DETAILED SOIL SURVEY OF THE

MOUNT REVELSTOKE SUMMIT AREA

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with an Environmental Fragility Rating System

by L. Knapik and M. Landals

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INTRODUCTION

In recent years Parks Canada has commissioned environmental studies of various areas within the National Parks. These studies generally involve an inventory of natural resources, an assessment of present and potential user impact, and recommendations regarding the management of the area. The findings of these studies are used as a basis for resource management in the Parks.

Nature and Scope of Study

The present study was carried out in conjunction with a study by M. Landals and G. W. Scotter of the Canadian Wildlife Service which involves plant community analysis and mapping, and the evaluation and prediction of environmental damage. Data from the vegetation and soils studies have been pooled to rate the relative sensitivity of ecological units within the study area. The environmental fragility ratings are included in this report (page 60) and have also been included in the report by Landals and Scotter.

This study involved a description, classification, and mapping of the soils in detail and evaluation of the use limitations of the soils. Parallel aims of the study include providing information for efficient and ecologically sound use of the land resources and providing data for researchers in other branches of science.

Specific Objectives of this Study

The specific objectives of this study are described in the Terms of Reference for an Environmental Impact Assessment of the Mount Revelstoke Summit Area (Parks Canada files). These objectives include detailed mapping of the soils at a scale of 1:6,000 (1 inch = 500 feet) of an area 2.0 miles long and 0.75 miles wide along the summit of Mount Revelstoke. Soil interpretations were requested for erosion susceptibility, drainage characteristics, engineering foundation characteristics, and soil productivity. The pedological research is intended to provide input into the determination of the relative fragility of ecological units and in assigning fragility ratings to ecological units so as to provide information for area planning and management.

Use of Report

This report consists of a written text, a detailed soils map (in rear pocket), and interpretive maps and tables showing soil limitations for various uses. The report includes general and detailed morphological descriptions of the soils, chemical and physical analyses data, and interpretive ratings of the soils for recreational uses.

In order to obtain information about the soil in a given area, locate the area on the map and identify the soil in the legend. Some basic information is given in the legend but the descriptive and interpretive sections of the report should be consulted for further information. General descriptions of the soils are included within the main body of the report and detailed soil map unit descriptions and analytical data are located in Appendix A.

Definitions of descriptive terms are included in Appendix B.

THE STUDY AREA

Geographic Location

The study area comprises an area of approximately 1.5 square miles, with dimensions of 2 miles by .75 miles, along the summit of Mount Revelstoke (Figure 1). This area is located to the northeast of the city of Revelstoke, British Columbia in Mount Revelstoke National Park. Approximate co-ordinates are lat. 51° 03'N and long. 118° 08'W. Included within the study area are Heather Lake, Balsam Lakes and the Summit viewpoint.

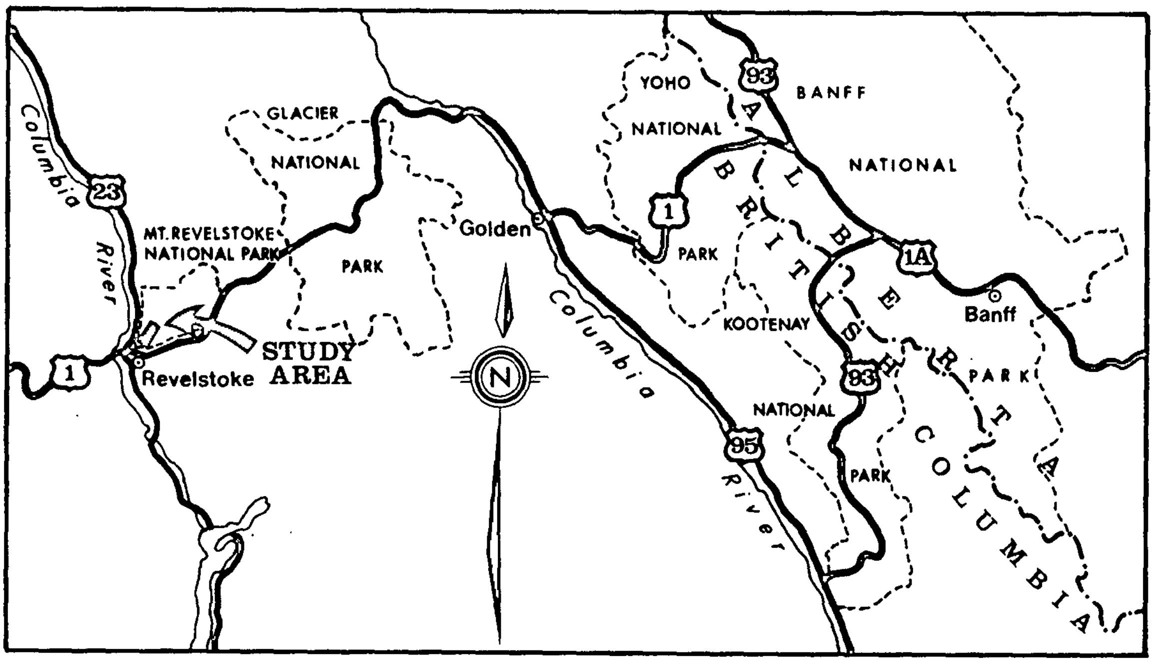
Physiography

This is a mountainous area, being part of the medium sized Selkirk Mountains. Elevation of the summit ridge is approximately 6,300 to 6,400 feet ASL[1] and the lowest parts of the study area approach 5,500 feet ASL. Topography of the area is rough, with most slopes being steeply to extremely sloping (15 to 70 percent) (Canada Soil Survey Committee, 1970). The topography is controlled by the bedrock which outcrops frequently.

Bedrock geology of the area has been mapped by the Geological survey of Canada at a scale of 1:250,000 (1" = 4 miles) (Geol. Surv. Can. map 12, 1964). Wheeler (1964) describes the bedrock in the area as being composed of a great variety of metamorphic and granitic rocks. The bedrock is part of the Clachnacudainn Salient structure of the Shuswap Metamorphic Complex. The dominant rocks are hornblende granodiorite-gneiss, and leucogranite. The leucogranite occurs as dikes and as extensive masses. The age of these rocks is not certain but they appear to be of variable age, with the youngest rocks being lower Cambrian (Wheeler, 1964). We found no

[1] ASL = Above sea level.

FIGURE 1: LOCATION MAP.



calcareous rocks in the study area and all the surficial deposits are non-calcareous.

Observations made during this study indicate that the area has been glaciated and the bedrock outcrops generally display a rounded appearance due to glacial abrasion. A thin veneer (2 - 10') of glacial till is present on most of the summit area. Local deposits of colluvial debris (talus) are present at the base of steep bedrock exposures and accumulations of slope wash and alluvial sediments are found in stream channels and basins. Volcanic ash is present in two distinct, separated layers (indicating at least two separate falls) in several of the alluvial sections and over much of the area it is probably mixed in with other materials in a less conspicuous manner.

Climate

Meteorological data for the summit area are very limited. Snow depth studies have been carried out in the area (Files, Mt. Revelstoke N.P. Headquarters) and climatic data were collected at four sites during the summer of 1973 (Landals and Scotter, in prep.). Data from stations in the general area are shown in Table 1. The elevation of Mount Revelstoke Summit (6,360 feet ASL) is comparable to that of the meteorological stations at Mount Copeland (6,060 feet ASL) and Fidelity Mountain (6,380 feet ASL) and general climatic conditions should also be similar. It is obvious that this is a high snowfall area, the amount of snowfall generally increasing with elevation. Snowmelt on the Summit is not complete until mid-July and freezing temperatures and snowfall may occur any day of the year. The effect of altitude on temperatures and precipitation may be seen by comparing the data for the Revelstoke stations (ca. 1,500 feet ASL) with the data for

TABLE 1. METEOROLOGICAL DATA FROM NEARBY STATIONS

Station	Revelstoke (CP&A)[1]	Mt. Copeland	Mt. Fidelity (GNP)[2]	Rogers Pass (GNP)[3]
Location	51°00'N, 118°12'W	51°12'N, 118°23'W	51°14'N, 117°42'W	51°17'N, 117°31'W
Elevation	1,497'	6,060'	6,380'	4,340'
Mean Annual Temperature (°F)	44.8	40.8[4]	30.3	35.1
Mean Annual Precipitation (inches)	42.0	95.2[5]	76.7	63.8
Total Annual Snowfall (inches)	170	834[4]	586	440

(1) - Data from 1960 to Nov. '69 from Canadian Pacific Railway station, Revelstoke. Data from Dec.'69 to Dec. '71 from new Revelstoke airport location (Rev. airport 50 58'N, 118 11'W, 1,467').

(2) - Data from 1969 to 1971. (GNP = Glacier National Park.)

(3) - Data from 1966 to 1967 and 1969 to 1971.

(4) - Data from 1970 only.

(5) - Data from 1970 and 1971.

Source of data = Canada Department of Meteorology and Transport, Monthly Summaries.

Mount Copeland (6,060 feet ASL). At Revelstoke mean annual precipitation is 42.0 inches with about 17 inches occurring as snow and at Mount Copeland there is a total precipitation of 95.2 inches with about 83.4 inches as snow.

Vegetation

The Summit area represents the upper limit of the continuous forest zone in this area. This timberline zone (Daubenmire, 1943) or forest-tundra ecotone (Weaver and Clements, 1938; Marr, 1961) is characterized by clumps and individuals of coniferous trees, *Abies lasiocarpa* with occasional *Picea engelmannii* and meadows of mixed herbaceous vegetation (dominant species include *Luetkea pectinata*, *Carex* spp., *Valeriana sitchensis*, *Arnica latifolia*, *Erigeron peregrinus*, *Antennaria lanata*, and patches of *Cassiope mertensiana*). The forested areas are dominated by *Abies lasiocarpa*, with *Rhododendron albiflorum* and *Vaccinium membranaceum* understory vegetation.

Complete descriptions and a map of plant communities are included in the report by Landals and Scotter (in prep.). Plant nomenclature is according to Hitchcock and Cronquist (1973). A table of scientific and common plant names is included in the Appendix.

History and Development

Mount Revelstoke Park was established in 1914 and in 1927 the first road was built to the Summit. A commercial tourist lodge was operated on the Summit from 1940 to 1963. In 1967 the road was rebuilt to its present gravel surfaced standards. The lodge has been removed and the area is presently a day-use area only. A system of hiking trails traverses the area, originating from the two parking lots, which are located at the Summit and beside Balsam Lake. These trails connect the Summit area to Millar Lake, Eva Lake, and Jade Lakes. Because of the dead end nature of the road at the scenic Summit and the sedentary nature of most park visitors, use of the area is concentrated into a small area surrounding the parking lots where people walk around the small Summit area to look at the view.

METHODS OF INVESTIGATION

Field Techniques

The first step in a soil survey project such as this is to examine the soils and set up a working map legend or key to the soils. In order to accomplish this, soil profiles are examined and described and related to landform, landscape position, and vegetation patterns. The soil profiles serve as reference points in the continuum of soil variation and because no two profiles are identical it is necessary, for practical purposes, to define a class (soil mapping unit) with properties that vary within specified limits. Soil map units, which consist of mappable groups of soils with a high degree of homogeneity, are defined with a limited variation in such inherent soil properties as horizonation, texture, and drainage. The nomenclature and guidelines of the System of Soil Classification for Canada (Canada Soil Survey Committee, 1970 and 1973) was used throughout the study with soil classification following the 1973 guidelines. Soil areas were identified through field observations of soil characteristics and then delineated on aerial photographs using stereoscopic techniques. As mapping progressed, concepts and limits of soil map units were refined and separations were checked until a final map was completed. Because slope is an integral part of the concept of a soil mapping unit, separations were made according to topographic classes and each soil area is identified as to its slope.

In a detailed soil survey such as this (mapping scale 1:6,000) the soil areas delineated have a high degree of homogeneity; however some heterogeneity, in the form of inclusions too small to show on the map, is always present.

Panchromatic black and white aerial photographs at a scale of approximately 1:12,000 (1 inch = 1,000 feet) were used for field mapping. Color infrared aerial photographs covering a large portion of the study area were obtained after the field work was completed. These photos, which were the same scale (1:6,000) as the desired scale of publication, were used for checking and refining soil boundaries.

Thirteen soil pedons representing ten soil map units were described in detail and sampled for laboratory analyses (more than one type pedon was described and sampled for some map units to show variation). In total over 100 observations of soil profiles were made.

Bulk densities of soil horizons were determined at several locations using a hand coring device.

Chemical and Physical Analyses

Chemical and physical analyses were carried out in the Alberta Institute of Pedology laboratories using standard procedures. The determinations and methods used were as follows:

1. Soil Reaction; pH was determined in a 2:1 solution to soil ratio using 0.01 M $CaCl_2$ (Peech, 1965).
2. Total Nitrogen; the Kjeldahl-Wilfarth-Gunning method (A.O.A.C., 1955).
3. Organic Carbon; determined by dry combustion in a Leco combustion furnace.
4. Exchangeable Cations; extraction with ammonium acetate at pH 7 (A.O.A.C., 1955) and K, Na, Mg, and Ca determined by atomic absorption spectrophotometry.
5. Exchange Capacity; measured by displacement of ammonium with sodium chloride (Chapman, 1965).

6. Pyrophosphate-Extractable Aluminum and Iron; organically complexed aluminum and iron were extracted using a 0.1 M pyrophosphate extraction (McKeague, 1967). Al and Fe were determined by atomic absorption spectrophotometry.
7. Particle Size Distribution; determined using the pipette method of Kilmer and Alexander as modified by Toogood and Peters (1953) with removal of organic matter by oxidation with hydrogen peroxide.
8. Liquid Limit and Plastic Limit; by the method outlined by ASTM (1970).

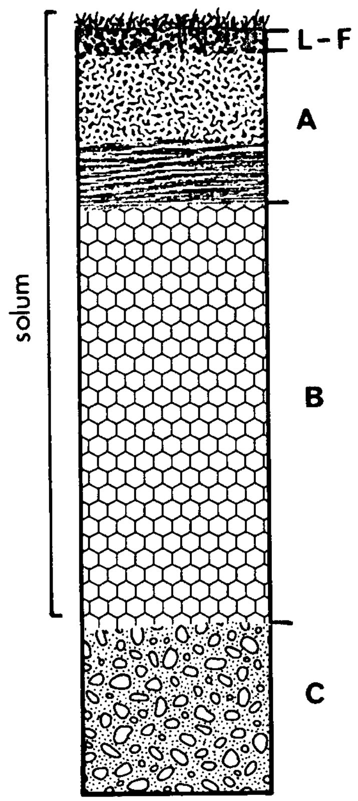
THE SOILS

Soil Genesis

Soils are natural bodies present on the earth's surface that are an integral part of the environment. Soils display variation both vertically and horizontally and by examining these variations soil individuals may be recognized. Soils have evolved from their geological parent material through the action of a combination of soil forming processes, which are controlled by environmental parameters or "soil forming factors". These soil forming factors are commonly listed as being the parent material, climate, biotic agents and topography all acting through time. The variations in relative importance or dominance of one or more of the soil forming processes such as addition and removal of organic matter, translocation of clays or iron and aluminum, and chemical and physical transformations result in the formation of horizons or layers of various kinds within the soil body. These horizons differ from one another in such properties as color, texture, structure, consistence, and chemical and biological activity. The major, or master horizons are designated O for organic layers developed mainly from mosses, rushes, and woody materials; L, F and H for organic layers developed mainly from leaves, twigs, woody materials, and a minor component of mosses; and A, B and C for mineral horizons. Subdivisions of the master horizons are denoted by suffix letters appended to the master horizon symbol (see Figure 2, Table 2, and glossary).

The A horizon is at or near the surface in the zone of maximum accumulation of organic matter (Ah), or removal of materials in solution and suspension (Ae).

FIGURE 2. DIAGRAM OF A SOIL PROFILE



L-F --Organic layer which may be subdivided into L,F,H or Of, Om, and Oh

A --A mineral horizon at or near the surface. It may be a dark colored horizon in which there is an accumulation of humus(Ah), or a light colored horizon from which clay, iron, and humus have been leached(Ae).

B --Mineral horizon that (1) may have an enrichment of iron(Bf), or organic matter(Bh); or (2) may be altered to give a change in color or structure (Bm).

C --Mineral horizon comparatively unaffected by the soil forming process operative in the A and B horizons except for the process of gleying (Cg).

The B horizon is the zone of accumulation of materials carried down from the A or is markedly altered by chemical and physical processes to give a change in color or structure. Bf horizons have accumulations of significant amounts of iron and aluminum. Bm horizons have lesser amounts. The C is underlying material which is comparatively unaffected by the pedogenic (soil forming) processes.

Through observation of soil characteristics it is possible to classify soils into taxanomic units. In this report the System of Soil Classification for Canada (Canada Soil Survey Committee, 1973) is used (see Table 3, Key to the Soils). The criteria used for making the taxonomic separations are significant for understanding soil genesis and for land use applications.

TABLE 2. DEFINITION OF SOIL HORIZON SYMBOLS (after C.S.S.C., 1973)

Organic Layers

Organic layers are found at the surface of some mineral soils, and may occur at any depth beneath the surface in buried soils, or overlying geologic deposits. They contain more than 17% organic carbon by weight. Two groups of these layers are recognized.

O - This is an organic layer developed mainly from mosses, rushes, and woody materials.

Of - The fibric layer is the least decomposed of all the organic soil materials. It has large amounts of well-preserved fibre that are readily identifiable as to botanical origin.

Om - The mesic layer is the intermediate stage of decomposition with intermediate amounts of fibre, bulk density and water-holding capacity. The material is partly altered both physically and biochemically. A mesic layer is one that fails to meet the requirements of fibric or of humic.

Oh - The humic layer is the most highly decomposed of the organic soil materials. It has the least amount of fibre, the highest bulk density, and the lowest saturated water-holding capacity. It is very stable and changes very little physically or chemically with time unless it is drained.

L-F-H - These organic layers develop primarily from leaves, twigs, woody materials, and a minor component of mosses.

L - This is an organic layer characterized by an accumulation of organic matter in which the original structures are easily discernible.

F - This is an organic layer characterized by an accumulation of partly decomposed organic matter. The original structures in part are difficult to recognize. The layer may be partly comminuted by soil fauna, as in moder[1], or it may be a partly decomposed mat permeated by fungal hyphae, as in mor.[1]

H - This is an organic layer characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible. This material differs from the F layer by its greater humification chiefly through the action of organisms. This layer is a zoogenous humus form consisting mainly of spherical or cylindrical droppings of microarthropods. It is frequently intermixed with mineral grains, especially near the junction with a mineral layer.

Master Mineral Horizons and Layers

Mineral horizons are those that contain less organic matter than that specified for organic layers.

A - This is a mineral horizon or horizons formed at or near the surface in the zone of removal of materials in solution and suspension, or of maximum in situ accumulation of organic matter, or both. Included are:
(1) horizons in which organic matter has accumulated as a result of biological activity (Ah);
(2) horizons that have been eluviated of clay, iron, aluminum, or organic matter, or of all of these (Ae).

B - This is a mineral horizon or horizons characterized by one or more of the following:
(1) an enrichment in iron, aluminum, or humus, alone or in combination (Bf, Bhf, and Bh);
(2) an alteration by hydrolysis, reduction, or oxidation to give a change in color or structure from horizons above or below (Bm and Bg).

C - This is a mineral horizon or horizons comparatively unaffected by the pedogenic processes operative in A and B, excepting the process of gleying.

