Ecological Impact Study of the

Mt. Edith Cavell Area, Jasper National Park

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INTRODUCTION

The Mt. Edith Cavell area is a well-known landmark in Jasper Park, and one of its most popular recreational locales. It is the fourth most visited place in the park, third in total and average man-hours of recreation, and second in length of stay of visitors (Drapell, 1969).

Historically this area has seen a good deal of human activity. Early in the century some notable biologists collected plants and animals in the area. A road from Jasper to Mt. Edith Cavell was completed in 1924 (Canada, Dept. of Indian Affairs & Northern Development, 1970). Besides serving as a tourist attraction in its own right, the Cavell area is a departure point for trips to Tonquin Valley and Amethyst Lakes.

The provisional master plan for Jasper Park provides for an activity centre, a manned information kiosk, and an improved trail system in the Cavell area. It also recommends basic reconstruction of the road leading to the area. The purpose of this report is to describe the general ecology of the area and evaluate the impact of development on it.

As understood in this report the Cavell area embraces ca. 20 km^2. This includes most of the terrain that visitors might cover when they visit Mt. Edith Cavell, and is therefore the area susceptible to change. Plate 1 presents an aerial photograph of the study area; and the map accompanying this report covers the ecosystems and some points of interest in the area.

I would like to thank the following people for their aid in various phases of this study: Toni Klettl, Cavell Warden, particularly for his

comments on proposed developments, and on mammals in the area; Dave Pick and Bob Pot of the Interpretive Service for help in locating relevant references; Drs. D.H. Vitt and C.D. Bird for aid in identification of mosses and lichens respectively; Drs. F.J. Hermann, C. Feddema and G.W. Argus for identification of some critical sedge, grass and willow specimens; Henri Goulet and Dr. W.G. Evans for their comments on insects in the region; R. de Ruette for identification of some beetle specimens; Dr. & Mrs. G.C.D. Griffiths for field data which they made available to me; Julie Hrapko for use of a report prepared by her; Les Norvedt for insights into trail construction; my brother Len for able field assistance; and George Douglas for interesting discussions on relevant ecological topics.

CLIMATE

Mount Edith Cavell is in a strategic position as far as weather in the immediate area is concerned. It overshadows the south-western part of the study area, and is so high that as the prevailing westerlies come over the top, they swirl down in a turbulent curl (W. Pfisterer, pers. comm.). Often, while most of the general region is clear and sunny, a small cloud will hang in the lee side of the mountaintop. At this altitude snow can fall in any month, and even the daily weather patterns can show a good deal of fluctuation.

In winter the precipitation within about a 3 km radius of the mountain's lee side is strikingly higher than in nearby areas. For example, snow depths along the road are 'normal' up to the Canadian Youth Hostel, but past it there is a rather sudden deepening of the snow (W. Pfisterer, pers. comm.).

Due to the abovementioned unique local conditions, direct extrapolation of weather, through use of weather records of areas even as close by as Marmot Basin, would not be justifiable. It would be very interesting to see just what the annual precipitation trend is, say near the teahouse or some other such location which is definitely in the 'shadow' of the mountain. Other environmental factors in the Cavell area would also exhibit a trend peculiar to this locale. Temperatures are probably depressed, due to the early shadowing of the sun each day.

The richness of some of the vegetation, particularly the bryophytes, can be attributed to the greater precipitation and moisture.

GEOLOGY

No geological map is as yet available for the Cavell area. The stratigraphy is not complex however, and consists of rock beds uniformly dipping gently south-west (Baird, 1963). The mountain itself is made up mostly of Cambrian quartzites. These are underlain in turn by dolomites, shale, and sandstone, with some limestone stringers. The latter crop up at the ridge in the north-east part of the area. Shale and sandstone comprise the bulk of the bedrock in the area (H.A.K. Charlesworth, pers. comm.).

