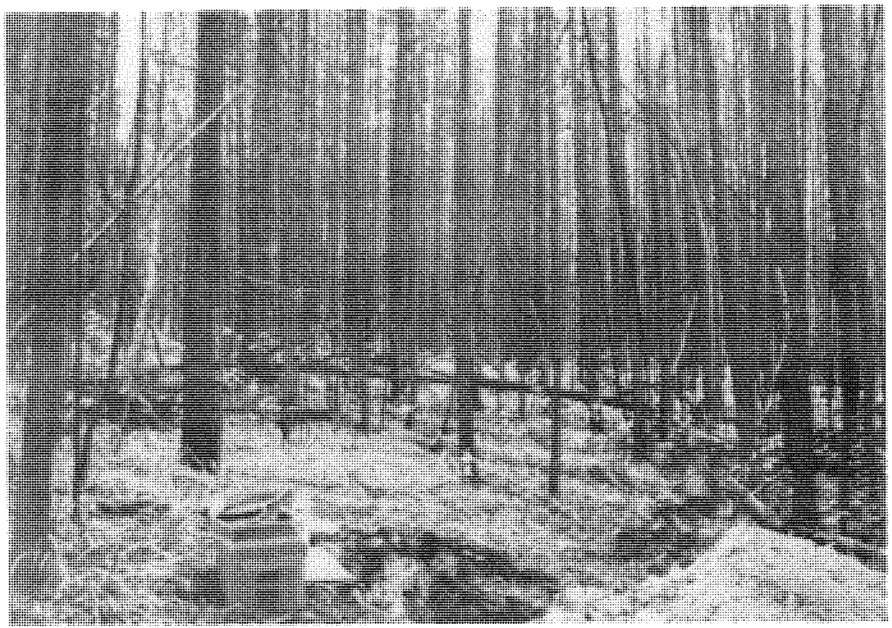
Table 16. Vegetation structure at the Portal Creek Site

Layer		Species	Cover Class*
Tree Layer: A			
	A1:	*Pinus contorta*	3
	A2:	*Pinus contorta*	2
Shrub Layer: B			
	B1:	*Pinus contorta*	2
	B2:	*Rosa acicularis*	1
		Shepherdia canadensis	+
Herb Layer: C			
	C:	*Calamagrostis rubescens*	2
		Arctostaphylos uva-ursi	2
		Vaccinium vitis-idaea	2
		Elymus innovatus	2
		Linnaea borealis	2
		Aster conspicuus	1
		Pyrola secunda	1
		Pyrola asarifolia	1
		Aquilegia sp. *(prob. flavescens)*	+
Moss and Lichen Layer: D			
	Db:	*Hylocomium splendens*	2
		Pleurozium schreberi	2
		Barbilophozia hatcheri	1
		Dicranum polysetum	1
		Dicranum sp.	1
		Aulacomnium palustre	+
		Tortula princeps	+
	Dl:	*Peltigera aphthosa*	1
		Cladonia spp.	2
		Peltigera canina	1

* 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 17: Long-term meteorological data for Jasper Lat. 52° 53' N Long. 118° 04 W Elevation 1,060 m. a.s.l.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Daily Temp C	-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
Mean Daily Max Temp C	-7.1	0.44	3.5	9.7	16.0	19.6	22.9	21.5	16.9	10.6	0.83	-4.6	9.1
Mean Daily Min Temp C	-17.3	-12.7	-8.9	-3.1	1.4	5.4	7.5	6.6	2.9	-1.1	-8.4	13.6	-3.4
Extreme Max Temp C	13.3	15.0	20.0	25.6	29.4	32.8	36.7	33.9	31.1	27.2	16.7	15.0	36.7
Extreme Min Temp C	-46.7	-43.3	-36.7	-28.9	-13.9	-6.7	-1.7	-2.8	-11.1	-21.7	-36.1	-42.2	-46.7
No. of Days with Frost	30	28	30	25	12	1		1	8	19	28	31	213
Mean Rainfall mm	2.0	2.3	3.1	13.5	32.3	49.8	47.5	48.0	34.0	25.9	9.4	5.8	274
Mean Snowfall mm	309.9	231.1	119.4	94.0	25.4	0	0	0	7.6	45.7	248.9	287	1369
Mean Total Pptn. mm	30.2	24.1	14.7	22.6	34.8	49.8	47.5	48.0	34.8	30.2	32.5	33.0	401

a 

Photography by G. Coen

b 

Photography by G. Coen

FIG. 54 Lodgepole pine community (a) and Orthic Gray Luvisol on till (b) at the Signal Mountain Site.