R - This is consolidated bedrock that is too hard to break with the hands or dig with a spade when moist, and that does not meet the requirements of a C horizon. The boundary between the R layer and any overlying unconsolidated material is called a lithic contact.

Lowercase Suffices

b - A buried soil horizon.

e - A horizon characterized by the removal of clay, iron, aluminum, or organic matter alone, or in combination. When dry, it is higher in color value by 1 or more units than an underlying B horizon. It is used with A (Ae, Ahe).

f - A horizon enriched with amorphous material, principally Al and Fe combined with organic matter. It usually has a hue of 7.5 YR or redder. It contains 0.6% or more pyrophosphate-extractable Al and Fe in textures finer than sand and 0.4% or more in sands. The ratio of Al and Fe to clay is more than 0.05 and organic C exceeds 0.5%.

g - A horizon characterized by gray colors, or prominent mottling, or both, indicative of permanent or periodic intense reduction. Chromas of the matrix are generally 1 or less.

h - A horizon enriched with organic matter. When used with A it must show one Munsell unit of value darker than the horizon below, or have 0.5% more organic matter than the IC. It contains less than 17% organic carbon by weight. When used with B (Bh) it contains more than 1% organic carbon, less than 0.3% pyrophosphate-extractable Fe, and has a ratio of organic carbon to pyrophosphate-extractable Fe of 20 or more.

m - A horizon slightly altered by hydrolysis, oxidation, or solution, or all three, to give a change in color or structure, or both.

[1] Bernier, B. 1968. Soils under forest. Proceedings of the Seventh Meeting of the National Soil Survey committee of Canada. p. 145 and 147.

Soils of the Summit Area

The soils in the Summit area reflect the cool, fairly moist climatic conditions. Podzolic soils are most common, especially in the forested areas. Two main types of Podzolic profiles are present in the area; those with a fairly deep, dark colored surface (Ah) horizon and those in which this horizon is very thin or absent, and a light gray, eluviated (Ae) horizon is present in its place. In both cases the underlying B horizon is dark reddish brown and contains high amounts of amorphous iron and aluminum oxides (criteria for Bf horizon). These B horizons may be quite firm due to cementation of soil aggregates, probably by iron oxides. Thin Podzolic soils over bedrock (Lithic Podzols) are present whenever the bedrock is within 50 cm (20 in.) of the surface.

Podzolic soils with lesser amounts of iron and aluminum concentrated in the B horizon are dominant along the Summit ridge above the continuous forest under predominantly alpine vegetation. These soils have a turfy layer overlying a thick dark Ah horizon and a dark brown Bf horizon.

Regosolic soils having a very thick, dark Ah horizon directly overlying the C horizon, are associated with steep slopes. Soil creep is often active on the steep slopes, disrupting horizon differentiation and thus preventing the formation of B horizons. Imperfectly to "moderately" poorly drained Regosolic soils with thick organic (Oh) surface horizons are found in poorly defined snowmelt runoff channels and in areas of late snowmelt.

Poorly and very poorly drained soils, that are saturated with water throughout the year or for a considerable part of the year, are present marginal to stream channels, in depressional basins, and in areas of groundwater discharge. These soils generally exhibit reduced (gleyed)

TABLE 3. KEY TO THE SOILS OF THE MOUNT REVELSTOKE SUMMIT AREA

Soil Map Unit No.	Soil Subgroup Classification	Parent Material	Major Horizons	Surface Horizon Texture	Topography Classes	Dominant Vegetation	Internal Drainage	Comments
1	Orthic Humo-Ferric Podzol	shallow aeolian over till	Ah,B(h)f, C	SiL	E,F,G	Carex nigricans Luetkea	well drained	Occur mostly under alpine vegetation at the north end of the summit ridge in fairly stable slope positions. Bhf horizons of less than 10 cm thickness are often present.
2	Orthic Sombric Brunisol & minor Sombric Humo-Ferric Podzol	till, colluvium	Ah 10 cm Bm,C	SL	F,G,H	Valeriana, Veratrum, Heracleum. Epilobium, Abies-Vaccinium	well drained	Soil creep is active on steep slopes of up to 75%. Ah is 10 to 40 cm thick.
3	Orthic and Cumulic Regosol	alluvium slope wash	Oh,(AC), C	Organic	C to F	Luetkea Carex nigricans	imperfectly drained	These soils occupy snowmelt drainage channels and areas of late snowmelt. Organic surface horizons contain 30 to 50% organic matter.
4	Rego Gleysol	alluvium, lacustrine, volcanic ash	Oh,Cg	Organic	B to F	Carex nigricans	poorly and very poorly drained	Soils occur in areas of groundwater seepage, and marginal to streams. Surface horizons contain 60 to 70% organic matter. Volcanic ash layers commonly found in profile.
5	peaty Rego Humic Gleysol	alluvium slope wash	Of,Ahg,Cg	Organic	F	Eriophorum Carex Sphagnum	very poorly drained	Surface accumulation of peaty organic material. Occur in areas of groundwater seepage, often on 15 to 30% slopes.
6	Sombric Ferro-Humic Podzol	volcanic ash, alluvium lacustrine	Ah,Bhf, Bhf2,C	SiL	B to C	Carex nigricans	imperfectly and poorly drained	Weakly cryoturbated soils (earth hummocks) in enclosed basins developed on accumulations of volcanic ash. Ponding occurs in July.
7	Orthic and Cumulic Regosol	colluvium till	Ah (40 cm) (AC),C	SL	F,G	Abies-Rhododendron, Veratrum, Senecio, Erigeron, (Gramineae)	well drained	Soil creep is very active on very steep slopes, causing disruption of horizons. Ah is 40 cm thick. Map unit 7A refers to an avalanche track location of these soils.
8	Sombric Humo-Ferric Podzol	till	Ah,Bf,C	SiL	C to G	Abies-Rhododendron, Luetkea, Cassiope	well drained	Ah >7.5 cm, occasional ortstein cementation of Bf.
9	Ortstein Ferro-Humic Podzol	till	L-F,Ae(h) Bhf,Bfc,C	SL	E to G	Abies-Rhododendron, Vaccinium membranaceum, Luetkea,Phyllococe	well drained	The lower Bf horizon is firmly cemented (ortstein). No Ah is present.
10	Lithic Humo-Ferric Podzol	till,shallow to bedrock	L-F,(Ah), Ae,Bf,R	SL	G,H	Abies-Rhododendron, Vaccinium, Luetkea,Arnica	well drained	Bedrock contact occurs at less than 50 cm. Some of these soils have a thin Ah.

MISCELLANEOUS MAPPING UNITS

R Bedrock exposure

T Talus and other coarse colluvial materials

w Water

colors and are classified as Gleysolic soils. Fairly deep accumulations of peaty organic materials may be present on the surface of these soils overlying dark colored A horizons and dull gray C horizons.

Features of minor areal extent, but of considerable interest, are the earth hummocks developed in isolated basins in the southern portion of the study area. These features are apparently a result of frost action and are fairly common in alpine and arctic regions (Washburn, 1956; Knapik, Scotter and Pettapiece, 1973). Another interesting feature in the area is the disturbance of some surface horizons by burrowing of small mammals (voles?).

Map Unit Descriptions

Soil Map Unit 1 (Orthic Humo-Ferric Podzol)

These are well drained Podzolic soils occurring mainly along the upper slopes and summit of the ridge in the north half of the study area. The vegetation cover consists of alpine communities of *Carex nigricans* and *Luetkea pectinata* with scattered individuals and clumps of *Abies lasiocarpa*. The land surface is freely drained and is moderately rolling to very steeply sloping. Surface boulders are common in these soil areas.

The soils are characterized by a dark colored Ah horizon with a turfy surface and a thin, dark brown Bhf (Plate 1). In many cases these two horizons with silt loam textures overlie another complete Ah, Bf, C profile which is sandy loam textured. The upper profile has developed in what seems to be an aeolian (wind-deposited) material which overlies the glacial till. This surficial deposit is not continuous over the soil area but it is common.

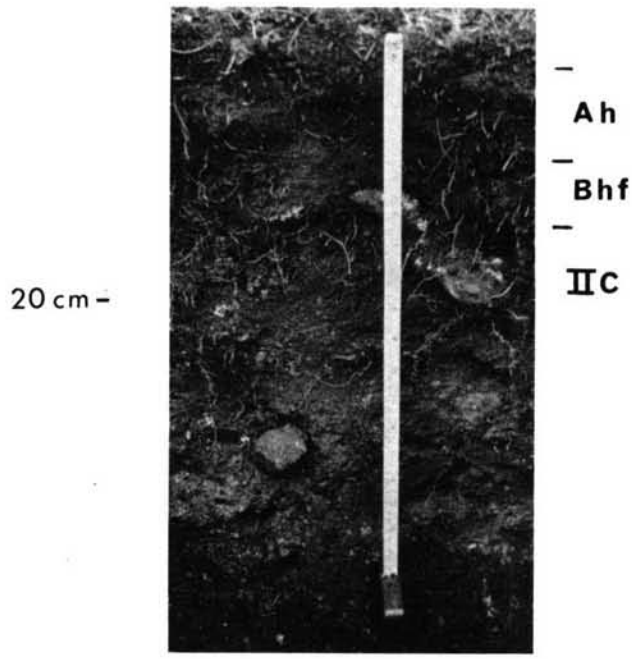


Plate 1. The Humo-Ferric Podzols of map unit 1 have thin Ah and Bhf horizons developed in silt loam textured aeolian material overlying sandy loam glacial till.

The following is a brief description of an Orthic Humo-Ferric Podzol typical of map unit 1.

Horizon	Depth (cm)	Color[1]	Texture	% C.F.[2]	% O.M.[3]
Ah	0 - 6	very dark grayish brown	SiL	--	16.2
Bhf	6 - 11	dark brown	SiL	5	14.8
IIAhb	11 - 21	dark yellowish brown	SL	10	5.2
IIBfb	21 - 35	dark brown	SL	10	3.1
IIC	35+	dark yellowish brown	SL	20	--

The shallower (<10 cm) Ah horizons of map unit 1 separate these soils from those of map unit 2 which generally have Ah horizons 10 to 40 cm thick. The thicker Ah horizons are often found on the steeper slopes. The thinner Ah (<10 cm) and Bf (<10 cm) horizons of the soils of map unit 1 separate them from the soils of map unit 8. The thinner Ah horizons also generally have a lower organic matter content.

The turfy surface usually present on these soils acts to hold the soils together, thus resisting wind and water erosion. At the same time this type of surface helps to resist compaction. If the turf is removed these soils will be highly susceptible to erosion, especially on the steep slopes.

Soil Map Unit 2 (Orthic Sombric Brunisol with major inclusions of Sombric Humo-Ferric Podzol)

These moderately coarse textured soils are closely associated with those of map unit 1 and generally occur on very steeply sloping to

[1] Munsell color name (Munsell, 1954).

[2] estimated coarse fragment content.

[3] organic matter (laboratory determination).

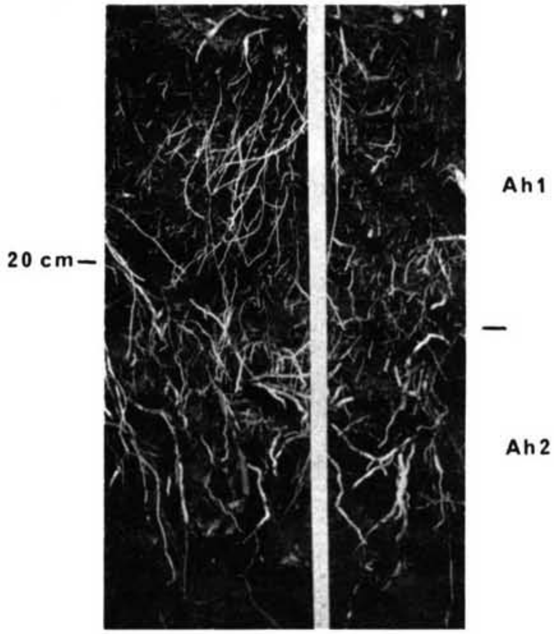
extremely sloping land surfaces on the sides of the glaciated bedrock ridges. Soil creep on these slopes seems to be primarily responsible for the development of deep (10 to 50 cm) Ah horizons (Plate 2) and the lower iron and aluminum contents in the B horizons. While most of these soils are classified as Brunisols, there is sufficient mobile iron and aluminum present in the B horizons of some of the soils to meet the requirements for Podzolic soils.

Surface drainage on these steep slopes is rapid and there are few boulders on the surface. Vegetation consists mainly of herbaceous plants and grasses. Common species include *Veratrum viride*, *Epilobium angustifolium*, *Heracleum lanatum*, *Erythronium grandiflorum*, and *Elymus* sp. The following is a brief description of an Orthic Sombric Brunisol profile typical of map unit 2 soils.

Horizon	Depth (cm)	Color	Texture	% C.F.	% O.M.
Ah1	0 - 26	dark brown	SL	5	12.2
Ah2	26 - 46	dark yellowish brown	SL	5	7.8
Bm	46 - 61	dark yellowish brown	SL	15	4.9
C	61+	yellowish brown	SL	15	--

These soils are differentiated from those of map unit 1 by a deeper (generally 10 cm) Ah horizon and a yellowish brown B horizon. The steep slopes on which these soils occur and the resulting soil instability result in severe limitations to use and a very high susceptibility to erosion if plant cover is removed.

2 - a



2 - b

Plate 2. The predominantly Brunisolic soils of map unit 2 have deep Ah horizons with abundant roots (2-b). Soil creep is active in these soils which are found on steep slopes (2-a).

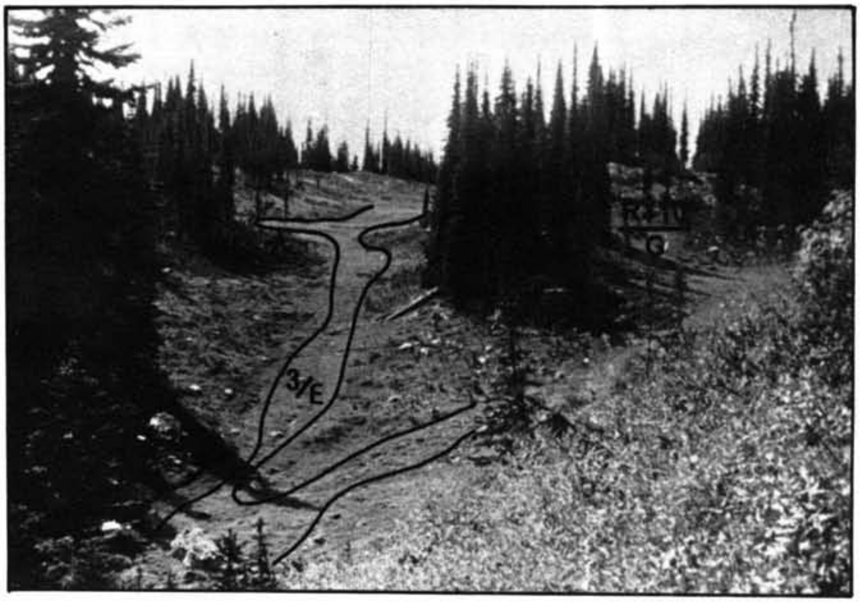
Soil Map Unit 3 (Orthic and Cumulic Regosol)

The imperfectly to somewhat poorly drained soils of this map unit occur in weakly defined snowmelt runoff channels and depressional areas of late snow cover and seasonal ponding of meltwater (Plate 3). Plant cover is predominantly *Luetkea pectinata* in the runoff channels and *Carex nigricans* or *Luetkea pectinata* in the depressional areas.

These soils have deep (20 to 40 cm), black, organic Oh surface layers which contain 30 to 65 percent organic matter. The organic matter is well decomposed and is mixed with predominantly silt-sized alluvial materials overlying till. Bulk density of the Oh horizons is very low, in the order of 0.3 g/cm^3, and there are few coarse fragments. Thin volcanic ash layers often occur at approximately the 20 cm depth. The Oh layers overlie a yellowish brown C horizon, thus the soils are classified as Regosols. The C horizons consist of the sandy loam till materials that cover most of the Summit area.

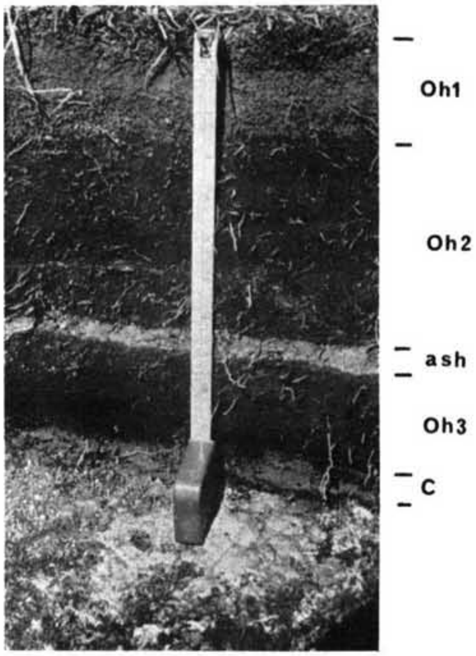
These soils do not display mottling or gleying and are better drained than the soils of map unit 4 and do not have a hummocky surface like the soils of map unit 6. The Regosols of map unit 7 are better drained than the map unit 3 soils and do not have organic layers. The following is a brief description of an Orthic Regosol typical of map unit 3 soils.

Horizon	Depth (cm)	Color	Texture	% C.F.	% O.M.
Oh1	0 - 7	black	organic	0	64.9
Oh2	7 - 19	black	organic	0	32.0
ash	19 - 21	yellowish brown	SiL	0	--
Oh3	21 - 31	black	organic	0	37.8
C	31+	yellowish brown	GSL	25	--



3 - a

3 - b



3 - c

Plate 3. The Regosolic soils of map unit 3 have deep, dark colored organic layers and often buried layers of volcanic ash (3-c). These soils are found in weakly incised snowmelt runoff channels (3-a) under Luetkea communities and in late snowmelt depressions under Carex vegetation (3-b). See Table 2 or the soils map legend for a description of the mapping symbols.

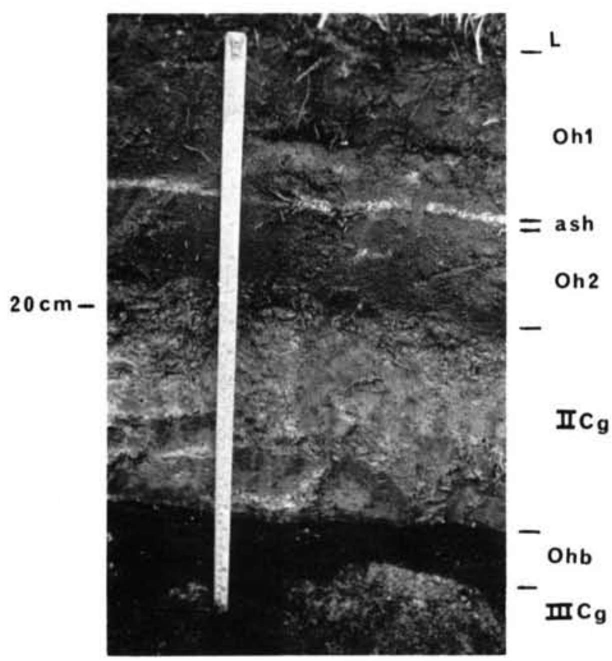
These soils have severe limitations for recreational use due to seasonally high moisture conditions, late snow release, and high susceptibility to erosion. The high organic matter content reduces soil strength and bearing capacity and produces a high water holding capacity resulting in slow drying. These soils are susceptible to compaction. Such properties make the soils unsuitable as a construction material, for a trail base, or for other intensive uses.