Snow-covered Mount Edith Cavell is, at 11033'(3617m), a prominent regional landmark. It was sharply truncated by Pleistocene glaciers moving along the main, i.e. Athabasca, valley (Baird, 1963). These glaciers evidently overrode the hilly topography in the eastern part of the study area. Signs of glaciation, both fossil and active, are quite the most obvious and striking characteristic of the area.

Angel Glacier, originating in a cirque basin that it has carved into the northern shoulder of the mountain, is a focal point of visitors' trips to the area. The recent history of this glacier's activity is discussed by Heusser (1956). Signs of its former greater extent are evident in a number of depositional features. The most striking of these is the series of lateral moraines directly south of the memorial cairn. They are composed of angular, coarse rocks and boulders which are only very slowly being colonized by plants. An ice-cored moraine, consisting of a thin mantle of rock debris over solid ice at the foot of Mt. Edith Cavell, is another reminder of how recent the latest retreat of this glacier has actually been. A further

depositional feature is the delta at the upper end of Cavell Lake, formed by glacio-fluvial debris issuing from the glacier as it stood at its outermost (recent) position.

The periglacial environment in the Cavell area finds expression in a number of surficial landforms, particularly those arising through congeliturbation (frost heave & flow). The most prominent examples are the large solifluction lobes past the east ridge of the study area, as well as less distinct but very large lobes in the south-east part of the area. Common throughout unforested parts of the study area, especially at the higher elevations, are smaller varieties of patterned ground such as polygons, earth hummocks and stone nets.

SOILS[1]

The soils in the Cavell area, as in the Maligne Lake area (Kuchar, 1972), may be conveniently divided into three groups: forest, tundra, and wet meadow soils. Although this approach is to a degree artificial it does embrace, in a simplistic fashion, the range of soil types in the area.

Detailed descriptions of soil profiles representative of forest, tundra, and wet meadow situations are given on p.8-10. Description and classification follow the system proposed by the National Soil Survey Committee (Canada, Dept. of Agriculture, 1970). Results of mechanical and chemical analyses are presented in table 1. Mechanical analysis of fines was done with the hydrometer method. Chemical analysis (T.E.C., Na, K, Ca, Mg) and pH was run by the Univ. of Alberta Soils Lab, Dept. of Soil Science.

Most of the forested slope in the Cavell area is underlain by quartzite till, on which a typical forest soil profile with its eluviated Ae and illuviated Bt horizon has developed. Drainage is generally good, but there are numerous small depressions and level spots where the flow of water is impeded. Here a gleyed layer develops in the usually water-saturated soil profile, and conifers give way to meadow-type vegetation. The largest single Gleysol expanse is on the delta at the south end of Cavell Lake.

Above timberline, where mountain heathers assume dominance, an Alpine Dystric Brunisol develops. The profile is shallow and very simple, and the virtual lack of any soil structure reflects the unfavorable (cold) conditions

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[1]With the assistance of L. Knapik, Soils Department, U. of Alberta, Edmonton.

under which soil development is proceeding. This soil is more fragile than most of the other types in the area, since it tends to break down easily due to its structureless nature (Root & Knapik, 1972).

Soil development on ridges and exposed slopes at higher elevations is virtually at a standstill. Here the coarse gravelly surface, very superficially altered, could be assigned to the regosolic order. Some scree slopes and ridges would probably not qualify for any soil status whatsoever. Much of the morainal debris deposited by recent advances of Angel Glacier likewise cannot be classified as soil, for it is composed of essentially unaltered rock fragments with occasional pockets of fines.

A noteworthy feature of the large west-facing slope system is the prevalence of groundwater discharge, in the form of springs and seepage places. Fed by late-melting snow and seasonal precipitation, this water is to a large extent resposible for the rather high gross fragility of the overall slope system. By gross fragility I mean the relative instability to large-scale alterations of which roadcuts are the best example. In places along the present road to Mt. Edith Cavell, even where the slope angle is relatively low, seepage is maintaining whole sections of slope in a state of total instability.