Description of an Orthic Gray Luvisol at the Signal Mountain site.

Location:	UTM 11U MJ 3290 6390 Near the start of the Signal Mountain fire road, Jasper National Park
Elevation:	1160 m a.s.l.
Landform:	Rolling moraine
Slope:	12% complex slope, midslope, northwest
Estimated drainage:	Well drained
Surface runoff:	Moderate
Parent Material:	Calcareous, dense, coarse loamy till
Vegetation:	Representative species include lodgepole pine, buffalo berry and pinegrass (see stand description, Table 19)
Climate:	Continental with fairly long cold winters and cool summers. Annual precipitation is in the 400 to 500 mm range.
Classification:	Canada - Orthic Gray Luvisol U.S.A. - Typic Cryoboralf F.A.O. - Albic Luvisol
Notes:	Soil temperature at 50 cm was 6 C. This site and pedon is typical of much of the montane areas in Jasper National Park.

Horizon	Depth (cm)	Description
L-H	4-0	Very dark gray (10YR 3/1m) and dark grayish brown (10YR 4/2m) well decomposed organic litter; abundant medium and coarse horizontal roots; abrupt wavy boundary; 3 to 5 cm thick
Ae1	0-3	Light gray (10YR 7/2m) loam; weak to moderate medium platy; very friable; plentiful fine roots; many very fine random pores; no effervescence; no clay films; estimated coarse fragments 5% gravels; abrupt broken boundary; 0 to 5 cm thick
Ae2	3-11	Pale brown (10YR 6/3m) fine sandy loam; weak medium platy; friable; plentiful fine roots; common very fine and fine pores; no clay films; no effervescence; estimated coarse fragments 5% gravels; clear wavy boundary; 6 to 9 cm thick
Bt	11-22	Yellowish brown to dark yellowish brown (10YR 4.5/4m) ped surfaces and light yellowish brown (10YR 6/4m) ped interiors; clay loam; moderate, medium to coarse subangular blocky; firm; few fine and medium oblique roots; common fine random pores; many moderately thick clay films in many voids and on some horizontal and vertical ped faces; no effervescence; estimated coarse fragments 5% gravels and 15% cobbles; clear wavy boundary; 8 to 12 cm thick
BCk	22-34	Yellowish brown (10YR 5/5m) ped surfaces and light yellowish brown (10YR 6/4m) ped interiors; loam; moderate medium subangular blocky; friable; few fine and medium roots; common fine random inped pores; few clay films in voids and on some vertical and horizontal ped faces; moderate effervescence; estimated coarse fragments 5% gravels and 15% cobbles; clear wavy boundary; 10 to 13 cm thick
Cca	34-75	Light brownish gray (2.5Y 6/2m) and dark brown (10YR 4/3m) loam to sandy loam; structureless; friable; few fine random roots; few fine random pores; few very thin films in voids or channels; strong effervescence; estimated coarse fragments 5% gravels and 15% cobbles; clear wavy boundary; 32 to 41 cm thick
Ck	75-102+	Grayish brown (2.5Y 5/2m) sandy loam; structureless; firm; very few roots; few fine random pores, few very thin clay films in voids or channels; strong effervescence; estimated coarse fragments 5% gravels and 15% cobbles.