Soil Map Unit 4 (Rego Gleysol)

These poorly and very poorly drained soils occur in depressional areas of groundwater discharge and in areas of ponded runoff, often marginal to streams (Plate 4). The water table is near the surface of these soils for a considerable part of the year, thus they have severe limitations for recreational use. The vegetation and the soils reflect the high water table conditions. Plant communities are often dominated by <u>Carex nigricans</u> which forms a densely rooted turf on the soil surface. Organic layers (Oh), which contain approximately 60 to 70 percent organic matter, occur beneath the turf. These dark colored layers have a low bulk density (0.2 g/cm^3), are approximately 20 cm thick, and often have a thin layer of volcanic ash separating Oh layers. Silt loam textured volcanic ash deposits of about 30 cm thickness may underlie the upper Oh layers and often display prominent mottling. A buried Oh layer often separates the ash from underlying silt loam textured alluvial deposits which have strongly reduced gray colors. Boulders from the underlying till occasionally protrude through the soil surface.

The following is a brief description of a Rego Gleysol typical of map unit 4 soils.

4 - a



4 - b

Plate 4. The Gleysolic soils of map unit 4 are found in areas of groundwater discharge and high water table (4-a). Thick, dark colored organic layers overlie mottled volcanic ash deposits and buried organic layers (4-b). These soils have severe limitations for recreational use.

Horizon	Depth (cm)	Color	Texture	% C.F.	% O.M.
L	3 - 0	Densely rooted turf of Carex origin			
Oh1	0 - 11	dark brown	organic	0	67.6
ash	11 - 12	yellowish brown	SiL	volcanic ash layer	
Oh2	12 - 21	very dark grayish brown	organic	0	65.7
IICg1	21 - 28	yellowish brown	SiL	0	--
IICg2	28 - 42	very pale brown	Si	0	--
Ohb	42 - 52	very dark grayish brown	organic	0	59.2
IIICg	52+	dark gray	SiL	10	--

These soils differ from the Gleysols of map unit 5 by having thick humic organic (Oh) layers but lack a fibric organic (Of) surface layer. These soils are more poorly drained than those of map unit 3, but have similar morphology. These soils have severe limitations for use as trails or recreation sites due to a high water table, susceptibility to flooding and ponding, and deep organic surface horizons.

Soil Map Unit 5 (Peaty Rego Humic Gleysol)

These very poorly drained Gleysolic soils are found in areas of groundwater discharge on steeply sloping (topography class F) land surfaces. The water table is at or near the soil surface throughout the year and strongly influences soil and vegetation characteristics and use potential.

Vegetation characteristically consists of sedge communities with Eriophorum polystachion and Carex sp. being dominant, and Senecio triangularis and Sphagnum sp. are often present in abundance.

A 15 to 20 cm layer of peaty organic material (Of) overlies a water saturated soil profile. Anaerobic conditions result in dull gray reduced soil colors (gley) in the C horizons which vary in texture from silt loam to loamy sand. Parent materials consist of slope wash deposits covering the till to varying depths or in some cases the parent material consists of modified till. The following is a brief description of a Peaty Rego Humic Gleysol typical of map unit 5 soils.

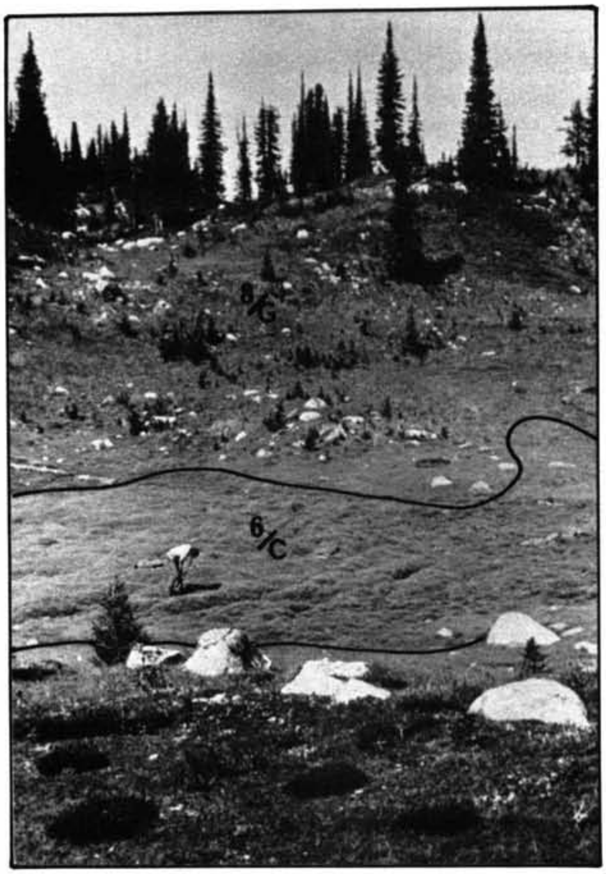
Horizon	Depth (cm)	Color	Texture	% C.F.	% O.M.
Of	20 - 0	dark brown	-	-	-
Ahg	0 - 35	very dark gray	SiL	5	10.8
Cg	35+	greenish gray	LCS	20	-

These soils are separated from those of map unit 4 by the presence of Of and Ahg horizons and the absence of thick Oh layers. They are separated from all other soils on the basis of drainage. These soils are wet throughout the season of use, with the water table at the surface. They are therefore severely limited for recreational use. Since the soils are wet due to groundwater seepage, artificial drainage would be difficult.

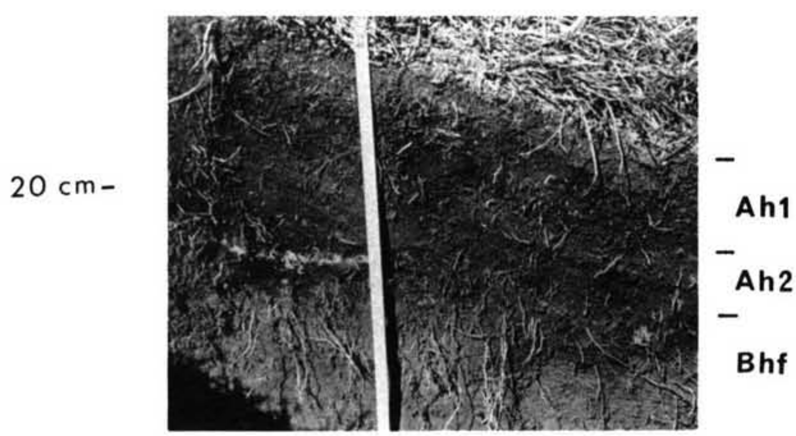
Soil Map Unit 6 (Sombric Ferro-Humic Podzol)

These soils occur under earth hummocks in small basins where drainage is restricted (Plate 5-a). The soil surface has an irregular microtopography due to the earth hummock pattern, with the hummocks being approximately 80 cm in diameter and having a relief of up to 20 cm. These hummocks support a continuous cover of Carex nigricans. The soils are imperfectly to somewhat poorly drained with ponding occurring in July.

The upper soil horizon boundaries are wavy, reflecting the surface morphology of the hummocks; however, the horizons are not disrupted or folded (Plate 5-b). This perhaps reflects rather weak frost action or cryoturbation processes.



5 - a



5 - b

Plate 5. The hummocky soils of map unit 6 are found in small enclosed basins (5-a) where snowmelt water ponds in July. These soils are classified as Sombric Ferro-Humic Podzol due to the presence of Ah and Bhf horizons. Soil parent materials are predominantly volcanic ash.

The soils have developed in volcanic ash deposits with predominantly silt-sized particles which are highly susceptible to frost action. The densely rooted turf formed by the Carex overlies thick Ah horizons and B horizons that have sufficient content of organic carbon and iron and aluminum to qualify as Bhf horizons.

These are the only soils in the area with hummocky microtopography. The following is a brief description of a Sombric Humo-Ferric Podzol typical of map unit 6 soils.

Horizon	Depth (cm)	Color	Texture	% C.F.	% O.M.
L	4 - 0	densely rooted Carex turf			
Ah1	0 - 10	very dark grayish brown	SiL	0	24.3
Ah2	10 - 18	very dark gray	SiL	0	--
Bf	18 - 26	yellowish red	SiL	0	--
Bhf	26 - 43	strong brown	SiL	0	9.5
Cgj	43 - 73	brownish yellow (mottled)	SiL	0	--
Ahb	73 - 74	thin buried Ah horizon			
IICgj	74 - 95+	light olive brown (mottled)	SiL	0	--

The hummocky pattern and restricted drainage of these soils results in severe limitations for recreational use.

Soil Map Unit 7 (Orthic and Cumulic Regosol)

The Regosolic soils of map unit 7 occur on very steeply sloping to extremely sloping land surfaces (topography classes F to H) where there appears to be considerable soil creep. Surface drainage is rapid.

These soils occur under predominantly herbaceous vegetation, often in open forest stands. Common herbaceous species include Senecio triangularis, Ligusticum canbyi, and Erigeron peregrinus. The forest stands are made up of Abies lasiocarpa - Rhododendron albiflorum communities with Vaccinium membranaceum often being abundant.

These soils have deep (40 cm) dark colored Ah horizons which have high organic matter content and low bulk density. Textures are typically sandy loam. B horizons are not present, probably as a result of disturbance of the soil by creep. The C horizons are yellowish brown sandy loam textured glacial till materials with 15 to 20 percent gravel and cobble sized coarse fragments.

The following is a brief description of an Orthic Regosol typical of map unit 7 soils.

Horizon	Depth (cm)	Color	Texture	% C.F.	% O.M.
Ah	0 - 40	very dark grayish brown	SL	5	6.2
C	40+	yellowish brown	SL	15	-

These soils are often associated with Podzolic soils of map unit 9. Typically the Podzolic soils occur under established tree cover and the Regosolic soils (map unit 7) occur under herbaceous vegetation in small openings in the forest stands.

The Regosolic soils of map unit 7 are differentiated from the Regosols of map unit 3 on the basis of being well to moderately well drained rather than imperfectly to poorly drained. Also, the soils of map unit 7 lack a distinct organic surface layer.

The steep slopes (F to G) on which these soils occur are the prime limiting factor to recreational use. The deep Ah, with high organic matter content and low bulk density is easily eroded on steep slopes once the surface is disturbed and artificial runoff channels (such as trails) are established.

occurs under the Bf. This horizon is very difficult to penetrate and acts as a barrier to water movement and plant root development. Below the Bfc is the yellowish brown sandy loam textured till of the C horizon.

The following is a brief description of an Ortstein Ferro-Humic Podzol typical of map unit 9 soils.

Horizon	Depth (cm)	Color	Texture	% C.F.	% O.M.
Ahe	0 - 5	dark brown	SiL	5	10.8
Bhf	5 - 11	dark reddish brown	SiL	10	18.0
Bfc	11 - 24	dark reddish brown	LS	15	2.9
C	24+	yellowish brown	SL	15	-

The Podzolic soils of map unit 9 are distinguished from those of map unit 8 by the absence of an Ah horizon, or only a very thin Ah in the former, and from the soils of map unit 1 by the absence of an Ah and the presence of the ortstein horizon in the map unit 9 soils.

The landscape on which these soils occurs ranges from class E to class G with the more steeply sloping class G (30 to 60 percent slopes) being of greater areal extent. The slopes are often limiting for various recreational uses. Erosion hazard of the disturbed soils is high. The Ae and upper Bf horizons are very loosely structured and friable and the ortstein layer restricts downward water movement.

Soil Map Unit 10 (Lithic Humo-Ferric Podzol)

The Podzolic soils of this map unit have a bedrock (lithic) contact within 50 cm of the surface. These soils are associated with the Podzolic soils of map units 9 and 8 and represent a lithic phase of these soils where bedrock and shallow deposits of till occur (Plate 6-a). The

6 – a

6 – b

Plate 6. The Lithic Podzolic soils of map unit 10 have a bedrock contact within 50 cm of the surface (6-b). Bedrock outcrops (R) are associated with these soils in areas of steeply sloping topography (6-a).

Bf often extends to the bedrock. Textures are generally sandy loam and coarse fragment content is approximately 5 percent.

The following is a brief description of a Lithic Humo-Ferric Podzol typical of the map unit 10 soils.

Horizon	Depth (cm)	Color	Texture	% C.F.	% O.M.
L-F	1 - 0	dark brown	leaf litter		-
Ae	0 - 7	dark grayish brown	SL	5	7.7
Bf	7 - 18	dark reddish brown	SL	5	12.4
R	18+	bedrock			0

The bedrock (lithic) contact at less than 50 cm depth differentiates these soils from those of other map units.

The proximity of consolidated bedrock near the soil surface presents obvious limitations for use of these soils as septic tank filter fields, road locations, parking lots or buildings or any use where land levelling is required.

INTERPRETATIONS

Soil Properties and Land Use

Soils are perhaps the most basic resource to consider when planning land use activities. Proper use and management of soil resources is required to accommodate user activities and facilities at minimal cost, both in terms of construction and maintenance and in terms of the amount of impairment to the environment. Soils vary in their type and severity of limitations as sites for developments such as trails, camping areas, buildings, or septic tank filter fields. Some soils have severe limitations for one or more uses, while other soils may be well suited for a number of uses. Knowledge of soil characteristics is basic to good planning and management.

This section of the report provides predictions of soil performance based on field observations and laboratory data as well as past experience and published information. These predictions are intended to serve as input into the planning process, not as recommendations for land use, thereby providing tools for the use of planners.

It must be realized that the interpretations are based on the characteristics of natural soils to a depth of 1 or 2 meters (3 to 6 feet) (although characteristics at greater depths can often be extrapolated from available information). Due to the variable nature of soils, small inclusions of unmappable (due to scale) soil types may be present in an area where a development is planned. Therefore, _on site_ investigation by a person familiar with soils is recommended prior to construction of facilities.

The following are some of the basic soil properties that singly or in combination with others commonly affect recreational land use. The limitations of these soil properties are summarized in Tables 4 to 9.

Wetness affects bearing strength, compactibility and erodibility of soils. Wetness may result from proximity to late snowbeds or streams, ponding of runoff water, or groundwater seepage and high water table. Soil properties (and vegetation) reflect the high moisture conditions even at a time in the year when the soil is dry. Soils that are wet for all, or part, of the season of use have obvious limitations as sites for trails, camping areas or other such uses.

Flooding hazard can be predicted from soil properties and landscape position. Soils that may be flooded during the season of use cannot be used for camping areas or building sites and have limitations for uses such as picnic areas and trails.

Soil texture may limit the amount and type of use an area is suited to. Properties such as permeability, bearing strength, erodibility, available water capacity and nutrient availability for plant growth are all related to soil texture. In the Mount Revelstoke Summit area high contents of volcanic ash and sand-sized mica particles have a serious effect on soil strength and erodibility. The binding ability of clay- and to a lesser degree silt-sized particles are important for soil stability. Generally, medium to moderately coarse textures such as loam or sandy loam are most suitable for recreational uses.

The content of gravel, cobbles and stones in a soil may be an important factor to consider when planning camping areas, trails, or septic tank filter fields.

Slope may cause limitations for use. Steeply sloping areas are severely limited for use as parking lots or septic tank filter fields,

TABLE 4. GUIDES FOR ASSESSING SOIL LIMITATIONS FOR CAMP AREAS

This guide applies to soils to be used intensively for tents and the accompanying activities of outdoor living. It is assumed that little site preparation will be done other than shaping and leveling for tent and parking areas. The soil should be suitable for heavy foot traffic and for limited vehicular traffic.[1] Soil suitability for growing and maintaining vegetation is not a part of this guide, except as influenced by moisture, but is an important item to consider in the final evaluation of site.

Items Affecting Use	Degree of Soil Limitation		
	None to Slight	Moderate	Severe
Wetness	Rapidly, well and moderately well drained soils. Water table below 30" during season of use.	Moderately well and imperfectly drained soils. Water table below 20" during season of use.	Imperfectly, poorly, and very poorly drained soils. Water table above 20" during season of use.
Flooding	None.	None during season of use.	Floods during season of use.
Permeability[2]	Very rapid to moderate inclusive.	Moderately slow and slow.	Very slow.
Slope	0 to 9% (AD).	9 to 15% (E).	Greater than 15% (greater than E).
Surface soil texture[3]	SL, FSL, VFSL, L.	SiL, CL, SCL, SiCL, LS and sand other than loose sand.	SC, SiC, C, loose sand subject to severe blowing, organic soils.
Coarse fragments on surface[4]	0 to 20%.	20 to 50%[5].	>50%.
Stoniness[6] (stony)	Stones greater than 25' apart.	Stones 25 to 5' apart.	Stones less than 5' apart.
Rockiness[6] (rock)	No rock exposures.	Rock exposures greater than 30' apart and cover less than 25% of the area.	Rock exposures less than 30' apart and cover greater than 25% of the surface.

1. For information specific to roads and parking lots see Table 7.

2. Infiltration tests show that in most, if not all, of the soils found there is little if any limitation in permeability with regard to camp areas.

3. Surface soil texture influences soil ratings as it affects foot trafficability, dust, soil permeability and erosion hazard. Most of these textures are not applicable to this specific area.

4. Coarse fragments include both gravels and cobbles.

5. Some gravelly soils may be rated as slight if the content of gravel exceeds 20% by only a small margin providing (a) the gravel is embedded in the soil matrix, or (b) the fragments are less than 3/4 inch in size. See the definition for gravels in the System of Soil Classification for Canada (C.S.S.C., 1970), pp. 213-214.

6. Very shallow soils are rated as having a severe soil limitation for rockiness and/or stoniness. See also definitions of rockiness and stoniness in the System of Soil Classification for Canada (C.S.S.C., 1970), pp. 213-214.

TABLE 5. GUIDES FOR ASSESSING SOIL LIMITATIONS FOR PICNIC AREAS

This guide applies to soils considered for intensive use as park-type picnic areas. It is assumed that most vehicular traffic will be confined to access roads.[1] Soil suitability for growing and maintaining vegetation is not a part of this guide, except as influenced by moisture, but is an important item to consider in the final evaluation of site.

Items Affecting Use	Degree of Soil Limitation		
	None to Slight	Moderate	Severe
Wetness	Rapidly, well and moderately well drained soils. Water table below 20" during season of use.	Moderately well and imperfectly drained soils. Water table during season of use may be less than 20" for short periods.	Poorly and very poorly drained soils. Water table above 20" and often near the surface for a month or more during season of use.
Flooding	None during season of use.	May flood once a year for short period during season of use.	Floods more than once a year during season of use.
Slope	0 to 9% (AD).	9 to 15%(E).	Greater than 15% (greater than E).
Surface soil texture[2]	SL, FSL, VFSL, L.	SiL, CL, SCL, SiCL, LS, and sand other than loose sand.	SC, SiC, C, loose sand subject to severe blowing, organic soils.
Coarse fragments on surface[3]	0 to 20%.	20 to 50%[4].	>50%.
Stoniness[3]	Stones greater than 5' apart.	Stones 2 to 5' apart.	Stones less than 2' apart.
Rockiness[3]	Rock exposures roughly 100 to 300 or more feet apart and cover less than 10% of the surface.	Rock exposures 30 to 100' apart and cover about 10 to 25% of the surface.	Rock exposures less than 30' apart and cover greater than 25% of the surface.