SOIL PROFILE REC 1-4

Location: alluvial fan south of Cavell L.

Elevation: 5700'(1870m)

Slope & aspect: less than 1° N

Landform: alluvial fan

Drainage Class: very poorly drained

Vegetation type: willow - sedge - moss wet meadow

Soil Classification: Rego Gleysol

Horizon	Depth (inches)	
Ahg	0-2	Very dark grayish brown (2.5Y 3/2,m) sandy loam; few, fine faint (2.5Y 5/2,m) mottles; single grained; loose; abundant, fine random roots; abrupt wavy boundary; pH 6.6.
Cg	2-6	Light gray (2.5Y 7/2,m) sandy loam; many, coarse, prominent reddish yellow (7.5YR 6/8,m) mottles; single grained; loose; few, fine and medium roots; clear wavy boundary; pH 5.7.
II Cg	6-11	Dark gray (5Y 4/1,m) silt loam; many coarse, prominent, strong brown (7.5YR 5/8,m) mottles; amorphous; non-sticky; abundant fine random roots; clear wavy boundary; pH 5.5.
III Cg	11+	Dark gray (N 4/1,m) silt loam; many coarse, prominent, strong brown (7.5YR 5/6,m) mottles; amorphous; slightly sticky; plentiful, fine random roots; pH 5.1.

SOIL PROFILE REC 5-7

Location: 1½ km south-east from Mt. Edith Cavell chalet

Elevation: 7000'(2300m)

Slope & aspect: 12° W

Drainage Class: well drained

Vegetation type: mountain heather tundra

Soil Classification: Alpine Dystric Brunisol

Horizon	Depth (inches)	
Ahj	0-2	Dark grayish brown (10YR 4/2,m) sandy loam; amorphous; loose; plentiful fine random roots; clear irregular boundary; pH 4.8.
Bm	2-5	Dark brown (7.5YR 4/4,m) silt loam; amorphous, slightly sticky; few fine vertical roots; 3 percent coarse fragments; 0 to 10 inches in depth; clear irregular boundary; pH 5.6.
C	5+	Light olive brown (2.5Y 4.5/4,m) silty clay loam; amorphous to weak fine subangular blocky; friable; very few, fine vertical roots; 30 percent gravel size coarse fragments; pH 5.4.

SOIL PROFILE REC 8-11

Location: 1½ km north of Mt. Edith Cavell chalet; by highway

Elevation: 5800'(1900m)

Slope & aspect: 15° W

Drainage Class: rapidly drained

Vegetation type: subalpine spruce - fir forest

Soil Classification: Orthic Gray Luvisol

Horizon	Depth (inches)	
L-F	½-0	Dark brown (7.5YR 3/2,m) partially decomposed moss and needle litter; abundant, fine random roots; abrupt smooth boundary; pH 5.7.
Ae	0-2	Light gray (10YR 7/1,m) silt loam; weak fine platey; very friable; few, fine and medium roots; 2 percent coarse fragments; clear wavy boundary; 1 to 4 inches thick; pH 4.5.
Btfj	2-8	Dark brown (7.5YR 4/4,m) loam; weak fine subangular blocky; friable; few, medium horizontal roots; 5 to 10 percent coarse fragments; clear wavy boundary; 3 to 10 inches thick; pH 4.7.
C	8+	Dark yellowish brown (10YR 4/4,m) gravelly sandy loam; amorphous; friable; very few, medium horizontal roots; 70 percent coarse fragments; pH 5.4.

TABLE 1. PHYSICAL AND CHEMICAL DATA FOR SOME HORIZONS OF REPRESENTATIVE SOILS IN THE MT. EDITH CAVELL AREA.