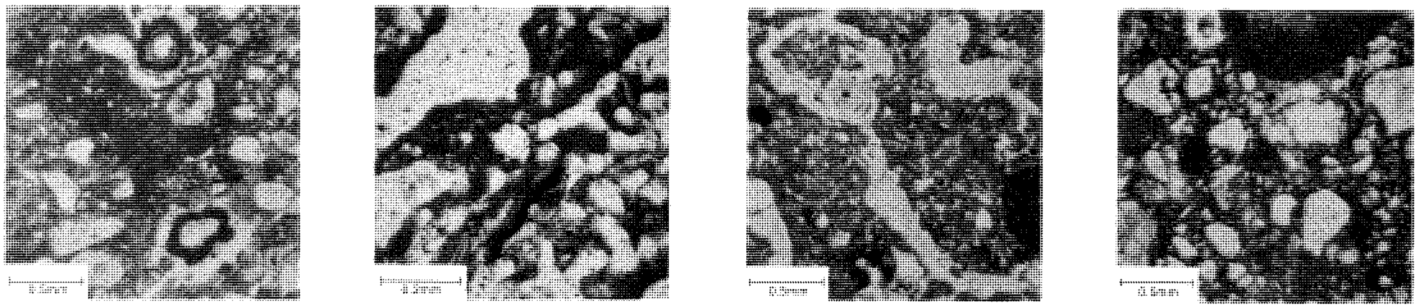
TABLE 18. ANALYTICAL DATA FOR AN ORTHIC GRAY LUVISOL AT THE SIGNAL MOUNTAIN SITE
DONNEES ANALYTIQUES DU LUVISOL GRIS ORTHIQUE A SITE SIGNAL MOUNTAIN

Horizon	pH H_2O	pH $CaCl_2$	C Total	$CaCO_3$ Equ.	N Total	C/N	Exch. Cations / Cations Ech. Buffered / Tamponée Total	Exch. Cations NH4OAc (pH7) Ca	Mg	Na	K	Avail. Nutrients / Assimilable N	P-Bray	K	S	Org. mat. / mat. org. Extracted / Extrait C	N	Cha/Cfa	FA E4/E6	HA E4/E6
			%	%	%		me/100g	me/100g	me/100g	me/100g	me/100g	ppm	ppm	ppm	ppm	%	%			
LH	6.8	6.1	35.4		1.16	31	107.	95.6	11.0	0.00	2.24	<1	8	138	6	27.8	51.3	0.60	10.3	6.8
Ae1	7.2	6.4	1.43		0.06	24	11.7	9.66	1.79	0.02	0.24									
Ae2	6.7	6.0	1.62		0.05	32	9.5	8.38	1.49	0.01	0.21	<1	1	78	2	39.1	54.8	0.45	9.6	5.4
Bt	7.5	6.8	1.01	2.10	0.06	17	10.4	19.4	2.51	0.00	0.56	<1	0	148	2	34.0	37.6	0.27	10.7	6.7
BCk	7.9	7.2		17.0																
Cca	8.1	7.4		22.65																
Ck	8.1	7.5		16.6																

Horizon	Mineralogy / Mineralogie (<2μm) Mica	Chlorite	Kaolin	Smect.	Verm.	Quartz	Felds.	Part. Size Dist (<2mm) / Anal. gran. Sand / Sable	Silt / Limon	Clay / Argile	F-Clay / Argile Fine	Bulk D. / dens. app.	Moisture / Humidité 1/3 atm	15 atm
								%	%	%	%	g/cc	%	%
LH														
Ae1	1	tr	0	1	1	1	tr	45	46	9	2		20	7.1
Ae2	2	tr	0	tr	1	1	tr	52	40	8	1	1.5	16	6.2
Bt	3	tr	0	0	0	1	tr	36	34	30	13	1.7	17	11.
BCk								40	33	27	10	1.6		
Cca	1	tr	0	0	0	1	tr	53	34	13	4	1.8		
Ck								55	33	12	3	1.7		

[1] Amount estimate from x-ray diffractograms: tr= trace, 1= 2-20%, 2= 20-40%, 3= 40-60%, 4= 60-80%, 5= 80-100%

Figure 55. Micromorphology of the Orthic Gray Luvisol at the Signal Mountain site.



a. plane light b. plane light c. plane light d. plane light

Ae2 This horizon is moderately packed grayish brown material with (C) channels (Fig. 55a), (O-C) vughs, and a few skew planes. The particle size is quite variable and includes a little gravel (sandstones and shales). The vughs and skew planes occasionally have smoothed surfaces and sometimes these surfaces are silty neoargillans (20-80μm). Some areas (10-20%) contain a high amount of birefringent clay with fine sand and silt. Diffuse ferruginous nodules (100-400μm) is (O-C).
-1- insepic porphyroskelic