1. For information specific to roads or parking lots see Table 7.

2. Surface soil texture influences soil ratings as it affects foot trafficability, dust, soil permeability and erosion hazard. Most of these textures are not applicable to this specific area.

3. See also definitions for gravels, rockiness and stoniness in the System of Soil Classification for Canada (C.S.S.C., 1970), pp. 213-214. Coarse fragments include both gravels and cobbles.

4. Some gravelly soils may be rated as slight if the content of gravel exceeds 20% by only a small margin providing (a) the gravel is embedded in the soil matrix or (b) the fragments are less than 3/4 inch in size.

TABLE 6. GUIDES FOR ASSESSING SOIL LIMITATIONS FOR TRAILS

This guide applies to soils to be used for trails assuming no hard surfacing. It is assumed that these areas will be used as they occur in nature and that little or no soil will be moved (excavated or filled). The steeper the slope upon which a trail is to be built the more soil that will have to be moved to obtain a level tread and the more miles of trail needed to cover a given horizontal distance. Severe limitation does not indicate a trail can not or should not be built. It does suggest higher design requirements, higher cost of construction and maintenance, and often greater potential for environmental impact. Soil features that affect trafficability, dust, design and maintenance of trails are given special emphasis.

Items Affecting Use	Degree of Soil Limitation		
	None to Slight	Moderate	Severe
Wetness	Rapidly, well and moderately well drained soils. Water table below 20" during season of use.	Imperfectly drained soils. Water table during season of use may be above 20" for short periods.	Poorly and very poorly drained soils. Water table above 20" and often near surface for month or more during season of use.
Flooding	Does not flood.	May flood but not during season of use.	Floods during season of use.
Slope[1]	0 to 15% (AE).	15 to 30% (F).	Greater than 30%[2] (>F).
Surface soil texture[3] (Text.)	SL, FSL, VFSL, L.	SiL, CL, SCL, SiCL, LS.	SC, SiC, C, sand, peaty and organic soils.
Coarse fragments on surface (CF)	0 to 20%.	20 to 50%.[4]	>50%.
Rockiness or stoniness[5] (Rock)	Stones greater than 25' apart. Rock exposures roughly 100' apart and cover less than 10% of the surface.	Stones 5 to 25' apart. Rock exposures 30 to 100' apart and cover 10 to 25% of the surface.	Stones less than 5' apart. Rock exposures less than 30' apart and cover more than 25% of the surface.

1. Slope in this context refers to the slope of the ground surface, not the slope of the tread of the trail.

2. A distinction between severe limitation (30 to 60%) and very severe limitation (greater than 60%) will be made in the interpretation table (Table 10).

3. Surface texture influences soil ratings as it affects foot trafficability, dust, design or maintenance of trails, and erosion hazard. Most of these textures are not applicable to this specific area.

4. Some gravelly soils may be rated slight if the content of the gravel exceeds 20% by only a small margin providing (a) the gravel is embedded in the soil matrix or (b) the fragments are less than 3/4 inch in size.

5. See also definitions for gravels, rockiness and stoniness in the System of Soil Classification for Canada (C.S.S.C., 1970), pp. 213-214. Coarse fragments include both gravels and cobbles.

TABLE 7. GUIDES FOR ASSESSING SOIL LIMITATIONS FOR ROADS AND PARKING LOTS

This guide applies to soils evaluated for construction and maintenance of roads and parking lots having some kind of surfacing, commonly gravel. They consist of: (1) underlying local soil material (either cut or fill) called the subgrade; and (2) gravel surface. They also are graded to shed water and have ordinary provisions for drainage. The roads are built mainly from the soil at hand, and cuts and fills are limited, usually less than 6 feet. Excluded from consideration in this guide are highways designed for fast-moving heavy trucks.

Properties that affect design and construction of roads are: (1) those that affect the load supporting capacity and stability of the subgrade; and (2) those that affect the workability and amount of cut and fill. The AASHO and Unified Classification, and the shrink-swell potential give an indication of the traffic supporting capacity. Wetness and flooding affect stability. Slope, depth of bedrock, stoniness, rockiness, and wetness affect the ease of excavation and the amount of cut and fill to reach an even grade.

Soil limitation ratings do not substitute for basic soil data or for onsite investigations.

Items Affecting Use	Degree of Soil Limitation		
	None to Slight	Moderate	Severe
Soil drainage class[1]	Rapidly[1], well and moderately well drained.	Imperfectly drained.	Poorly and very poorly drained.
Flooding	None.	Once in 5 years.	More than once in 5 years.
Slope	0 to 9% (AD).	9 to 15% (E).	More than 15% (>E).
Depth to bedrock	More than 40 inches.	20 to 40 inches.	Less than 20 inches.
Subgrade[2] (Str.) a. AASHO Group index[3] b. Unified soil classes	 0 to 4. GW, GP, SW, GM, SM, and GC[4] and SC[4].	 5 to 8. Cl (with PI[5] less than 15), ML, SP.	 more than 8. CL (with PI[5] 15 or more), CH, MH, OH, CL, Pt.
Shrink-swell potential[6]	Low (PI[5] less than 15).	Moderate (PI[5] 10 to 35).	High (PI[5] greater than 20).
Susceptibility to frost heave[7]	Low (F1, F2)[6].	Moderate (F3)[6].	High (F4)[6].
Stoniness[8]	Stones greater than 5' apart.	Stones 2 to 5' apart.	Stones less than 2' apart.
Rockiness[8]	Rock exposures greater than 300' apart and cover less than 2% of the surface.	Rock exposures 300 to 100' apart and cover 2 to 10% of the surface.	Rock exposures less than 100' apart and cover greater than 10% of the surface.

1. For an explanation of soil drainage classes see the System of Soil Classification for Canada (C.S.S.C., 1970), pp. 215-216.

2. This item estimates the strength of a soil as it applies to roadbeds. When available, AASHO Group Index values from laboratory tests were used; otherwise the estimated Unified classes were used. On unsurfaced roads, rapidly drained, very sandy poorly graded soils may cause washboard or rough roads.

3. Group Index values were estimated from information published by the 1962), pp. 23-25.

4. Downgrade to moderate if content of fines (less than 200 mesh) is greater than about 30%.

5. PI means plasticity index.

6. Inherent swelling capacity is estimated as low when the plasticity index is less than 15, medium when the plasticity index is 10 to 15 and high when the plasticity index is greater than 20 (Tarzaghi and Peck, 1967). Gravelly and stony soils may not exhibit shrink-swell as estimated by the plasticity index because of dilution of the fines with coarse fragments. In these situations decrease a severe limitation to moderate and a moderate limitation to slight.

7. Frost heave is important where frost penetrates below the hardened surface layer and moisture transportable by capillary movement is sufficient to form ice lenses at the freezing front. The susceptibility classes are taken from the United States Army Corps of Engineers (1962), pp. 5-8. Table 11 is reproduced from the above article.

8. See also definitions for rockiness and stoniness in the System of Soil Classification for Canada (C.S.S.C., 1970), pp. 213-214.

TABLE 8. GUIDES FOR ASSESSING SOIL LIMITATIONS FOR PERMANENT BUILDINGS[1]

This guide provides ratings for undisturbed soils evaluated for single storey buildings and other structures with similar foundation requirements. The emphasis for rating soils for buildings is on foundations; but soil slope, and susceptibility to flooding and other hydrologic conditions, such as seasonal wetness, that have effects beyond those related exclusively to foundations are considered. Also considered are soil properties, particularly depth to bedrock, which influence excavation and construction costs both for the building itself and for the installation of utility lines. Excluded are limitations for soil corrosivity (which is of little consequence in this area), landscaping and septic tank absorption fields. On site investigations are needed for specific placement of buildings and utility lines, and for detailed design of foundations. All ratings are for undisturbed soils on information gained from observations to a depth of 4 to 5 feet.

Items Affecting Use	Degree of Soil Limitation[2]		
	None to Slight	Moderate	Severe
Wetness[3]	With basements: Rapidly drained and well drained. Without basements: Rapidly, well and moderately well drained.	With basements: Moderately well drained. Without basements: Imperfectly drained.	With basements: Imperfectly, poorly and very poorly drained. Without basements: Poorly and very poorly drained.
Depth to seasonal water table (seasonal means 1 month or more)	With basements: Below 60 inches. Without basements: Below 30 inches.	With basements: Below 30 inches. Without basements: Below 30 inches.	With basements: Above 30 inches. Without basements: Above 20 inches.
Flooding (Flood)	None.	None.	Subject to flooding.
Slope[4]	0 to 9% (AD).	9 to 15% (E).	More than 15% (> E).
Shrink-swell potential[5]	Low (PI[6] less than 15)	Moderate (PI[6] 10 to 35).	High (PI[6] greater than 20).
Unified soil group[7]	GW, GP, SW, SP, GM GC, SM, SC.	ML, CL.	CH, MH, OL, OH, Pt.
Potential frost action[8]	Low (F1, F2).	Moderate (F3).	High (F4).
Stoniness[9]	Stones greater than 25' apart.	Stones 5 to 25' apart.	Stones less than 5' apart.
Rockiness[9]	Rock exposures greater than 300' apart and cover less than 2% of the surface.	Rock exposures 300 to 100' apart and cover 2 to 10% of the surface.	Rock exposures less than 100' apart and cover greater than 10% of the surface.
Depth to bedrock	With basements: More than 60 inches. Without basements: More than 40 inches.	With basements: 40 to 60 inches. Without basements: 20 to 40 inches.	With basements: Less than 40 inches. Without basements: Less than 20 inches.

1. By reducing the slope limits by 1/2, this table can be used for evaluating soil limitations for buildings with large floor areas but with foundation requirements not exceeding those of ordinary 3-storey dwellings.

2. Some soils rated as having moderate or severe limitations may be good sites from an aesthetic or use standpoint but require more preparation or maintenance.

3. For an explanation of soil drainage classes see the System of Soil Classification for Canada (C.S.S.C., 1970), pp. 215-216.

4. Reduce slope limits by 1/2 for those soils subject to hillside slippage.

5. Inherent swelling capacity is estimated as low when the plasticity index is less than 15, medium when the plasticity index is 10 to 35 and high when the plasticity index is greater than 20 (Terzaghi and Peck, 1967). Gravelly and stony soils may not exhibit shrink-swell as estimated by the plasticity index because of dilution of the fines with coarse fragments. In these situations decrease a severe limitation to moderate and a moderate limitation to slight.

6. PI means plasticity index.

7. This item estimates the strength of the soil, that is its ability to withstand applied loads.

8. Frost heave only applies where frost penetrates to the assumed depth of the footings and the soil is moist. The potential frost action classes are taken from the United States Army Corps of Engineers (1962), pp. 5-8.

9. See also definitions for rockiness and stoniness in the System of Soil Classification for Canada (C.S.S.C., 1970), pp. 213-214.

TABLE 9. GUIDES FOR ASSESSING LIMITATIONS FOR SEPTIC TANK SOIL ABSORPTION FIELDS

This guide applies to soils to be used as an absorption and filtering medium for effluent from septic tank systems. A subsurface tile system laid in such a way that effluent from the septic tank is distributed reasonably uniformly into the natural soil is assumed when applying this guide. A rating of severe need not mean that a septic system should not be installed in the given soil, but rather may suggest the difficulty, in terms of installation and maintenance, which can be expected.

Items Affecting Use	Degree of Soil Limitation		
	None to Slight	Moderate	Severe
Permeability class	Moderately rapid (approx. 1 - 5"/hr.).	Moderate (approx. 1 - 0.5"/hr.).	Slow (less than approx. 0.5"/hr.).
Percolation rate (Auger hole method[3])	About 20 to 45 min./inch.	45 to 60 min./inch.	Slower than 60 min./inch.
Depth to seasonal water table[4]	More than 72 inches.[5]	48 to 72 inches.	Less than 48 inches.
Flooding hazard	Not subject to flooding.	Not subject to flooding.	Subject to flooding.
Slope	0 to 9% (AD).	9 to 15% (E).	More than 15% (> E).
Depth to bedrock or other impervious materials.	Over 72 inches.[6]	48 to 72 inches.[6]	Less than 48 inches.

1. The limitation ratings should be related to the permeability of soil layers at and below depth of the tile line.

2. Soils having a permeability rate greater than about 5 inches/hour or percolation rate less than about 20 min./inch are likely to present a pollution hazard to adjacent waters. This hazard should be noted but the degree of hazard must, in each case, be assessed by examining the proximity of the proposed installation to water bodies, water table and related features.

3. Refer to Alberta Dept. of Manpower and Labour (1972) or U. S. Dept. of Health, Education and Welfare (1969) for details of this procedure.

4. Seasonal means for more than one month. It may, with caution, be possible to make some adjustment for the severity of a water table limitation in those cases where seasonal use of the facility does not coincide with the period of high water table.

5. A seasonal water table should be at least 4 feet below the bottom of the trench at all times for soils having a slight limitation (U.S. Dept. of Health, Education and Welfare, 1969). The depths used to water table or bedrock are based on an assumed tile depth of 2 feet. Where relief permits, the effective depth above a water table or rock can be increased by adding appropriate amounts of fill.

6. Where slope is greater than 9% a depth to bedrock of 48 to 72 inches is a severe limitation.

especially where bedrock is close to the surface. Slope is not as severely limiting for trails; however, it does increase erosion hazard as well as construction and maintenance costs.

Depth to bedrock is an important soil characteristic for almost all uses. Shallow depths are especially limiting for septic tank filter fields, buildings with basements, and road construction.

Soil infiltration capabilities should be considered when planning camping or picnic areas, especially in an area of late snowmelt and frequent summer showers. When considering sewage disposal, soil permeability may be the factor that results in success or failure of the system.

Further information regarding the interpretation of soil properties for limitations to recreational uses may be found in Montgomery and Edminster (1966), Soil Conservation Guide (1967), Brocke (1970), Knapik and Landals (1972), Greenlee (1973a, 1973b), and Coen and Holland (in press).

With a knowledge of soil properties and behaviour, interpretations can be made for various land uses. Through the use of a soils map these interpretations can be related to the planning area under study. The soils of the Mount Revelstoke Summit area have been grouped into three performance groups for each of various uses based on degree of soil limitations for each use.

The soils have been rated according to their limitations for camping areas, picnic areas, trails, roads and parking lots, buildings, and septic tank filter fields (Table 10). Rating groups of none to slight, moderate, and severe limitations are described as follows:

1. None to slight soil limitations. The soil properties are essentially suited for the intended use. Limitations are minor and easily overcome. Minimal environmental damage and good performance can be expected with proper management.

2. Moderate soil limitations. These soils are moderately suitable for the intended use. Soil limitations are present which may be overcome by proper soil manipulation, correct construction practices and continued maintenance.
3. Severe soil limitations. These soils have one or more limiting properties which make them unsuitable for the proposed use. The potential for environmental damage may be high, construction and maintenance costs may also be high, or both conditions may prevail. Soil reclamation may be possible but it may drastically alter the ecology of the surrounding area, and such work may not be economically feasible.

Limitations of the Summit Soils for Recreational Uses

Ratings of the severity of limitations of the soils on the Summit for various recreational uses are shown in Table 10. These ratings are based on inherent soil characteristics using guidelines from Tables 4 to 9 as they apply to this specific area. Essentially the same procedure was used in Waterton Lakes National Park (Coen and Holland, in press) and is being used also in Yoho National Park (study in progress by the authors). By using such a system of rating soil limitations, comparisons and extrapolations may be made between National Parks as well as within the specific study area. Due to the relative homogeneity of the soils within the small Summit area many of the soils fall into the same limitation grouping.

In general, the Summit area has a considerable limitation to recreational use, due largely to the topography. The steep slopes, usually greater than 15 percent (greater than class E), provide severe limitations for such uses as camping areas, picnic areas, roads and parking lots,

TABLE 10. DEGREE AND NATURE OF SOIL LIMITATIONS FOR SELECTED USES.

Map Unit	Camping Areas	Picnic Areas	Trails	Roads & Parking Lots	Buildings: no basements	Septic Tank Fields	Erosion Hazard
1/E	moderate - slope	slight - slope	none to slight	moderate - slope	moderate - slope	moderate - slope	moderate
1/F	severe - slope	severe - slope	moderate - slope	severe - slope	severe - slope	severe - slope	moderate to high
1/G	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	high
2/F	severe - slope	severe - slope, erosion hazard	moderate - slope	severe - soil creep, slope	severe - soil creep, slope	severe - soil creep, slope	high
2/G	severe - slope	severe - slope	severe - slope, soil creep	severe - slope, soil creep	severe - slope, soil creep	severe - slope, soil creep	high
2/H	severe - slope	severe - slope	severe - slope, soil creep	severe - slope, soil creep	severe - slope, soil creep	severe - slope	high
2+R / G	severe - slope, bedrock	severe - slope, bedrock (but small usable areas exist)	severe - slope, bedrock	severe - bedrock, slope	severe - slope, bedrock	severe - bedrock	high
3/C, 3/D 3/E	moderate to severe - wetness, organic layers	moderate to severe - wetness, organic layers	moderate to severe - wetness, organic layers	moderate to severe - wetness, organic layers	moderate to severe - wetness, organic layers	moderate - wetness, slope if E	
3/F	severe - wetness, slope, organic layers	moderate to severe - wetness, slope, organic layers	moderate to severe - wetness, organic layers, slope	severe - wetness, slope, organic layers	severe - wetness, organic layers	severe - wetness, slope	high
3+5 / F	severe - wetness	severe - wetness	severe - wetness, organic layers	severe - wetness, organic layers, slope	severe - wetness, organic layers, slope	severe - wetness, slope	high
4/B, 4/C	severe - wetness, flooding, organic layers	severe - wetness, organic layers	severe - wetness, flooding, organic layers	severe - wetness, organic layers, frost action	severe - wetness, flooding, organic layers	severe - high water table	nil (depressional)
4/D, 4/F	very severe - wetness, slope, organic layers	very severe - wetness, slope, organic layers	very severe - wetness, organic layers	very severe - wetness, organic layers, slope (F)	very severe - wetness, organic layers, slope	very severe - wetness, slope	high
5/F	very severe - wetness, slope, organic layers	very severe - wetness, organic layers, slope	very severe - wetness, organic layers	very severe - wetness, organic layers, slope	very severe - wetness, organic layers, slope	very severe - wetness, slope	high
6/B, 6/C	severe - ponding and hummocky surface	severe - ponding and hummocky surface	severe - ponding and hummocky surface	severe - ponding and frost action	severe - ponding and frost action	severe - ponding	nil (depressional)
7/F	severe - slope	severe - slope	moderate - slope, soil creep, erosion hazard	severe - slope, soil creep	severe - slope, soil creep	severe - slope, soil creep	high
7/G	severe - slope	severe - slope	severe - slope, soil creep, erosion hazard	severe - slope, soil creep	severe - slope, soil creep	severe - slope, soil creep	high
7A/G	severe - slope	severe - slope	severe - slope, soil creep, erosion and avalanche hazard	severe - slope, soil creep and avalanche hazard	severe - avalanche hazard, slope, soil creep	severe - slope, soil creep	high
8/C	none to slight	none to slight	none to slight	none to slight	none to slight	none to slight	moderate
8/E	moderate - slope	moderate - slope	none to slight	moderate - slope	moderate - slope	moderate - slope	moderate
8/F	severe - slope	severe - slope	moderate - slope	severe - slope	severe - slope	severe - slope	high
8/G	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	high
8+10 / G	severe - slope	severe - slope (but small usable areas exist)	severe - slope	severe - slope, shallow to bedrock	severe - slope	severe - shallow to bedrock, slope	high
8/H	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	high
9/E	moderate - slope	slight - slope	none to slight	moderate - slope	moderate - slope	moderate - slope	moderate
9/F	severe - slope	severe - slope	moderate - slope	severe - slope	severe - slope	severe - slope	high
9/G	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	high
9+R / G	severe - slope, bedrock outcrops	severe - slope	severe - slope, bedrock outcrops	severe - slope, bedrock outcrops	severe - slope, bedrock outcrops	severe - bedrock outcrops, slope	high
9/H	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	severe - slope	high
10/G, 10/H	severe - slope	severe - slope	severe - slope, shallow to bedrock	severe - slope, shallow to bedrock	severe - slope, shallow to bedrock	severe - shallow to bedrock, slope	high
R+10 / G, R+10 / H	severe - bedrock outcrops, slope	severe - bedrock outcrops, slope	severe - slope, bedrock outcrops	severe - bedrock outcrops, slope	severe - slope, bedrock outcrops	severe - bedrock outcrops, slope	high

buildings, and septic tank filter fields. Besides the physical constraints of steep slopes, soil instability and erosion hazard increase with slope. Since most of the area is steeply sloping, recreational facilities or sites may have to be designed and constructed in such a way as to reduce slope limitations. In addition there are several soil factors to be considered when choosing sites for development.