SAMPLE NUMBER	HORIZON	DEPTH (INCHES)	COLOR[1]	TEXTURE	SAND	SILT	CLAY	pH	T.E.C.[2]	Na	K	Ca	Mg
REC 1	Ahg	0-2	2.5Y 3/2	sandy loam	73	21	6	6.55	-	.36	.12	1.58	.78
2	Cg	2-6	2.5Y 7/2	sandy loam	71	26	3	5.7	.98	.07	.05	.11	.07
3	II Cg	6-11	5Y 4/1	silt loam	27	56	17	5.5	3.44	.17	.08	.63	.48
4	III Cg	11+	N 4/1	silt loam	40	51	9	5.1	5.66	.28	.06	.99	1.15
5	Ahj	0-2	10YR 4/2	sandy loam	59	35	6	4.8	2.40	.16	.31	1.36	.49
6	Bm	2-5	7.5YR 4/4	silt loam	41	51	8	5.6	29.02	.12	.06	.06	.05
7	C	5+	2.5YR 4/4	silty clay loam	12	54	34	5.4	-	-	-	-	-
8	L-F	½-0	7.5YR 3/2	-	-	-	-	5.7	35.17	.21	.32	19.88	3.01
9	Ae	0-2	10YR 7/1	silt loam	30	60	10	4.5	11.80	.42	.16	.56	.25
10	Btfj	2-8	7.5YR 4/4	loam	44	40	16	4.7	4.92	.07	.05	.16	.09
11	C	8+	10YR 4/4	sandy loam	60	32	8	5.4	10.82	.08	.09	.25	.08

[1]Color according to Munsell Color Charts, 2nd ed., 1963, Munsell Color Co., Baltimore, Md.

[2]Total exchange capacity, as m.e./100g.

NOTE: Sand, silt, & clay as percentages of 0-2mm fraction.

VEGETATION

INTRODUCTION

Botanically the Cavell area along with Tonquin Valley make up one of the best-known regions in the park, or at any rate most frequented by botanists. Of course this is true only from a relative standpoint, since there are no areas in the park that could be considered truly well-known botanically.

J.M. Macoun, visiting the park in 1917, collected largely near Mt. Edith Cavell (Heusser, 1956). In 1918 he published a short account of vascular plants that he found there. This is one of the earliest such accounts, and noteworthy in spite of what seems to have been some misidentification of specimens or localities.

Porsild (1959), preparing a handbook for the 1959 Botanical Excursion to Jasper and Banff parks, allotted a day for the Cavell area. Many vascular plants were identified, and a very brief summary of plant assemblages in different habitats was prepared.

In the last ten or fifteen years a number of botanists have collected in the area, but the results are scattered and unpublished. A limited amount of quantitative work has been done on forest vegetation in the area (e.g. Beil, 1966; Evans & La Roi, 1964).

The Cavell and Tonquin Valley region have been visited, one might almost say traditionally, by bryologists. The first significant contribution to bryological knowledge of the mountain parks was made by MacFadden (1927), who devoted most of a ten-day trip to Tonquin Valley to the collecting of bryophytes. Included in her publication were 29 hepatics and 92 species of

mosses, most of these presumably new for the park at the time. Although far from ideal, this is still the most complete bryological study of a single area in Jasper Park.

In 1955, H. Crum and W.B. Schofield collected here and elsewhere in the mountain parks (D.H. Vitt, pers. comm.), though the results were never published. C.D. Bird collected in the area several times. In his 1962 publication 70 new records of mosses are cited for Jasper Park, of which 22 were from the Cavell area, four of them being new records for Alberta.

Recently, during a field trip of the CBA/AIBS (Bird & Vitt, 1972), a number of bryologists collected in a meadow in the subalpine forest above the teahouse. Some lichens were also collected and these, along with my own records, constitute the majority of the lichens known from the area.

It is perplexing that in-depth studies of vegetation have never been done in the Cavell area. It is a quite accessible area; it has been frequented for a relatively long time by white man; and it possesses a rich, heterogeneous assemblage of plant communities and species.