Bt This horizon consists of moderately packed brown material with (C) vughs (250-1000μm), (O) skew planes, and (O) channels. The particle size is again quite variable and in some areas there is clustering of grains with sparse matrix material. It is in these loose areas that translocated clay partly to completely fills the intergranular spaces (Fig. 55b). Moderately oriented argillans (20-100μm) are (C) and occur on almost all void and free grain surfaces. There are some areas containing a high amount of birefringent clay with fine sand and silt. Diffuse ferruginous nodules (50-300μm) are (VR) and irregular manganiferous nodules are (R). Black organic material (300-2000μm) is (R-O). Carbonates are (C) occuring mainly as gravel and coarse sand but with some fine sand and silty. Channel calcans (50-200μm) are (VR).
-1- mosepic porphyroskelic
-2- matriplectic//matrigranoidic porphyroskelic

BCk This horizon is grayish brown material in which two fabrics are prominent. The first is large dense matrix aggregates (1-5mm), partially accommodated, being separated by channels and skew planes (Fig. 55c). These aggregates contain a few vughs (200-350μm). The second consists of smaller aggregates (50-1000μm) moderately to strongly fused and the resulting vughs are irregular, often interconnected and lined with (O) moderately oriented argillans (<80 with most 20μm). Carbonates are fairly abundant and occur as sand and coarse silt but mainly as fine material in the matrix and its content is quite variable from one area to another. Dark brown moderately humified organic material is (O). Gravel is (VR) and consists of shale and carbonates.
-1- insepic porphyroskelic and intertextic areas
-2- matrifragmic-matrigranoidic

Ck This horizon is dense brownish gray material with a wide range in particle size including (O-C) gravel (Fig. 55d). Irregular vughs are (C) and skew planes are (O). Silty vugh and skew plane weakly oriented argillans (20-120μm) are (R). Carbonates are not as abundant as in the BCk but are still plentiful and occur as gravel, sand, coarse silt and fine matrix material.
-1- silasepic porphyroskelic

Table 19. Vegetation structure at the Signal Mountain Site

Layer	Species	Cover Class*
Tree Layer: A		
A1:	*Pinus contorta*	3
	Populus tremuloides	1
A2:	*Pinus contorta*	2
Shrub Layer: B		
B1:	*Picea glauca*	2
	Pinus contorta	2
B2:	*Juniperus communis*	2
	Shepherdia canadensis	2
	Picea glauca	1
	Rosa acicularis	1
	Spiraea lucida	1
Herb Layer: C		
C:	*Calamagrostis rubescens*	2
	Vaccinium vitis-idaea	2
	Linnaea borealis	2
	Arctostaphylos uva-ursi	1
	Elymus innovatus	1
	Pyrola secunda	1
	Aster conspicuus	1
	Cornus canadensis	1
	Aster ciliolatus	1
	Pyrola spp.	2
Moss and Lichen Layer: D		
Db:	*Hylocomium splendens*	2
	Pleurozium schreberi	2
	Dicranum sp.	1
	Mnium sp.	1
	Barbilopozia hatcheri	1
	Other Mosses	1
	Tortula princeps	+
Dl:	*Peltigera aphthosa*	1
	Cladonia spp.	2
	Peltigera canina	1
Epiphyte Layer: E		
E:	*Usnea* sp.	1
	Hypogymnia sp.	+
	Letharia sp.	+

* 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 20: 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	-0.33	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	0.51	0.25	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

Appendix D: 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 20) is 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.