Bedrock exposures and shallow (less than 50 cm) depths to bedrock are common in the area and are designated as R and map unit 10, respectively, on the soils map. The combination of bedrock exposures and the accompanying steep slopes results in severe limitations for general recreational use in these areas. These areas cannot be levelled for installation of facilities except at considerable cost.

Soil wetness causes severe limitations to use in soil map units 4 and 5. These soils are poorly to very poorly drained and are saturated with water through most or all of the year. Wetness is generally associated with groundwater discharge, with the water table being at or very close to the soil surface. Some areas are also subject to flooding during the peak runoff periods; all such areas would be very difficult, if not impossible, to drain. Soils of map units 4 and 5 have organic surface horizons and tend to silt loam textures in lower horizons. These properties contribute to low bearing strength and high erodibility.

The soils of map units 3 and 6 are imperfectly drained, being wet during early season of use. They have severe limitations for use as camping or picnic areas due to wetness. Soils of map unit 3 have organic surface horizons and may also have limitations due to slope, whereas those of map unit 6 have severe limitations due to the hummocky microtopography of the soil surface.

The soils of map units 1, 8 and 9 have the least severe limitations to use, especially where they occur on C to E topography classes (2 to 15 percent slopes). These soils have sandy loam textures, are well drained, fairly stable, and generally have high infiltration and permeability rates. Permeability, however, may be restricted in the ortstein layers in some of the map unit 9 soils. Surface stoniness and bedrock outcrops may result in moderate limitations in some of the soils. The areal extent of these soils on suitable slopes is small, however.

Limitations to use of an area may also arise from vegetation parameters. Aspects of vegetation fragility have been studied by Landals and Scotter (in preparation) and a consolidated rating of fragility of ecological units, employing vegetation and soils limitations was made. This environmental fragility rating is explained in the included report by Knapik and Landals (page 60) and the rating of the area is shown on the Fragility Rating Map.

SOIL SUSCEPTIBILITY TO EROSION

Soil susceptibility to erosion refers to the expected rate and amount of soil loss by either wind or water following removal of vegetation.

Similarities between the soils of the small summit area result in a fairly uniform erosion hazard. Most of the soils have developed on the sandy loam glacial till deposits that cover much of the area. Surface horizons are finer textured due to the higher content of silt-sized material, which is largely volcanic ash. This volcanic ash, and the muscovite particles which are abundant in many of the soils, act to increase erosion hazard. These materials have very little ability to bind soil particles together and the low density volcanic ash is easily transported by running water. The low clay content and lack of carbonate cements in the granodiorite-derived tills also contribute to erosion susceptibility.

The textures, low bulk densities, and weak structure of these soils result in high infiltration and percolation rates which reduces the amount of overland flow of water and thus somewhat reduces erosion hazard. If the soils are compacted by heavy use erodibility will increase. The high organic matter content in the deep Ah horizons of many of the soils acts to resist compaction due to moderate pressures by reinforcing soil aggregate stability.

The eluvial (Ae) horizons of the soils of map units 9 and 10 are very susceptible to erosion due to a lack of fines and absence of cementing agents such as iron and aluminum oxides. The Bf horizons of these soils are often indurated and cemented with iron and aluminum compounds thus inhibiting percolation and forming a potential erosion surface at the top of the B horizon.

Vegetation cover is very important in preventing and checking soil erosion. The alpine vegetation of the Summit area, especially the *Carex* species, often form a densely rooted fibrous turf covering on the soils which effectively protects the soil surface from splash and rill erosion. Tree cover in the forested areas intercepts rainfall before it can cause splash erosion and the roots of the trees and understory vegetation effectively hold the soils together to check erosion. Vegetation cover must be maintained as much as possible in order to keep soil erosion to a minimum. As long as the soils remain undisturbed, with vegetation intact, they are quite resistant to erosion under prevailing climatic conditions. However, if vegetation is removed and the soil surface exposed, all soils in the Summit area rate as being moderately highly susceptible to erosion.

In order to evaluate inherent soil erodibility it must be assumed that the vegetation has been removed. Due to the common properties of many of the soils in this study area, the most important variable to consider in ranking the soil map unit separations as to erodibility is gradient of slope. As slope increases, the amount and velocity of runoff increases and the erosive ability of the water is increased. The rating of soil susceptibility to erosion is based largely on topography with modifications for texture, drainage conditions, and soil horizonation. For this report the soils of this area have been divided into three groups on the basis of moderate, high, and very high susceptibility to erosion. However, when considered in a broader continental sense all of these soils rate as being highly erodible.

SOIL DRAINAGE CONDITIONS

Drainage conditions have been described in the Glossary of this report using the soil moisture classes defined by the Canada Soil Survey Committee (1970). These classes are defined in terms of actual excess moisture content and length of period during which such excess water is present in the plant root zone.

Moisture conditions are defined for each soil map unit (see Key to the Soils, Table 3).

Soil drainage is an important factor to consider when planning such facilities as trails, buildings, roads, camping areas, and sewage disposal systems. Close correlations exist between moisture conditions and soil morphology, plant community type, and position on the landscape. Poorly drained habitats are highly susceptible to environmental damage.

The major portion of the study area is well drained but there are several significant areas of restricted drainage. The high moisture content is often due to groundwater discharge which occurs mostly along the flanks of the Summit ridge. There are also areas where snowmelt runs and is ponded for varying lengths of time in basin areas and stream channels. These wet areas are often of small areal extent but are of considerable importance to land use planning due to their fragile nature.

PRODUCTIVITY

Productivity ratings as traditionally applied to soils refer to the suitability of the soil, within its environment, for the production of some commercial crop -- usually an agricultural or forest product. The rating of soil productivity in a timberline environment within a National Park presents somewhat unique problems. First of all, what is the measurement of productivity or what is to be produced? Secondly, are the soils or individual soil properties limiting factors in such an environment?

Perhaps primary (plant) productivity as measured in units of weight per unit area per year is the most fundamental measurement of productivity. Measurement of this sort would require carefully controlled, exhaustive experimental work to differentiate between climatic, botanical, and edaphic parameters and is beyond the scope of this study.

Some comments can be made, however, regarding plant productivity in the area and general comparisons can be made between different soils based on a knowledge of their properties and present plant growth.

Climatic factors probably exert the greatest amount of control over forest productivity in timberline environments such as the Summit area (Bliss, 1966). Cool temperatures, a short snow-free period (and therefore short growing season) restrict plant growth considerably. The time of snow release is locally modified by aspect and wind exposure, with the early release areas having greater productivity potential.

Due to late snow release, summer showers, and low evaporation rates available moisture is not likely to be limiting in the soils of this area except in very shallow Lithic soils. Excess moisture may be limiting to plant growth in some gleysolic soils.

Shallow depth to bedrock is one edaphic factor limiting to plant production in the Summit area. Bedrock exposures and areas where depth to bedrock is less than 20 cm are severely limited in productive ability for most plants, and especially for trees. Lichens grow well on the bare rock and various plants (including small trees) grow on the shallow to bedrock soils where rooting depth is restricted.

The soils with deep Ah horizons and considerable depth to bedrock mapped as map unit 2 on the open meadow slopes in the northeast quadrant of the study area are probably the most productive soils in the study area. Slope gradients in these areas are typically 15 to over 60 percent with a south to east aspect. These soils are freely drained and are classified as Orthic Sombric Brunisol. Vegetation consists of lush meadow stands of *Valeriana sitchensis*, *Veratrum viride*, *Heracleum lanatum*, *Epilobium angustifolium*, *Erythronium grandiflorum*, *Arnica* spp., and *Erigeron peregrinus*.

The Sombric Humo-Ferric Podzol of map unit 8, which also has an Ah horizon, is probably the next most productive soil in this area. This soil occurs mainly in the south half of the study area and supports mixed forest-meadow communities at present.

The soils of map units 7, 4, 5, 9, 1, 3, and 6 appear somewhat less productive and may be ordered in diminishing productivity as shown. This rating, however, must be taken as being only a rough estimate. The lithic soils of map unit 10 probably rate below these in productivity.

TABLE 11. DISTRIBUTION OF SOIL SEPARATES IN PARENT MATERIALS AND CLASSIFICATION ACCORDING TO USDA, AASHO AND UNIFIED SYSTEMS

Map Unit	Hor.	CF % by Vol.	% of < 2 mm: Sand Fractions VCS	CS	MS	FS	VFS	Pipette Sand	Silt	Clay	% Passing Sieve #4	#10	#40	#200	Classification USDA	AASHO	Unified
2*	C	15-20	2.0	9.2	16.0	24.4	10.7	65	29	6	63	58	46	24	SL	A-1-b	SM
3	C	15	10.5	13.1	15.5	16.6	8.9	68	26	6	78	68	47	27	SL	A-2-4	SM
4	II Cg2	0	-	-	-	-	-	4	92	4	100	99	98	97	Si	A-4	ML (ash)
6	C1	0	0.1	0.1	0.1	3.4	11.3	19	75	6	100	100	100	90	SiL	A-4	ML (ash)
8	C	15	5.1	13.7	17.0	18.9	9.4	67	28	5	69	58	41	23	SL	A-1-b	SM
9	C	20	9.3	13.9	15.3	16.7	9.3	65	30	5	66	57	40	23	(G)SL	A-1-b	SM

*Parent material from map units 1, 5 and 7 will be very similar to that of map units 2, 3, 8 and 9.

TABLE 12. DISTRIBUTION OF SOILS IN THE STUDY AREA, SHOWN AS PERCENTAGE OF TOTAL AREA.

Map Unit	Topographic Class							Total %
	B	C	D	E	F	G	H	
1	--	0.10	--	3.87	2.63	6.21	0.76	13.57
2	--	--	--	--	4.64	7.66	2.00	14.30
2 + R	--	--	--	--	--	--	0.82	0.82
R + 2	--	--	--	--	--	--	0.38	0.38
3	0.03	0.78	0.38	0.08	0.94	--	--	2.21
3 + 5	--	--	--	--	1.35	--	--	1.35
4	--	0.67	--	0.16	1.11	--	--	1.94
5	--	--	--	--	0.92	--	--	0.92
6	--	0.19	--	--	--	--	--	0.19
7	--	--	--	--	0.44	4.43	0.56	5.43
7A	--	--	--	--	--	0.83	--	0.83
7 + 9	--	--	--	--	--	12.53	--	12.53
8	--	--	0.06	0.26	3.85	3.87	2.16	10.20
8 + 4	--	--	--	--	1.39	--	--	1.39
8 + 10	--	--	--	--	--	1.36	--	1.36
8 + R	--	--	--	--	--	5.43	--	5.43
9	--	--	--	0.29	0.76	6.23	0.53	7.81
9 + 10	--	--	--	--	--	1.28	--	1.28
9 + R	--	--	--	--	--	1.11	--	1.11
$\frac{9}{G} + \frac{R}{H}$	--	--	--	--	--	0.54		0.54
10	--	--	--	--	--	0.54	0.45	0.99
10 + R	--	--	--	--	--	5.01	--	5.01
R	--	--	--	--	--	--	4.55	4.55
R + 10	--	--	--	--	--	1.35	2.87	4.22
T	--	--	--	--	--	--	--	0.90
W	--	--	--	--	--	--	--	0.74
	0.03	1.74	0.44	4.66	18.03	57.84	15.08	100.00

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ENVIRONMENTAL FRAGILITY RATING

L. Knapik and M.M. Landals

Introduction

The rating of the landscape according to its sensitivity to the effects of human use is increasingly recognized as an important consideration in land use planning. Although reference is often made to the fragility of alpine and sub-alpine ecosystems, there has been little quantitative definition of actual levels of fragility.

Kuchar (1972a, 1972b, 1972c) developed fragility ratings for alpine and sub-alpine ecosystems in three areas of Jasper National Park. By estimating the vulnerability of vegetation to trampling, the rate of vegetation recovery and the susceptibility of the soil surface to erosion, he set up a five-point fragility scale. This rating scale was devised without the benefit of quantitative data. Landals and Knapik (1972) devised a similar type of five-point scale to rate landscape fragility with emphasis on trail location in Jasper National Park. This system was based on quantitative data from experimental trampling of five common plant communities and considerations of soil bearing capacity and erosion potential.

As used in this report, an environmental fragility rating is defined as a classification of vegetation and soil units according to their predicted response to anthropogenic use. Response is evaluated by the estimated amount of change in the natural ecosystem. Many specific types of human use could be considered, but some assumptions must be made to retain some universality of the system and eliminate the need for a separate rating for each land use. If a site is subjected to construction or very intensive use, it is destroyed as a natural ecosystem. While the activities involved in camping, picnicking, hiking, sight-seeing and related land uses are many and varied, one common activity of consequence to vegetation and soils is trampling by foot traffic. Trampling has therefore been selected as the type of use on which quantification of our rating is based.

The purpose of the rating system is to describe the type and degree of change which is expected to occur. The vegetation changes are primarily loss of plant cover and change in species composition. The changes to soils include erosion and the production of puddled, quagmire conditions.

The vegetation communities and soil units have been arranged in order of their susceptibility to damage. It is not possible to define the precise carrying capacity of each segment of the landscape. However, data from experimental trampling studies provide a quantitative guide to the relative amount of stress each unit can withstand.

Derivation

Vegetation and soils are interdependent in rating environmental fragility: soils will not erode unless the protective vegetation cover is removed and damaged vegetation will not recover if soils are eroding. Because the fragility of vegetation may not coincide with the fragility of soils, the two had to be rated separately and the ratings combined to give a dual index of fragility for each unit. In this way, excessive generalization was avoided and a more specific description of the fragility of each unit could be given. A map of the distribution of the fragility classes is included in the map pocket.

Vegetation Fragility Rating

The relative susceptibility of vegetation types to damage was gauged by considering the loss of plant cover when subjected to trampling, the expected rate of regeneration provided there is no soil erosion and the likelihood of changes in species composition. A more comprehensive account of vegetation fragility is given in Landals and Scotter (1974).

Experimental trampling was applied at weekly intervals to the five major communities of the area, *Valeriana sitchensis*, *Vaccinium membranaceum*, *Cassiope mertensiana*, *Luetkea pectinata* and *Carex nigricans*. Five, 10, 20, 40, 80 and 160 walks were applied each week for five weeks. Weekly trampling has been used to rate communities for the fragility scale because this most closely simulates visitor use over an entire season. Communities have been ordered according to their performance after the 100 walks treatment which is thought to be indicative of moderate visitor use.

According to cover loss, communities can be ordered, from most to least fragile, as *Vaccinium* and *Valeriana*, *Cassiope*, *Luetkea* and *Carex*. Considering regenerative capacity and tendency for species change during the recovery of vegetation, the order of the communities changes only slightly to *Vaccinium*, *Valeriana*, *Cassiope*, *Luetkea* and *Carex*.

Other communities were assimilated into this order by observation of their performance when subjected to visitor trampling or by guidance from other research, principally Nagy and Scotter, 1974.

TABLE A. CLASSES OF FRAGILITY FOR PLANT COMMUNITIES, MOUNT REVELSTOKE SUMMIT AREA.

Class	Definition and Attributes of Class	Plant Communities*
0	Little susceptibility to damage. This class includes unvegetated or sparsely-vegetated areas on bedrock exposures and talus slopes.	scattered vegetation on rock outcrops or talus
1	Slight susceptibility to damage. Under 25 percent loss of vegetation cover is expected with moderate trampling pressure. There should be a high recovery of vegetation with little species change from season to season, slowly deteriorating with constant use. Most areas are unsuitable for use because of spring flooding.	Carex nigricans basin community
2	Low susceptibility to damage. A vegetation loss of under 25 percent is expected with moderate trampling pressure. However, vegetation recovery from season to season will be slight with rapid deterioration under constant use. There is a probability of a change in species composition. The nature of the vegetation discourages random trampling.	Rhododendron albiflorum, Alnus sinuata, Salix monticola
3	Moderate susceptibility to damage. Between 25 and 50 percent of vegetation cover will likely be lost with moderate trampling pressure. Good vegetation recovery from season to season is expected with slow deterioration upon constant use. Only a slight change in species composition is likely. Some areas are very unsuitable for use because of poor drainage conditions.	Luetkea pectinata, Carex nigricans north slope community, Carex nigricans seepage community
4	Moderately high susceptibility to damage. A 50 to 70 percent loss of vegetation cover is expected with moderate trampling pressure. There will be virtually no recovery of dominant vegetation from season to season and a great change in species composition is likely.	Cassiope mertensiana
5	High susceptibility to damage. A 70 to 90 percent loss of vegetation cover is expected with moderate trampling pressure and even low trampling intensities will probably cause a great vegetation loss. Chances of vegetation recovery from one season's use are good but will probably deteriorate rapidly with continued use. A great change in species composition is likely.	Valeriana sitchensis, Luzula glabrata
6	Great susceptibility to damage. From 70 to 90 percent of vegetation cover will likely be lost with moderate trampling pressure. Little recovery of the dominant vegetation can be expected from season to season and there is the possibility of a great change in species composition.	Vaccinium membranaceum
7	Extreme susceptibility to damage. Greater than 90 percent of the vegetation cover will probably be lost with moderate trampling and regeneration will be slow because of the production of quagmire conditions.	Eriophorum polystachion

*Refer to Ecological Assessment of the Summit Area, Mount Revelstoke National Park (Landals and Scotter, 1974) for descriptions of plant communities.

Other communities were assimilated into this order by observation of their performance when subjected to visitor trampling or by guidance from other research, principally Nagy and Scotter, 1974.

Table A presents the final definition and description of the classes of plant community fragility and ordering of plant communities.

It must be realized that the rating of plant communities is only relative and it does not imply a regular gradation in fragility to trampling. There is, for example, a large gap between the durability of vegetation in classes 3 and 4. On the environmental fragility overlay map some units unmappable due to scale have been absorbed into the surrounding units. For example, within the boundaries of vegetation fragility class 6 (Vaccinium membranaceum), there are many scattered areas of Rhododendron albiflorum which has a fragility rating of 2.