METHODS AND TERMINOLOGY

Most of the data on vegetation were gathered through seven field trips in the Cavell area in the summer and fall of 1971. During these trips, I took notes on phenology and any vegetational patterns of especial interest, and collected plant specimens whenever identification was in doubt. These collections are deposited in the herbarium of the Botany Department, U. of Alberta, Edmonton. I also selected some stands of vegetation where I enumerated the vascular species, estimated cover of the dominant vasculars and non-vasculars, and described the community structure.

Outside sources (reports, thesis, scientific papers) furnished a

modest amount of additional data on Cavell vegetation. A herbarium search at the Botany Department, U. of Alberta, brought to light a few additional records of lichens and vascular plants.

Above timberline, the vegetation in the Cavell area is similar to that in the Bald Hills (Kuchar, 1972), therefore I spent little time at the higher elevations here but concentrated my field efforts on subalpine vegetation. Aerial photographs (1:50000 scale, 1969 series, Canada Dept. of Energy, Mines & Resources) were helpful particularly in locating small meadows in the large expanse of forest on the west-facing slopes.

Three main vegetational zones can be delineated in the Cavell area, alpine, forest-tundra, and subalpine. The forest-tundra zone (called the subalpine zone by some ecologists) is an altitudinal band with timberline (forest line) as its lower border, and flagging krummholz as its upper limit. Above this extends the alpine zone, and below it the subalpine zone. Timberline in the Cavell area follows roughly the 7000'(2300m) contour. At the south-eastern end of the area, the coarse steep colluvial topography precludes forest vegetation and the typical zonation therefore.

The forest-tundra zone occurs throughout the Rocky Mountains, as well as in other ranges such as the Cascades and Olympics. It is definitely distinct from the usually more xeric habitats of the alpine zone, although some of the alpine species do descend into forest-tundra meadows. The forest-tundra zone includes, both floristically as well as structurally, readily recognizable units that have strong affinities with forest meadows (Bliss, 1971).

Treeline is a term often encountered in the ecological literature,

but it would have little merit in the Cavell area. Here there is really no such thing as a physical treeline. Above timberline the forest breaks up into a patchwork of conifer clumps and meadow or tundra vegetation. The conifers stunt with altitude and, depending on local conditions of snow accumulation and wind exposure, they flag or assume a total krummholz habit. A more complete discussion of relevant zones can be found in Kuchar (1972).

The process of classification of vegetation is not an arbitrary one, but on the other hand it is certainly far from immutable. Rowe (1969) lists three initial difficulties in vegetation classification:

i. The absence of a generally accepted descriptive method for vegetation.

ii. The absence of a framework classification of Canadian vegetation.

iii. The rapid reaction of vegetation to disturbance, with the resultant occurrence of variable vegetation cover on similar kinds of land.

The third point is not a problem in the study area, since only a small percentage is 'unnaturally' vegetated; but the first two are definite and self-evident problems.

In the Cavell area, the biotic unit is the ecosystem. Theoretically the ecosystem is a unit of any particular size that the ecologist wishes to use, and for our purposes it shall have a fairly broad connotation, approximately homologous with the sub-formation as seen by Fosberg (1967). It can also be considered as a basic habitat type, characterized chiefly on the basis of vegetational structure along with basic environmental features.

Although the kinds and abundances of plant species in each ecosystem can be important for characterization, floristics have not really played a significant role in the classification used here. Floristics would be much more critical if a finer level of subdivision were used, such as the association of Daubenmire (1968). In the association, stands of vegetation must have the same species dominant in corresponding strata in order to belong to the same unit of vegetation (association). This is a rather fine level of subdivision, and in as small an area as the Cavell, it would be unreasonable to separate out associations (communities) based on same-dominants-in-each-stratum, yet expect the classification to be a natural one.

A further difficulty is the gradient nature of the environment, resulting in a large number of different plant groupings. A good example of this is the meadow vegetation in the area. If we used the Daubenmire criterion of the association, we would likely have practically as many associations as there are stands (see tables 2,3).