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.
Landform:	Eolian blanket over undulating moraine. The blanket thins to veneer eastward from Brûlé Lake
Slope:	3 to 5% complex slopes, crest
Estimated drainage:	Well drained
Surface runoff:	Moderate
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)
Vegetation:	Representative species include a predominance of 200 years old white spruce with an understory of hairy wild rye (see stand description, Table 22)
Climate:	Subhumid continental with moderate mean annual precipitation in the range of 450 to 550 mm
Classification:	Canada - Orthic Melanic Brunisol U.S.A. - Cumulic Cryoboroll F.A.O. - Calcic Chernozem
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 pseudo blocky; 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 pseudo blocky; 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 pseudo blocky; 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 pseudo blocky; 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 to sandy loam; friable; numerous pebbles and cobbles; moderately alkaline

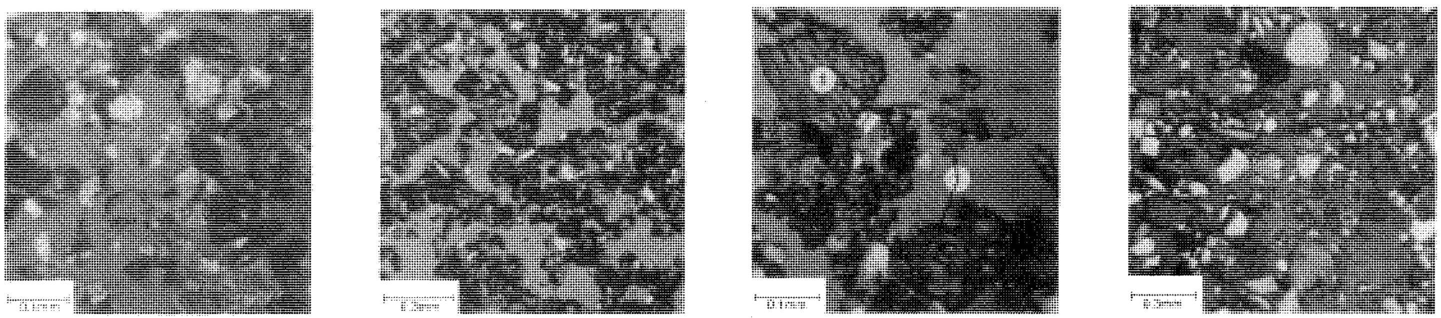
TABLE 21. ANALYTICAL DATA FOR THE ORTHIC MELANIC BRUNISOL (CALCAREOUS, CUMULIC) AT THE OVERLANDER SITE

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	0.31	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	ppm	ppm	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

Figure 56. 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)

Table 22. Vegetation structure at the Overlander Site

		Cover
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.	

APPENDIX E: SPECIES LIST

Scientific Name	Common Name
Abies balsamea	Balsam poplar
Abies lasiocarpa	Subalpine fir
Abietinella abietina	Moss or lichen
Achillea millefolium	Common yarrow
Agropyron repens	Couch or quack grass
Agropyron subsecundum	Bearded wheat grass
Alectoria sp.	Lichen
Amelanchier alnifolia	Saskatoon-berry
Antennaria lanata	Pussy-toes or everlasting
Aquilegia flavescens	Yellow columbine
Arctostaphylos uva-ursi	Common bearberry or kinnikinnick
Arnica cordifolia	Arnica
Arnica latifolia	Arnica
Aster ciliolatus	Lindley's Aster
Aster conspicuous	Snowy Aster
Astragalus alpinus	Milk vetch
Aulacomnium palustre	Moss
Barbilophozia hatcheri	Moss
Betula papyrifera	White, Paper, or Canoe birch
Betula pumila	Swampbirch
Bouteloua sp.	Grama grass
Brachythecium sp.	Moss
Calamagrostis rubescens	Pine grass
Campylium sp.	Moss
Carex corcinna	Sedge
Carex seirpoidea	Sedge
Castilleja miniata	Red Paint-brush
Castilleja raupii	Indian Paint-brush
Cladonia sp.	Lichen
Clematis verticellaris	Purple clematis
Cornus canadensis	Bunchberry
Corylus cornuta	Beaked hazelnut
Cypripedium calceolus	Yellow Lady's-slipper
Delphinium glaucum	Tall larkspur
Deschampsia atropurpurea	Mountain Hair Grass
Dicranum fuscescens	Moss
Dicranum polysetum	Moss
Disporum trachycarpum	Fairy-bells
Drepanocladus uncinatus	Moss
Dryas drummondii	Yellow Dryad
Dryas octopetala	White Dryad
Elaeagnus commutata	Silver-berry or Wolf willow
Elymus innovatus	Hairy Wild Rye
Epilobium angustifolium	Fireweed
Equisetum scirpoides	Horsetail
Eriqeron aureus	Fleabane or Wild Daisy
Erigeron peregrinus	Fleabane or Wild Daisy
Festuca sp.	Fescue