Soil Fragility Rating

Soil fragility has been rated according to water erosion potential and susceptibility to disturbance by trampling. The trampling susceptibility is a fragility parameter that may not be recognized in a rating that only evaluates erosion potential. Soils on gently sloping land surfaces or in depressional areas have low erosion potential, but they may have low bearing strength due to wetness and fine textures or organic layers. These soils are easily churned up by trampling thus plant rooting systems are destroyed and quagmire conditions result.

Soil susceptibility to erosion refers to the expected rate and amount of soil loss by water -- and to a lesser degree wind -- transport

TABLE B. CLASSES OF FRAGILITY FOR SOILS AND MISCELLANEOUS LAND UNITS, MOUNT REVELSTOKE SUMMIT AREA.

Class	Definition and Attributes of Class	Soil Units
0	No susceptibility to damage. This rating is applied to non-soil areas such as bedrock exposures and coarse colluvial (talus) deposits.	R (bedrock) T (talus)
1	Moderate susceptibility to damage. Soils in this class are moderately susceptible to erosion. These are well-drained soils on slopes of less than 15 percent gradient.	1/E, 8/C, 8/E
2	High susceptibility to damage. Soils in this class are highly erodible or susceptible to disturbance by trampling. Well-drained soils on 15 to 60 percent slopes and poorly-drained soils with silty surface textures or organic layers on slopes of less than 5 percent are included in this class. Erosion preventive measures are definitely required if the vegetation cover is removed from the steeply sloping soils.	4/C, 6/B, 6/C, 3/C and all map units on F to G slopes except 4/F and 5/F
3	Very high susceptibility to damage. Soils in this class are very highly erodible and may also be susceptible to disturbance by trampling. Well-drained soils on slopes greater than 60 percent gradient and poorly-drained soils on 5 to 30 percent slopes are included in this class. These soils should not be used for site development if any alternatives are possible. There is a definite risk that erosion preventive practices would not be successful.	4/D, 4/E, 4/F, 5/F and all map units on H slopes except R/H

following removal of vegetation. Soil properties such as texture, organic matter content, bulk density, infiltration and percolation rates, drainage conditions, slope stability, and especially slope angle have all been evaluated in the estimation of soil erosion potential. A more comprehensive discussion of erodibility of the soils of the Summit area may be found on pages 50 - 51.

The soils and miscellaneous land units have been grouped into four classes of damage susceptibility described in Table B.

Discussion

The rating can be used to aid the planning of recreational development because it indicates the relative durability of vegetation and soils. It is not directed to specific uses such as campgrounds and picnic areas, but the ordering of the units for these uses would likely be the same as for random trampling.

The basic application of the rating system is to minimize damage by avoiding use of areas at the fragile end of the scale and channeling intensive traffic through the most resilient areas. However, planning decisions cannot be made that easily. Some vegetation fragility classes at the more resistant end of the scale coincide with fragile soil classes. In the derivation of the fragility classes, no account has been taken of the rarity of vegetation types. For example, vegetation class 4 includes *Cassiope mertensiana* stands which, although hardier, are less extensive than the mixed herbaceous meadows in vegetation class 5 or the stands of *Vaccinium membranaceum* beneath sub-alpine fir in vegetation class 6. Value judgments therefore have to be made and it may be more desirable to sacrifice part of an extensive though fragile vegetation type than to channel use to a rarer type even though it is hardier. A factor to consider in the location of trails is scenic value. At the Summit, the most spectacular features of the vegetation are the floral displays of the mixed herbaceous meadows which are at the fragile end of the scale.

The most important factor to consider in planning for developments such as trails and picnic areas is that intensive use will destroy the vegetation no matter how resistant it is to trampling. Therefore the ultimate decision on where to place heavy traffic depends on the resistance of the soil to erosion.

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APPENDIX A

SOIL MAP UNIT DESCRIPTIONS AND ANALYTICAL DATA

Soil Map Unit 1

These medium to moderately coarse textured soils are found mainly on the Summit ridge in the north half of the study area. The soil profile is often developed in fairly thin, discontinuous deposits of aeolian materials which overlie previously developed profiles. Slopes are commonly less than 15 percent with variations of up to 60 percent, and aspect is variable.

Classification:

These soils are classified as Orthic Humo-Ferric Podzol since there is sufficient amorphous aluminum and iron (pyrophosphate extraction) in both the upper and paleo B horizons to qualify as Bf horizons. The upper Bf has greater than 5 percent organic carbon content, and therefore it is actually a Bhf; however, it does not satisfy minimum depth requirements for a Ferro-Humic Podzol. Typical podzolic morphology is absent or very weak in these soils. Colors of the B horizons are 7.5 YR hues; and amorphous structure, pellets and "slippery" feel are not obvious.

Associated Map Units:

Map Unit 2 soils are often closely related geographically and morphologically to those of Map Unit 1. The Map Unit 2 soils have a deeper Ah (>10 cm) and do not usually have B horizons that qualify chemically as Bf's, although some do. Even though the Ah horizons are 50 cm thick, and the B horizons are 10 YR hue, these soils may still be Podzols. Map Unit 8 soils are Podzolic soils with Ah horizons of approximately 10 cm thickness and Bf horizons which have 5 YR hues and typical podzolic Bf morphology. They occur in areas with tree and shrub cover and often heather understory vegetation.

Vegetation:

Vegetation consists of predominantly sedge-heath communities with *Carex nigricans* and bryophytes dominant and *Luetkea pectinata* co-dominant. Common species include *Arnica latifolia* and *Hieracium gracile*, with patches of *Abies lasiocarpa*, and occasionally *Cassiope mertensiana*, *Antennaria lanata* and *Valeriana sitchensis*.

Pedon Description:

Described by: L. Knapik

Date: August 28, 1973

Location: S-1[1]

Parent Material: aeolian/till

Landform: glaciated bedrock ridge

Slope: 11%

Aspect: north

Elevation: 6,400 ft. ASL (1,940 m)

Drainage Class: well drained

Soil Classification: Orthic Humo-Ferric Podzol

Ah	0 to 6 cm; very dark grayish brown (10 YR 3/2 m*) and black (10 YR 2/1 m) silt loam; weak fine granular; very friable; abundant, fine, random roots; clear, smooth boundary; 3 to 10 cm thick.
Bhf	6 to 11 cm; dark brown (7.5 YR 4/4 m) silt loam; weak fine granular; very friable; abundant, fine, vertical roots; less than 5% coarse fragments; clear, broken boundary; 0 to 9 cm thick.
IIAhb	11 to 21 cm; dark yellowish brown (10 YR 3/4 m) sandy loam; moderate fine, vertical roots; 10% coarse fragments; clear, smooth boundary.

[1] See soil map for sampling location.

* m - moist color; d - dry color.

IIBfb 21 to 35 cm; dark brown (7.5 YR 4/4 m) sandy loam; weak fine, subangular blocky; friable; few, fine, vertical roots; 10% coarse fragments; gradual, smooth boundary.

IIC 35+ cm; dark yellowish brown (10 YR 4/4 m) fine sandy loam; amorphous; firm; 20% coarse fragments.

ANALYTICAL DATA 1

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
Ah	0-6	4.3	.52	9.4	18.1	0.11	0.15	0.25	0.20	31.8
Bhf	6-11	4.5	.46	8.6	18.7	0.06	0.06	0.13	0.05	38.5
IIAhb	11-21	4.5	.20	3.0	15.2	0.04	0.04	0.06	0.05	18.8
IIBfb	21-35	4.6	.10	1.8	18.0	0.02	0.03	0.22	0.10	17.2
IIC	35+	4.6	-	-	-	0.01	0.03	0.22	0.05	9.90

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Ah	1.13	1.42	2.55	SiL	0	22	67	11	0.4
Bhf	-	-	-	SiL	5	23	70	7	-
IIAhb	-	-	-	SL	10	62	33	5	-
IIBfb	0.75	0.34	1.09	SL	10	64	31	5	-
IIC	-	-	-	SL	15	65	29	6	-

Soil Map Unit 2

These moderately coarse textured soils occur on very steeply to extremely sloping land surfaces mostly in the northern half of the study area. Surface drainage is rapid and there are few boulders on the surface.

Classification:

These soils have been classified as being predominantly Orthic Sombric Brunisol on the basis of their deep Ah (10 to 50 cm) and 10 YR hue in the B horizon. Some of the soils included in this map unit meet the chemical qualifications of Podzols, especially those soils that are intergrades between Map Units 2 and 1 and between Map Units 2 and 8. The map unit therefore includes some Sombric Humo-Ferric Podzols.

Associated Map Units:

Map Unit 2 soils often occur adjacent to Map Unit 1 soils, usually on more steeply sloping land surfaces that are susceptible to soil creep; and the Ah horizons are thicker and the B horizons have brownish hues. The Regosolic soils of Map Unit 7 occur on similar slopes and in similar slope positions as those of Map Unit 2 and the two units are often difficult to separate without examination of the profile. Even then B horizons may be discontinuous or difficult to recognize in the Map Unit 2 soils.

Vegetation:

In most of these soil areas vegetation consists of mixed herbaceous communities with *Valeriana sitchensis* often dominant and several species of common occurrence including *Veratrum viride*, *Epilobium angustifolium*, *Arnica latifolia*, *Erigeron peregrinus*, *Senecio triangularis*, and *Lupinus latifolius*. In some areas sedge communities similar to those of Map Unit 1 areas are present while in other areas these soils are under *Abies lasiocarpa* - *Vaccinum membranaceum* stands.

Pedon Description:

Described by: L. Knapik

Date: August 28, 1973

Location: S-2

Parent Material: colluvium of till origin

Landform: glaciated bedrock ridge

Slope: 65 to 75%, 65% across pit

Aspect: East

Elevation: 6,300 ft. ASL (1,910 m)

Drainage Class: well drained

Soil Classification: Orthic Sombric Brunisol

Ah1 — 0 to 26 cm; dark brown (7.5 YR 3/2 m) loam; moderate fine granular; very friable; abundant, fine and medium, random roots; 5% cobble-sized coarse fragments; gradual smooth boundary; 20 to 40 cm thick.

Ah2 — 26 to 46 cm; dark yellowish brown (19 YR 3/4 m) loam; weak, fine granular; very friable; abundant, fine and medium, random roots; 5% cobble-sized coarse fragments; gradual, broken boundary; 0 to 30 cm thick.

Bm — 46 to 61 cm; dark yellowish brown (10 YR 4/4 m) sandy loam; weak, fine granular; very friable; abundant, fine, vertical roots; 15% cobble-sized coarse fragments; clear, smooth boundary.

C — 61+ cm; yellowish brown (10 YR 5/6 m) sandy loam; friable; few, fine vertical roots; 15% gravel and cobble-sized coarse fragments.

ANALYTICAL DATA 2

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
Ah1	0-26	4.4	.68	7.09	10.4	0.10	0.50	2.56	0.46	27.0
Ah2	26-46	4.4	-	4.52	-	0.04	0.27	0.44	0.10	23.1
Bm	46-61	4.4	.17	2.83	16.6	0.04	0.12	0.13	0.05	15.6
C	61+	4.6	-	-	-	0.07	0.07	0.44	0.15	14.1

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Ah1	-	-	-	SL	5	57	32	11	0.7
Ah2	-	-	-	SL	5	60	33	7	0.5
Bm	0.54	0.28	0.82	SL-LS	15	71	26	3	-
C	-	-	-	SL	15	67	28	5	-

Soil Map Unit 3

The imperfectly to "moderately" poorly drained soils of Map Unit 3 occur in poorly defined snowmelt runoff channels (Plate 3) and depressional areas of late snow cover and seasonal ponding. These soils have deep (20 to 40 cm), dark colored organic (Oh) horizons that look very much like Ah horizons; however, they contain 30 to 65 percent organic matter.

Classification:

These soils are classified as Orthic and Cumulic Regosols as a result of their Oh, C or Oh1, Oh2, Oh3, C horizon sequences with brightly colored C horizons (no indication of gleying processes).

Associated Map Units:

These soils occur in close association with the peaty Rego Gleysols of Map Unit 5 in some groundwater discharge areas. Map Unit 4 soils have similar horizonation to Map Unit 3 soils; however, the latter are poorly and very poorly drained Gleysols.

Vegetation:

Vegetation is made up of communities with *Luetkea pectinata* dominant in the snowmelt drains and *Carex nigricans* dominant in the basin areas. Occurring with the *Luetkea pectinata* are such species as *Phyllodoce empetriformis*, *Erigeron peregrinus* and the occasional *Abies lasiocarpa*.

Pedon Description A:

(Soil pedons representative of this map unit were sampled in two locations.)

Described by: L. Knapik

Date: August 29, 1973

Location: S-3A

Parent Material: organic/slope wash

Landform: basin

Slope: depressional

Aspect: ---

Elevation: 6,250 ft. ASL (1,910 m)

Drainage Class: somewhat poorly drained

Soil Classification: Orthic Regosol

Vegetation: Carex nigricans (100% cover)

Oh1	0 to 7 cm; very dark grayish brown (10 YR 3/2 m) silt loam; moderate, fine granular; (turfy); abundant, fine, random roots; abrupt, smooth boundary.
Oh2	7 to 19 cm; black (10 YR 2/1 m) silt loam; moderate, fine, granular; friable; abundant, fine, random roots; abrupt, smooth boundary.
ash	19 to 21 cm; yellowish brown (10 YR 5/4 m) fine sandy loam, tephra layer.
Oh3	21 to 31 cm; black (N 2/ m) silt loam; moderate, fine granular; friable; few, fine, vertical roots; clear, smooth boundary; 8 to 15 cm thick.
IIC	31+ cm; yellowish brown (10 YR 5/6 m) gravelly sandy loam; amorphous; slightly firm; 25% coarse fragments.

Pedon Description B:

Described by: L. Knapik

Date: August 27, 1973

Location: S-3B

Parent Material: organic/slope wash

Landform: weakly incised channel

Slope: 18%

Aspect: North

Elevation: 6,200 ft. ASL (1,890 m)

Drainage Class: imperfectly drained

Soil Classification: Orthic Regosol

Vegetation: Luetkea pectinata (80% cover), Phyllodoce empetriformis (10%), Erigeron perigrinus (5%)

Oh1	0 to 15 cm; very dark gray (10 YR 3/1 m) fine sandy loam; moderate, fine granular; very friable; abundant, fine, random roots; clear, smooth boundary; (upper 5 cm is turfy).
Oh2	15 to 27 cm; very dark grayish brown (10 YR 3/2 m) fine, sandy loam; weak, moderate granular; friable; abundant, fine, vertical roots; clear, smooth boundary.
AC	27 to 42 cm; very dark grayish brown (10 YR 3/2 m) silt loam; moderate, fine subangular blocky; friable; plentiful, fine, vertical roots; 5% coarse fragments; clear, smooth boundary.
IIC	42+ cm; yellowish brown (10 YR 5/6 m) sandy loam; amorphous; firm; 15% coarse fragments.

ANALYTICAL DATA 3A

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
Oh1	0- 7	4.0	2.08	31.90	15.3	0.35	1.25	0.78	0.51	67.5
Oh2	7-19	4.3	1.12	18.60	16.6	0.08	0.21	0.31	0.26	70.2
Ash	19-21		-	-	-	-	-	-	-	-
Oh3	21-31	4.4	.98	22.01	22.5	0.07	0.05	0.13	0.10	73.2
IIC	31+	4.8	-	-	-	0.20	0.02	0.13	0.05	6.70

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Oh1	-	-	-	Organic	0	5[1]	77	18	0.2
Oh2	-	-	-	Organic	0	15[1]	72	13	0.3
Oh3	-	-	-	Organic	0	16[1]	66	18	-
IIC	-	-	-	LS	25	82	15	3	-

[1] Particle size analysis after removal of organic matter. These are organic layers with greater than 17% organic carbon content.

ANALYTICAL DATA 3B

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
Oh1	0-15	4.2	.99	19.22	19.4	0.19	0.28	0.88	0.61	59.8
Oh2	15-27	4.4	.83	17.72	21.4	0.09	0.09	0.25	0.20	71.0
AC	27-42	4.4	.21	3.33	15.9	0.06	0.03	0.38	0.05	20.5
IIC	42+	4.7	-	-	-	0.03	0.02	0.31	0.10	8.50

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Oh1	-	-	-	Organic	0	27[1]	57	16	0.4
Oh2	-	-	-	Organic	0	29[1]	57	14	0.3
AC	-	-	-	SL	5	55	35	10	-
IIC	-	-	-	SL	15	68	26	6	-

[1] Particle size analysis after removal of organic matter. These are organic layers with greater than 17% organic carbon content.

Soil Map Unit 4

These poorly and very poorly drained soils are usually associated with groundwater discharge and a high water table in basin areas and stream channels. The organic surface horizons contain 60 to 70 percent organic matter which is mixed with alluvial sediment.

Classification:

These soils are classified as Rego Gleysols and have Oh, Cg horizon sequences in their profiles. The soils are often layered in a cumulic manner due to burying of former soil surfaces by volcanic ash and alluvial deposits.

Associated Map Units:

Few map units are associated directly with Map Unit 4 although some of the soils of Map Unit 4 may tend toward the peaty nature of Map Unit 5. The soils of Map Units 1 and 3 often border the Map Unit 4 areas.

Vegetation:

Plant communities are generally dominated by *Carex nigricans* although there are a few areas with mixed herbaceous communities.

Pedon Description:

Described by: L. Knapik

Date: August 28, 1973

Location: S-4

Parent Material: organic/volcanic ash and alluvium

Landform: alluvial channel

Slope: 3%

Aspect: ---

Elevation: 6,000 ft. ASL (1,830 m)

Drainage Class: very poorly drained

Soil Classification: Rego Gleysol

Vegetation: Carex nigricans

L	3 to 0 cm; densely rooted turf of Carex nigricans; abrupt smooth boundary.
Oh1	0 to 11 cm; dark brown (7.5 YR 3/2 m) silt loam; moderate, fine granular, (turfy); abundant, fine, random roots; abrupt smooth boundary.
Ash	11 to 12 cm; light yellowish brown (10 YR 6/4 m) tephra layer; abrupt, smooth boundary.
Oh2	12 to 21 cm; very dark grayish brown (10 YR 3/2 m) silt loam; weak, fine granular, (slightly turfy); abundant, fine, random roots; abrupt, smooth boundary.
IICg1	21 to 28 cm; yellowish brown (10 YR 5/4 m) fine sandy loam; stratified; friable; few, fine, vertical roots; clear, smooth boundary.
IICg2	28 to 42 cm; very pale brown (10 YR 7/3 m) with many, coarse, prominent yellowish red (5 YR 5/8 m) mottles; sandy loam; stratified; friable; many fine pores; abrupt, smooth boundary.
Ohb	42 to 52 cm; very dark grayish brown (10 YR 3/2 m) silt loam; pseudo-platy; slightly sticky; abrupt, irregular boundary.
IIICg	52+ cm; dark gray (5 Y 4/1 m) silt loam; 10% cobble-sized coarse fragments.

ANALYTICAL DATA 4

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
L	3- 0	-	-	-	18.2	-	-	-	-	-
Oh1	0-11	3.7	2.16	39.33	-	1.03	0.68	0.44	0.61	91.1
Ash	11-12	-	-	-	-	-	-	-	-	-
Oh2	12-21	4.0	.04	38.21	-	1.12	0.38	0.54	0.29	80.9
IICg1	21-28	4.6	-	--	-	0.12	0.02	0.45	0.15	10.5
IICg2	28-42	4.8	-	--	-	0.14	0.02	0.16	0.13	6.20
Ohb	42-52	4.6	-	34.43	-	0.18	0.14	5.05	1.88	68.4
IIICg	52+	-	-	-	-	-	-	-	-	-

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
L	-	-	-	-	-	-	-	-	-
Oh1	-	-	-	Organic	0	7[1]	73	20	0.2
Oh2	-	-	-	Organic	0	6[1]	69	25	0.2
IICg1	-	-	-	SiL	0	39	57	4	-
IICg2	-	-	-	Si	0	4	92	4	0.7
Ohb	-	-	-	Organic	0	6[1]	72	22	-
IIICg	-	-	-	-	-	-	-	-	-

[1] Particle size analysis after removal of organic matter. These are organic layers with greater than 17% organic carbon content.