Scientific Name	Common Name
Fragaria virginiana	Wild Strawberry
Galium boreale	Northern Bedstraw
Gentianella amarella	Felwort
Geocaulon lividum	Bastard Toad-flax
Habenaria sp.	Bog Orchid
Hedysarum alpinum	Sweetvetch
Hedysarum mackenzii	Sweetvetch
Hedysarum sulphurescens	Sweetvetch
Hieracium gracile	Hawkweed
Hylocomium splendens	Moss
Hypnum spp.	Moss
Hypogymnia spp.	Moss
Juniperus cleommunis	Ground Juniper
Juniperus horizontalis	Creeping Juniper
Koeleria sp.	June Grass
Larix laricina	Tamarack
Larix lyallii	Alpine Larch
Lathyrus ochroleucus	Vetchling or Pea Vine
Letharia sp.	Lichen
Linnaea borealis	Twin-flower
Lonicera dioica	Twining Honeysuckle
Lonicera involucrata	Bracted Honeysuckle
Luzula spicata	Wood Rush
Mertensia paniculata	Tall Mertensia
Mitella nuda	Bishop's cap
Mnium sp.	Moss
Orchis rotundifolia	Round-leaved Orchid
Oxytropis deflexa	Reflexed Loco-weed
Parmelia sp.	Lichen
Parmeliopsis sp.	Lichen
Pedicularis bracteosa	Lousewort
Peltigera aphthosa	Lichen
Peltigera canina	Lichen
Phyllodoce empetriformis	Red or Purple Heather
Phyllodoce glanduliflora	Yellow Heather
Picea engelmannii	Engelmann Spruce
Picea glauca	White Spruce
Picea mariana	Black Spruce
Pinus albicaulis	Whitebark Pine
Pinus contorta	Lodgepole Pine
Pinus flexilis	Limber Pine
Pleurozium schreberi	Moss
Poa nervosa	Bluegrass
Poa pratensis	Kentucky Bluegrass
Polytrichum commune	Moss
Polytrichum juniperinum	Moss
Populus balsamifera	Balsam poplar
Populus tremuloides	Trembling Aspen
Potentilla diversifolia	Cinquefoil
Pontentilla fruticosa	Schrubby cinquefoil
Prunus virginiana	Choke cherry
Psuedotsuga menziesii	Douglas fir

Scientific Name	Common Name
Ptillium crista-castrensis	Moss
Pyrola asarifolia	Common Pink Wintergreen
Pyrola secunda	One-sided Wintergreen
Pyrola virens	Greenish-flowered Wintergreen
Rosa acicularis	Prickly Rose
Rubus pubescens	Dewberry or Running Raspberry
Salix arctica	Willow
Salix glauca	Willow
Salix nivalis	Willow
Salix scouleriana	Willow
Sedum stenopetalum	Common Stonecrop
Selaginella densa	Little Club-moss
Senecio indecorus	Groundsel or Ragwort
Sheperdia canadensis	Canadian Buffalo-berry
Smilacina stellata	Star-Flowered Solomon's-seal
Solidago multiradiata	Goldenrod
Spiraea lucida	White Meadowsweet
Stengnthium occidentale	Bronze-bells
Stereocaulon sp.	Lichen
Stipa sp.	Needle Grass
Streptopus amplexifolius	Twisted stalk
Symphoricarpos albus	Snowberry
Symphoricarpus occidentalis	Buckbrush or Wolfberry
Taraxacum officinale	Common Dandelion
Thalictrum venulosum	Veiny Meadow Rue
Thuidium recognitum	Lichen
Tortula princeps	Lichen
Trisetum spicatum	Spike Trisetum
Usnea sp.	Lichen
Vaccinium caespitosum	Dwarf Bilberry
Vaccinium scoparium	Grouse-berry
Vaccinium vitis-idaea	Bog Cranberry or Cow-berry
Viburnum edule	Low-bush Cranberry
Vicia americana	Wild Vetch
Viola regulosa	Western Canada Violet
Zygadenus elegans	White Camas