ANALYTICAL DATA 4

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
L	3- 0	-	-	-	18.2	-	-	-	-	-
Oh1	0-11	3.7	2.16	39.33	-	1.03	0.68	0.44	0.61	91.1
Ash	11-12	-	-	-	-	-	-	-	-	-
Oh2	12-21	4.0	.04	38.21	-	1.12	0.38	0.54	0.29	80.9
IICg1	21-28	4.6	-	--	-	0.12	0.02	0.45	0.15	10.5
IICg2	28-42	4.8	-	--	-	0.14	0.02	0.16	0.13	6.20
Ohb	42-52	4.6	-	34.43	-	0.18	0.14	5.05	1.88	68.4
IIICg	52+	-	-	-	-	-	-	-	-	-

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
L	-	-	-	-	-	-	-	-	-
Oh1	-	-	-	Organic	0	7[1]	73	20	0.2
Oh2	-	-	-	Organic	0	6[1]	69	25	0.2
IICg1	-	-	-	SiL	0	39	57	4	-
IICg2	-	-	-	Si	0	4	92	4	0.7
Ohb	-	-	-	Organic	0	6[1]	72	22	-
IIICg	-	-	-	-	-	-	-	-	-

1 Particle size analysis after removal of organic matter. These are organic layers with greater than 17% organic carbon content.

Soil Map Unit 5

These very poorly drained peaty soils are associated with groundwater seepage on steeply sloping land surfaces. They occur for the most part in the northern half of the study area.

Classification:

Soils of Map Unit 5 are classified as Peaty Rego Humic Gleysols with an Of, Ahg, Cg horizon sequence. Gleysolic soils are wet soils and are typified by dull colors in the Cg horizon where reducing condtions perhaps dominate the soil forming process.

Associated Map Units:

There are areas in the northern half of the study area where soils of Map Units 3 and 5 are complexly intermingled and are mapped as a complex of the two map units. Soils of Map Unit 2 often border the Map Unit 5 areas.

Vegetation:

Sedge-moss communities are dominant on these soils. Sedge species include *Eriophorum polystachion* and *Carex* sp. and the mosses are commonly *Sphagnum* spp.

Pedon Description:

Described by: L. Knapik

Date: August 30, 1973

Location: S-5

Parent Material: organic/slope wash

Landfrom: moraine covered bedrock ridge

Slope: 20%

Aspect: southeast

Elevation: 6,200 ft. ASL (1,890 m)

Drainage Class: very poorly drained

Soil Classification: Peaty Rego Humic Gleysol

Of	20 to 0 cm; dark brown (7.5 YR 4/4 m) slightly decomposed sedge and moss-derived organic material; clear smooth boundary.
Ahg	0 to 35 cm; very dark gray (10 YR 3/1 m) silt loam; amorphous; slightly sticky; plentiful, fine, vertical roots; 5% cobble-sized coarse fragments; clear, smooth boundary.
Cg	35+ cm; greenish gray (5 GY 5/1 m) loamy coarse sand; amorphous; nonsticky; 20% gravel-sized coarse fragments.

ANALYTICAL DATA 5

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
Of	20- 0	4.2	-	-	-	0.68	0.75	8.02	2.05	75.3
Ahg	0-35	4.3	10.8	6.28	17.9	0.14	0.06	1.21	0.15	35.1
Cg	35+	4.3	-	-	-	0.04	0.06	0.44	0.10	4.50

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Of	-	-	-	-	-	-	-	-	-
Ahg	-	-	-	L	0	42	40	18	-
Cg	-	-	-	LS	15	78	17	5	-

Soil Map Unit 6

Hummocky microrelief is characteristic of the terrain on which these soils occur. The soils have developed on fairly thick deposits of silt loam textured volcanic ash in small basin areas subject to ponding of meltwater accumulation. The hummocky soil surface is probably a result of frost action.

Classification:

These soils pose a problem in classification. The pyrophosphate-extractable iron and aluminum and the organic carbon content of the B horizons are sufficient for Bhf horizon definition, thus the soils can be classed as Ferro-Humic Podzols; and since they have a deep Ah, as Sombric Ferro-Humic Podzols. They are perhaps best classified as Turbic Sombric Ferro-Humic Podzols due to their weakly cryoturbated surface. However, it should be noted that such a subgroup is not defined in the Canadian Soil Classification System.

Associated Map Units:

Map Units 1 and 8 are usually adjacent to Map Unit 6, on the well drained slopes surrounding the basins.

Vegetation:

The hummocks generally support a continuous cover of *Carex nigricans* with very few other species present.

Pedon Description:

Described by: L. Knapik

Date: August 29, 1973

Location: S-6

Parent Material: volcanic ash/lacustrine

Landform: basin

Slope: depressional

Aspect: ---

Elevation: 6,250 ft. ASL (1,910 m)

Drainage Class: somewhat poorly to imperfectly drained

Soil Classification: Sombric Ferro-Humic Podzol

L	4 to 0 cm; densely rooted turf of Carex; distinct, wavy boundary.
Ah1	0 to 10 cm; very dark grayish brown (10 YR 3/2 m) silt loam; weak, fine granular; friable; abundant, fine, vertical roots; clear, wavy boundary.
Ah2	10 to 18 cm; very dark gray (10 YR 3/1 m) silt loam; weak, fine granular; friable; abundant, fine, vertical roots; clear, wavy boundary.
Bf	18 to 26 cm; yellowish red (5 YR 4/6 m) silt loam; weak, fine, subangular blocky; friable; plentiful, fine, vertical roots; clear, wavy boundary.
Bhf	26 to 43 cm; strong brown (7.5 YR 5/6 m) silt loam; weak, fine, subangular blocky; friable; plentiful, fine vertical roots; clear smooth boundary.
C	43 to 73 cm; brownish yellow (10 YR 6/6 m) with common, fine, distinct strong brown (7.5 YR 5/8 m) mottles; silt loam; amorphous; slightly firm; clear, smooth boundary.
Ahb	73 to 74 cm.
IIC	74 to 95+ cm; light olive brown (2.5 Y 5/4 m) with few, fine distinct yellowish brown (10 YR 5/4 m) mottles; silt loam; stratified.

ANALYTICAL DATA 6

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
L	4- 0	3.9	-	-	-	0.09	1.44	0.94	0.51	91.7
Ah1, Ah2	0-18	4.4	.78	14.15	18.1	0.15	0.26	0.88	0.20	34.7
Bf	18-26	-	-	-	-	-	-	-	-	-
Bhf	26-43	4.6	.31	5.50	17.7	0.04	0.08	0.09	0.15	29.9
C	43-73	5.0	-	-	-	0.04	0.04	0.13	0.10	13.8
Ahb	73-74	-	-	-	-	-	-	-	-	-
IIC	74-95+	-	-	-	-	-	-	-	-	-

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
L	-	-	-	-	-	-	-	-	0.3
Ah1, Ah2	-	-	-	SiL	0	19	71	10	0.3
Bf	-	-	-	-	-	-	-	-	-
Bhf	0.75	0.66	1.41	SiL	0	27	67	6	0.4
C	0.16	0.22	0.38	SiL	0	19	75	6	-
Ahb	-	-	-	-	-	-	-	-	-
IIC	-	-	-	-	-	-	-	-	-

Soil Map Unit 7

The moderately coarse textured soils of Map Unit 7 occur on steeply to very steeply sloping land surfaces where there appears to be considerable soil movement which is disrupting and impeding soil profile development.

Classification:

These soils are classified as Orthic and Cumulic Regosol. Profiles consist of a deep Ah horizon often apparently cumulic in nature, directly overlying the C horizon.

Associated Map Units:

The Regosols of Map Unit 7 are often closely associated and complexed in mapping with the Podzols of Map Unit 9. The Regosols occur under herbaceous plant communities in open areas within the forest community and the Podzols under tree stands in these areas. The soils of Map Unit 2 are often closely related, geographically and genetically, to Map Unit 7 soils; however, the former have B horizons.

Vegetation:

Plant communities of this map unit are made up of mixed herbaceous stands, often occurring as open areas in discontinuous forest. Typical species include *Senecio triangularis*, *Ligusticum canbyi* and *Erigeron peregrinus* with *Abies lasiocarpa*, *Rhododendron albiflorum* and *Vaccinium membranaceum* surrounding and occasionally covering the areas.

Pedon Description:

Described by: L. Knapik and G. Coen

Date: September 19, 1973

Location: S-7

Parent Material: glacial till

Landform: moraine covered mountain slope

Slope: 35%

Aspect: east

Elevation: 5,800 ft. ASL (1,770 m)

Drainage Class: moderately well to well drained

Soil Classification: Orthic Regosol

Ah	0 to 40 cm; very dark grayish brown (10 YR 3/2 m) sandy loam; moderate, fine granular; friable; abundant, fine and medium, random roots; many, fine pores; 5% coarse fragments; clear, wavy boundary; 36 to 45 cm thick.
C	40+ cm; yellowish brown (10 YR 5/6 m) sandy loam; amorphous (somewhat angular); friable (firm in place); few, fine, vertical roots; many fine and medium pores; 15 to 20% gravel and cobble-sized coarse fragments.

ANALYTICAL DATA 7

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
Ah	0-40	4.2	0.32	4.39	13.7	0.03	0.11	0.39	0.13	23.1
C	40+	4.4	-	-	-	0.04	0.02	0.31	0.00	8.4

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Ah	-	-	-	SL	5	54	34	12	-
C	-	-	-	SL	15	70	28	2	-

Soil Map Unit 8

These soils have medium textured, black Ah horizons overlying dark reddish brown podzolic B horizons that are much sandier in texture. These soils are found mainly in the central part of the study area within the upper fringes of forest cover.

Classification:

These soils are classified as Sombric Humo-Ferric Podzols due to the presence of an Ah greater than 7.5 cm and a Bf more than 5 cm thick. There are no Ae horizons in these soils and only occasionally an Ahe.

Associated Map Units:

Map Unit 8 soils are often associated with bedrock outcrops (R) and with lithic soil phases (Map Unit 10). Map Unit 9 soils often border and intergrade to the Map Unit 8 soils, with the Map Unit 9 soils generally found under a heavier tree and shrub cover. Map Unit 8 soils also grade to Map Unit 1 soils which have less pronounced podzolic morphology and browner colored B horizons.

Vegetation:

Plant cover is often made up of *Cassiope mertensiana*, *Luetkea* pectinata communities scattered clumps and individuals of *Abies lasiocarpa*.

Pedon Description A: (This soil was described and sampled in two locations.)

Described by: L. Knapik

Date: August 29, 1973

Location: S-8A

Parent Material: till

Landform: moraine covered bedrock ridge

Slope: 25%

Aspect: west

Elevation: 6,200 ft. ASL (1,890 m)

Drainage Class: well drained

Soil Classification: Sombric Humo-Ferric Podzol

Vegetation: *Cassiope mertensiana* and *Luetkea pectinata* dominant, with *Abies lasiocarpa* saplings.

L	7 to 0 cm; turfy organic layer; abundant, fine, random roots; abrupt, smooth boundary.
Ah	0 to 11 cm; black (10 YR 2/1 m) silt loam; moderate, fine, granular; friable; plentiful, fine, random roots; clear, smooth boundary; 6 to 15 cm thick.
Bf	11 to 31 cm; dark reddish brown (5 YR 3/4 m) sandy loam; weak, medium, subangular blocky; slightly firm; very few, fine, vertical roots; 10% cobble-sized coarse fragments; gradual, irregular boundary.
C	31 to 60+ cm; dark brown (7.5 YR 4/4 m) and dark reddish brown (5 YR 3/4 m) sandy loam; weak, fine, subangular blocky; slightly firm; 15% coarse fragments. Several large boulders below.

Pedon Description B:

Described by: L. Knapik

Date: August 30, 1973

Location: S-8B

Parent Material: till

Landform: moraine covered bedrock ridge

Slope: 10%

Aspect: east

Elevation: 6,250 ft. ASL (1,910 m)

Drainage Class: well drained

Soil Classification: Sombric Humo-Ferric Podzol

Vegetation: Abies lasiocarpa with Cassiope mertensiana and Luetkea pectinata understory

L	4 to 0 cm; abrupt, smooth boundary.
Ah	0 to 15 cm; black (10 YR 2/1 m) and dark reddish brown (5 YR 3/2 m) silt loam; moderate, fine granular; friable; abundant, fine, random and plentiful, fine vertical roots; 5% coarse fragments; abrupt, smooth boundary, 8 to 20 cm thick.
Bf	15 to 35 cm; dark reddish brown (5 YR 3/4 m) sandy loam; weak, fine, subangular blocky; firm; few, fine, vertical roots; 15% coarse fragments; clear, smooth boundary.
C	35+ cm; yellowish brown (10 YR 5/6 m) sandy loam; amorphous; firm; 15% coarse fragments.

ANALYTICAL DATA 8A

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
L	7- 0	4.1	-	-	-	0.05	0.96	0.63	0.51	116
Ah	0-11	4.2	.70	14.58	20.8	0.05	0.18	0.44	0.20	53.6
Bf	11-31	4.3	.15	3.17	21.1	0.02	0.03	0.13	0.10	23.8
C	31-60+	4.4	-	-	-	0.03	0.03	0.13	0.05	12.9

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
L	-	-	-	-	-	-	-	-	-
Ah	-	-	-	SiL	0	29	63	8	0.3
Bf	1.04	0.34	1.38	SL	10	62	33	5	-
C	-	-	-	SL	15	67	28	5	-

ANALYTICAL DATA 8B

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
L	4-0	3.6	-	-	-	0.09	0.66	0.16	0.38	65.5
Ah	0-15	4.3	.44	10.41	23.7	0.08	0.09	0.21	0.17	39.9
Bf	15-35	4.5	.11	2.89	26.3	0.02	0.02	0.31	0.41	19.3
C	35^+	4.7	-	-	-	0.01	0.01	0.06	0.05	4.40

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Ah	0.68	0.57	1.25	SiL	5	22	69	9	0.4
Bf	-	-	-	SL	15	66	28	6	-
C	-	-	-	LS	15	84	15	1	-

Soil Map Unit 9

The soils of Map Unit 9 occur mostly at the lower elevations in the southern half of the study area, under fairly continuous tree cover. These are well developed Podzolic soils with eluviated surface horizons and cemented B horizons.

Classification:

These soils are classified as Ortstein Ferro-Humic Podzols, although the Bhf horizon may not always satisfy the 10 cm minimum depth requirement for such horizons. The lower B horizons are firmly cemented (ortstein layer).

Associated Map Units:

Map Unit 9 soils are often associated with bedrock outcrops (R) and lithic soil phases (Map Unit 10). Map Unit 9 soils grade to Map Unit 8 soils as Ah horizons become thicker and Ae horizons disappear.

Vegetation:

Vegetation commonly consists of *Abies lasiocarpa* - *Rhododendron albiflorum* dominated communities with *Vaccinium membranaceum*, *Luetkea pectinata* and *Phyllodoce empetriformis* often abundant.

Pedon Description:

Described by: L. Knapik

Date: August 27, 1973

Location: S-9

Parent Material: till

Landform: moraine covered bedrock ridge

Slope: 5%

Aspect: north

Elevation: 6,100 ft. ASL (1,860 m)

Drainage Class: well drained

Soil Classification: Ortstein Ferro-Humic Podzol

Ahe	0 to 5 cm; dark brown (7.5 YR 4/2 m) fine sandy loam; weak, fine, granular; very friable; plentiful, fine, random roots; less than 5% coarse fragments; clear, smooth boundary; 3 to 8 cm thick.
Bhf	5 to 11 cm; dark reddish brown (5 YR 3/3 m) and yellowish red (5 YR 4/6 m) silt loam; moderate, medium granular; very friable; abundant, fine, vertical roots; 10% cobble-sized coarse fragments; gradual, smooth boundary; 4 to 9 cm thick.
Bfc	11 to 24 cm; dark reddish brown (5 YR 3/3 m) coarse sandy loam; amorphous; firm; very few, fine, vertical roots, 15% cobble-sized coarse fragments; gradual, smooth boundary; 11 to 30 cm thick.
C	24+ cm; yellowish brown (10 YR 5/4 m) sandy loam; amorphous, slightly firm; 15% gravel-sized coarse fragments.

ANALYTICAL DATA 9

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
Ahe	0- 5	3.8	.30	6.26	20.9	0.11	0.14	0.31	0.15	26.1
Bhf	5-11	4.3	.40	10.45	26.1	0.10	0.05	0.06	0.10	55.8
Bfc	11-24	4.5	.07	1.69	24.1	0.10	0.02	0.13	0.05	13.0
C	24+	4.9	-	-	-	0.05	0.03	0.38	0.10	6.40

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Ahe	-	-	-	SiL	5	26	66	8	0.4
Bhf	1.80	1.50	3.30	SiL	10	15	76	9	-
Bfc	0.46	0.28	0.74	LS	15	82	16	2	-
C	-	-	-	SL	15	65	30	5	-

Soil Map Unit 10

Map Unit 10 soils have a lithic (bedrock) contact within 50 cm of the soil surface. Soils of this unit may occur on the crests of bedrock masses or on extremely sloping land surfaces.

Classification:

These soils are generally Lithic Humo-Ferric Podzols although there is a fair degree of profile variation. Ah, Ahe, or Ae horizons may be present and B horizons differ in their amount of podzolic morphology and may or may not extend to the lithic contact.

Associated Map Units:

The most commonly associated Map Units are 8 and 9, along with bedrock outcrops (R). Map Unit 10 soils are the undifferentiated lithic phases of Map Units 8 and 9.

Vegetation:

Plant communities are quite variable with *Abies lasiocarpa*, *Rhododendron albiflorum*, *Luetkea pectinata*, *Arnica latifolia* and various bryophytes being common.

Pedon Description A:

Described by: L. Knapik

Date: August 29, 1973

Location: S-10A

Parent Material: thin till/bedrock

Landform: bedrock ridge

Slope: nil (ridge summit)

Aspect: ---

Elevation: 6,300 ft. ASL (1,920 m)

Drainage Class: well drained

Soil Classification: Lithic Humo-Ferric Podzol

Vegetation: Abies lasiocarpa and Luetkea pectinata dominant species, with 20% bare surface

L - F 1 to 0 cm; slightly decomposed moss and needle litter, abrupt, smooth boundary.

Ae 0 to 7 cm; dark grayish brown (10 YR 4/2 m) loam; weak, fine granular; very friable; abundant, very fine and fine, random roots; 5% coarse fragments; abrupt, smooth boundary; 5 to 10 cm thick.

Bf 7 to 18 cm; dark reddish brown (5 YR 3/3 m) sandy loam; moderate, fine ranular; friable; abundant, very fine and fine, vertical roots; 5% coarse fragments; abrupt, smooth boundary; 10 to 21 cm thick.

R 18+ cm; bedrock.

Pedon Description B:

Described by: L. Knapik and G Coen

Date: September 19, 1973

Location: S-10B

Parent Material: thin colluvium/bedrock

Landform: colluvium covered bedrock ridge

Slope: 70%

Aspect: north

Elevation: 6,050 ft. ASL (1,850 m)

Drainage Class: well drained

Soil Classification: Lithic Humo-Ferric Podzol

Vegetation: Abies lasiocarpa (shrub sized), Rhododendron albiflorum, Luetkea pectinata, Arnica latifolia and bryophytes.

Ah 0 to 5 cm; very dark gray (10 YR 3/1 m) loam; weak, fine granular; very friable; plentiful, fine, vertical roots; 10% coarse fragments; clear, smooth boundary; 3 to 6 cm thick.

Bf 5 to 12 cm; dark reddish brown (5 YR 3/2 m) sandy loam; moderate, fine granular; very friable; plentiful, fine, random roots; 10% coarse fragments; abrupt, wavy boundary; 5 to 13 cm thick.

R 12+ cm; bedrock.

ANALYTICAL DATA 10A

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
L-F	1- 0	3.9	-	-	-	0.18	3.38	5.58	2.56	38.3
Ae	0- 7	3.6	0.27	4.50	16.6	0.04	0.20	0.39	0.26	16.7
Bf	7-18	4.2	0.30	7.21	24.0	0.05	0.06	0.20	0.06	34.5
R	18^+	-	-	-	-	-	-	-	-	-

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
L-F	-	-	-	-	-	-	-	-	-
Ae	-	-	-	SL	5	54	43	3	-
Bf	1.05	0.57	1.62	SiL	5	44	52	4	-
R	-	-	-	-	-	-	-	-	-

ANALYTICAL DATA 10B

Horizon	Depth cm	$CaCl_2$ pH	N (%)	Org.C (%)	C/N	NH_4Ac Ext. Cations (me/100g) Na	K	Ca	Mg	T.E.C.
Ah	0- 5	4.0	.25	4.57	18.3	0.06	0.07	0.38	0.15	33.6
Bf	5-12	3.7	.26	5.30	20.4	0.07	0.15	0.85	0.22	19.4
R	12+									

Horizon	Pyrophosphate (%) Fe	Al	Fe+Al	Text. Class	>2mm (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Dens. g/cm^3
Ah	-	-	-	SL	10	63	32	5	-
Bf	0.27	0.06	0.33	SL-SiL	10	46	47	7	-
R	-	-	-	-	-	-	-	-	-

APPENDIX B

DEFINITION OF DESCRIPTIVE TERMS

Throughout this report frequent use is made of descriptive terms in describing features of significance within the map area. The following are definitions of some of these descriptive terms.

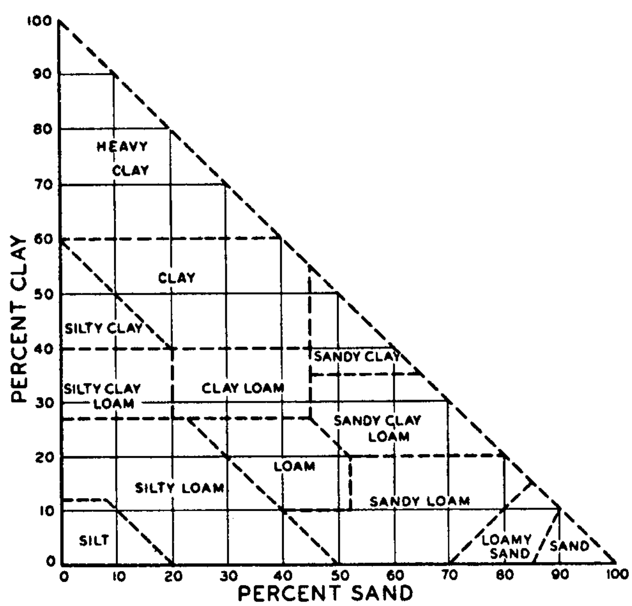
1. SOIL TEXTURE

(a) Soil Separates (Particle Size) on which Textural Classes are Based

Separates		Diameter in Millimeters
Very Coarse Sand (V.C.S.)		2.0 -1.0
Coarse Sand (C.S.)		1.0 -0.5
Medium Sand (M.S.)	Sand (S.)....	0.5 -0.25
Fine Sand (F.S.)		0.25-0.10
Very Fine Sand (V.F.S.)		0.10-0.05
Silt (Si.)...........................		0.05-0.002
Clay (C.)...........................		less than 0.002

(b) Proportions of Soils Separates in Various Soil Textural Classes

From: Toogood, J. A. 1958. A Simplified Textural Classification Diagram. Can. J. Soil Sci. 38:54-55.



A further separation of sands is made according to the prevelence of different sized sand fractions. Medium and coarse sands may contain over 25 percent coarse sand but not over 50 percent fine sands. Fine and very fine sands must contain over 50 percent of the respective fine sand fractions.

The soil textural classes are grouped according to the Canada Soil Survey Committee as follows:

Coarse-textured - sands, loamy sands.

Moderately coarse-textured - sandy loam, fine sandy loam.

Medium-textured - very fine sandy loam, loam, silt loam, silt.

Moderately fine-textured - sandy clay loam, clay loam, silty clay loam.

Fine-textured - sandy clay, silty clay, clay (40-60%).

Very fine-textured - heavy clay (more than 60% clay).

2. SOIL STRUCTURE AND CONSISTENCE

Soil structure refers to the aggregation of the primary soil particles into compound particles, or clusters of primary particles, which are separated from adjoining aggregates by surfaces of weakness. The aggregates differ in grade of development (degree of distinctness) as follows: weak, moderate, and strong. They vary in class (size) as follows: very fine, fine, medium, coarse, and very coarse. They also vary in kinds (character of the faces and edges of the aggregates). The kinds mentioned in this report are: Single-grain - loose, incoherent mass of individual particles as in sands. Subangular blocky - faces subrectangular, vertices mostly oblique, or subrounded. Granular - spheroidal, characterized by rounded vertices. Platy - horizontal planes more or less developed.

Soil consistence comprises the attributes of soil materials that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation and rupture. It deals with the strength and nature of the forces of attraction within a soil mass. The terms used in describing soils follow: Loose - non-coherent. Friable (specifies friable when moist) - soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together. Firm (specifies firm when moist) - soil material crushes under moderate pressure between thumb and forefinger but resistance is distinctly noticeable. Hard (specifies hard when dry) - moderately resistant to pressure, can be broken in the hands without difficulty but rarely breakable between thumb and forefinger. Compact - term denotes a combination of firm consistence and a close packing or arrangement of particles. Plastic (specifies plastic when wet) - wire formable by rolling the soil between the thumb and forefinger and moderate pressure required for deformation of the soil mass.

3. SOIL MOISTURE CLASSES

Soil moisture classes are defined in terms of (a) actual moisture content in excess of field moisture capacity, and (b) the extent of the period during which such excess water is present in the plant root zone.

(D1) Rapidly drained - soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions.

(D2) Well drained - soil moisture content does not normally exceed field capacity in any horizon except possibly the C, for a significant part of the year.

(D3) Moderately well drained - soil moisture in excess of field capacity remains for a small but significant period of the year.

(D4) Imperfectly drained - soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year.

(D5) Poorly drained - soil moisture in excess of field capacity remains in all horizons for a large part of the year.

(D6) Very poorly drained - free water remains at or within 12 inches of the surface most of the year.

Specific reference to surface drainage may be designated in terms of run-off and described as high, medium, low, or ponded. Similarly, specific reference to the characteristics of horizons within the profile may be designated in terms of permeability or percolation and described as rapid, moderate, slow, very slow, and none.

4. HORIZON BOUNDARIES

The lower boundary of each horizon is described by indicating its distinctness and form as suggested in the U.S. Department of Agriculture Soil Survey Manual (1951).

Distinctness

abrupt	less than 1 inch wide
clear	1 to 2.5 inches wide
gradual	2.5 to 5 inches wide
diffuse	more than 5 inches wide

Form

smooth	nearly a plane
wavy	pockets are wider than deep
irregular	pockets are deeper than wide
broken	parts of the horizon are unconnected with other parts

5. UNIFIED SOIL CLASSIFICATION SYSTEM

The Unified Soil Classification System identifies soils according to their textural and plasticity qualities, and their grouping with respect to their performances as engineering construction materials. The following properties form the basis of soil identification:

(a) Percentages of gravel, sand, and fines (fraction passing the No. 200 sieve).

(b) Shape of the grain-size distribution curve.

(c) Plasticity and compressibility characteristics.

The soil is given a descriptive name and a letter symbol indicating its principal characteristics.

Four soil fractions are recognized: cobbles, gravel, sand, and fines (silt or clay).

TABLE 13. UNIFIED SOIL CLASSIFICATION SYSTEM.

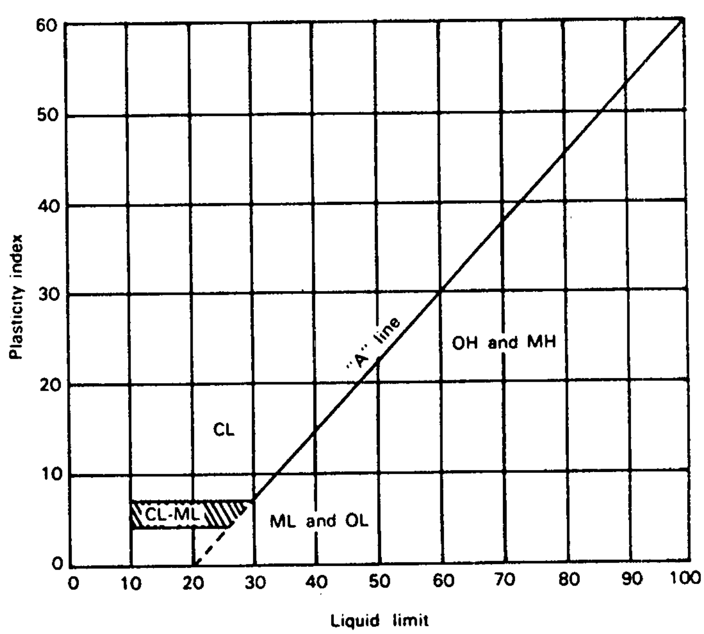
TABLE 51 Unified Soil Classification System

Major divisions			Group symbols		Typical names	
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentage of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 per cent ...... GW, GP, SW, SP; More than 12 per cent ...... GM, GC, SM, SC; 5 to 12 per cent ...... Borderline cases requiring dual symbols**
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines	
		Gravels with fines (Appreciable amount of fines)	GM*	d	Silty gravels, gravel-sand-silt mixtures	
				u		
			GC		Clayey gravels, gravel-sand-clay mixtures	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines	
			SP		Poorly graded sands, gravelly sands, little or no fines	
		Sands with fines (Appreciable amount of fines)	SM*	d	Silty sands, sand-silt mixtures	
				u		
			SC		Clayey sands, sand-clay mixtures	
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity	
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
			OL		Organic silts and organic silty clays of low plasticity	
	Silts and clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
			CH		Inorganic clays of high plasticity, fat clays	
			OH		Organic clays of medium to high plasticity, organic silts	
	Highly organic soils		Pt		Peat and other highly organic soils	

*Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterburg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

**Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder.

⊙Table from: "PCA Soil Primer", 1962. Portland Cement Association, Chic. Ill.



Plasticity Chart

The soils are divided as (1) coarse-grained soils, (2) fine-grained soils, and (3) highly organic soils. The coarse-grained soils contain 50 percent or less material smaller than the No. 200 sieve, and fine-grained soils contain more than 50 percent material smaller than the No. 200 sieve. Highly organic soils can generally be identified visually.

The coarse-grained soils are subdivided into gravels (G) and sands (S). The gravels have the greater percentage of the coarse fraction (that portion retained on the No. 200 sieve) retained on the No. 4 sieve, and the sands have the greater portion passing the No. 4 sieve. The four secondary divisions of each group - GW, GP, GM, and GC (gravel); SW, SP, SM, and SC (sand) - depend on the amound and type of fines and the shape of the grain-size distribution curve.

Fine-grained soils are subdivided into silts (M) and clays (C), depending on their liquid limit and plasticity index. Silts are those fine-grained soils with a liquid limit and plasticity index that plot below the "A" line in the diagram in Table 13, and clays are those that plot above the "A" line. The foregoing definition is not valid for organic clays since their liquid limit and plasticity index plot below the "A" line. The silt and clay groups have secondary divisions based on whether the soils have a relatively low (L) or high (H) liquid limit.

The highly organic soils, usually very compressible and with undesirable construction characteristics, are classified into one group designated by the symbol "Pt."

GLOSSARY

This is included to define terms commonly used in the report; it is not a comprehensive soil glossary.

aeolian deposit - material deposited by wind, includes both loess and dune sand

aggregate - a group of soil particles cohering so as to behave mechanically as a unit

alluvial deposit - material deposited by moving water

aspect - orientation of the land surface with respect to compass direction

Atterberg limits - see plastic limit, liquid limit

available plant nutrients - that portion of any element or compound in the soil that can be readily absorbed and assimilated by growing plants

carbon-nitrogen ratio - ratio of organic carbon to total nitrogen

cation - an ion carrying a positive charge of electricity. The common soil cations are calcium, magnesium, sodium, potassium and hydrogen.

cation-exchange capacity (C.E.C.) - a measure of the total amount of exchangeable cations that can be held by the soil. It is expressed in terms of milliequivalents per 100 grams of soil.

coarse fragments - rock or mineral particles greater than 2 mm in diameter

colluvium - a heterogeneous mixture of material that has been deposited mainly by gravitational action creep - slow mass movement of soil and soil material down rather steep slopes primarily under the influence of gravity, but aided by saturation with water and alternate freezing and thawing.

cryoturbation - frost action, including frost heaving

edaphic - (i) of or pertaining to the soil, (ii) resulting from, or influenced by, factors inherent in the soil or other substrate rather than by climatic factors

eluviation - the removal of soil material in suspension or in solution from a layer or layers of the soil

erosion - the wearing away of the land surface by running water, wind, or other erosive agents. It includes both normal and accelerated soil erosion. The latter is brought about by changes in the natural cover or ground conditions and includes those due to human activity.

gley - gleying is a reduction process that takes place in soils that are saturated with water for long periods of time. The horizon of most intense reduction is characterized by a gray, commonly mottled appearance, which on drying shows numerous rusty brown iron stains or streaks. Those horizons in which gleying is intense are designated with the subscript g.

groundwater - that portion of the total precipitation which at any particular time is either passing through or standing in the soil and the underlying strata and is free to move under the influence of gravity.

horizon - a layer in the soil profile approximately parallel to the land surface with more or less well-defined characteristics that have been produced through the operation of soil forming processes. Soil horizons may be organic or mineral.

illuviation - the process of deposition of soil material removed from one horizon to another in the soil, usually from an upper to a lower horizon in the soil profile. Illuviated compounds include silicate clay, iron and aluminum hydrous oxides and organic matter.

infiltration - the downward entry of water into the soil

intergrade - a soil that possesses moderately well-developed distinguishing characteristics of two or more genetically related taxa

lacustrine deposit - material deposited in lake water and later exposed either by a lowering of the water or by uplift of the land

liquid limit (upper plastic limit) - the water content at which a pat of soil, cut by a groove of standard dimensions, will flow together for a distance of 12 mm under the impact of 25 blows in a standard liquid limit apparatus

map unit - a defined aggregate of soil bodies occurring together in an individual and characteristic pattern over the land surface. As used in this report the map unit concept corresponds fairly closely to the concept of a soil association as used in the United States.

morphology, soil - the makeup of the soil, including the texture, structure, consistence, color, and other physical, mineralogical, and biological properties of the various horizons of the soil profile mottles - spots or blotches of different color or shades of color interspersed with the dominant color. Mottling in soils usually indicates poor aeration and drainage.

organic matter - the decomposition residues of plant material derived from: (i) plant materials deposited on the surface of the soil, and (ii) roots that decay beneath the surface of the soil

ortstein - a Bhf or Bf horizon that is strongly cemented by iron and aluminum oxides. It is designated Bhfc or Bfc, depending on the organic carbon content.

parent material - unconsolidated mineral material or peat from which the soil profile develops

peat - unconsolidated soil material consisting largely of undecomposed to partially decomposed organic matter accumulated under conditions of excessive moisture

ped - a unit of soil structure such as a prism, block, or granule, formed by natural processes (in contrast to a clod, which is formed artificially)

pedology - those aspects of soil science involving the constitution, distribution, genesis and classification of soils

percolation, soil water - the downward movement of water through soil. Especially, the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 or less

permeability - the ease with which gases, liquids, or plant roots penetrate or pass through a bulk mass of soil or a layer of soil. Since different soil horizons vary in permeability, the particular horizon under question should be designated.

pH - a notation used to designate the relative acidity or alkalinity of soils and other materials. A pH of 7.0 indicates neutrality, higher values indicate alkalinity, and lower values acidity.

phase, soil - a subdivision of a taxonomic class based on soil characteristics or combinations thereof which are considered to be potentially significant to man's use or management of the land

plastic limit - water content at which a soil will just begin to crumble when rolled into a thread approximately 3 mm in diameter.

plasticity index - the numerical difference between the liquid and the plastic limit

profile - a vertical section of the soil throughout all its horizons and extending into the parent material

relief - the elevations or inequalities of the land surface when considered collectively. Minor configurations are referred to as "microrelief".

seepage (groundwater) - the emergence of water from the soil over an extensive area in contrast to a spring where it emerges from a local spot

solum (plural - sola) - the part of the soil profile that is above the parent material and in which the processes of soil formation are active. It comprises the A and B horizons.

texture (soil) - the relative proportions of the various sized soil separates in a soil as described by the textural class names

till - unstratified glacial drift deposited directly by ice and consisting of clay, silt, sand, and boulders intermingled in any proportion turf (as used in this report) - the abundantly rooted (usually surface) organic layer common in alpine soils. This dense root mat extends into the surface mineral horizon. This layer is designated by the letter L.

watertable - the upper limit of the part of the soil or underlying rock material that is wholly saturated with water

LATIN AND COMMON NAMES OF PLANTS MENTIONED IN THIS REPORT

Latin Name	Common Name(s)
Abies lasiocarpa (Hook.) Nutt.	alpine fir, subalpine fir
Antennaria lanata (Hook.) Greene	wooly pussy-toes
Arnica latifolia Bong.	mountain arnica
Carex nigricans Retz	a sedge
Cassiope mertensiana (Bong.) G. Don	Merten's mountain heather
Epilobium alpinum L.	alpine willow-herb
E. angustifolium L.	fireweed
Erigeron peregrinus (Pursh) Greene	daisy, fleabane
Eriophorum polystachion L.	many spiked cotton-grass
Heracleum lanatum michx.	cow-parsnip
Hieraceum gracile Hook.	alpine hawkweed
Ligusticum canbyi Coult & Rose	lovage, licorice-root
Luetkea pectinata (Pursh) Kuntze	partridgefoot, luetkea
Lupinus latifolius Agardh	broadleaf lupine
Luzula	
Phyllodoce empetriformis (Sw.) D. Don	red mountain heather
P. glanduliflora (Hook.) Cor.	yellow mountain heather
Picea engelmannii Parry	engelmann spruce
Rhododendron albiflorum Hook.	white rhododendron
Senecio triangularis Hook.	ragwort
Vaccinium membranaceum Dougl.	tall bilberry
Valeriana sitchensis Bong.	valerian
Veratrum viride Ait.	false hellebore, skunk-cabbage