There are some bona fide plant assemblages in the area however, ones that are known to recur whenever similar environmental conditions obtain. These assemblages can be considered as plant communities (e.g. Carex nigricans community, Cassiope tetragona - Dryas octopetala community), in a sense somewhere between the narrow definition of the association and the broad concept of the ecosystem.

FLORA

The vascular flora of the Cavell area includes about 270 species of which 14 (5.2%) are cryptogams (ferns, clubmosses, horsetails), 6 (2.2%) conifers, and the remainder (92.6%) flowering plants. The breakdown by

growth form is 5 (1.8%) trees (all conifers), 16 (5.9%) shrubs, 17 (6.3%) dwarf shrubs, and the rest (86.0%) herbs.

Engelmann spruce (Picea engelmannii) and alpine fir (Abies lasiocarpa) jointly account for the bulk of the biomass in the area, and are prominent to an altitude of 7000'(2300m). Lodgepole pine (Pinus contorta) is uncommon; black spruce (Picea mariana) and white-bark pine (Pinus albicaulis) are definitely rare. Ground juniper (Juniperus communis), the only other conifer in the area, is not common.

Shrubs are thinly dispersed through the forest, and more thickly at edges of clearings and in various types of treeless terrain. The common forest shrubs are Menziesia glabella, tall bilberry (Vaccinium membranaceum), and silver pussy-willow (Salix drummondiana). Labrador tea (Ledum groenlandicum) is locally abundant. Some of the colluvial slopes are covered with dwarf birch (Betula glandulosa), which also occurs in higher-elevation meadows. Willows (Salix drummondiana, S. barclayi, S. glauca) are prominent on alluvial deposits, and sparsely scattered over recent morainal deposits.

Dwarf shrubs are abundant through some of the forest, especially in drier microsites, but only above continuous forest do they assume dominance. Mountain heathers (Cassiope spp., Phyllodoce spp.) are ubiquitous in the forest-tundra zone. White avens (Dryas octopetala), arctic willow (Salix arctica) and grouseberry (Vaccinium scoparium) are common in the alpine zone.

Many herbaceous plants flourish in the Cavell area. Notable are ferns in rock crevices (6 species), 28 grass species, 29 sedges, 7 rushes, 5 wintergreens, 11 saxifrages, 34 composites (daisy family), and 22 ericads (heath family) including the rare Loiseleuria procumbens, and Phyllodoce intermedia, a hybrid between red and yellow heather.

Porsild (1959) attributed the abundance of ericads in the area, and the complete absence of obligate calcicoles, to the fact that the soils are derived mainly from acid rock. This is also the reason for such a poor representation in the Umbelliferae, Cruciferae and Leguminosae. Porsild's most valuable finds in the area were Koenigia islandica, previously known only from Yukon and Colorado; and Carex pyrenaica and Loiseleuria procumbens, first Alberta records.

In broad phytogeographic terms the plants in the Cavell area fall into four major groups: Arctic-alpine, boreal, cordilleran, widespread. The Arctic-alpine element, comprising around 20% of the area's flora, includes many of the plants found above timberline, and represents, as elsewhere through the alpine zone in the Rockies, southward extensions of Arctic vegetation. White dryad (Dryas octopetala), Arctic willow (Salix arctica), moss campion (Silene acaulis), mountain sorrel (Oxyria digyna), and crowberry (Empetrum nigrum) are some of the more imprtant such plants.

The Cavell flora probably exemplifies this trend of southward migration of Arctic species better than any other area in the mountains. Some Arctic plants have been discovered here which are unknown or rare elsewhere in the Rocky Mountains: Carex glacialis, C. supina, Loiseleuria procumbens, Juncus biglumis, Koenigia islandica, Ranunculus gelidus, Cardamine bellidifolia.

About 35% of the flora is Cordilleran, that is, derived from the original Rocky Mountain flora that evolved here, a relatively ancient group of plants, well antedating all Pleistocene glaciation. This is the typical 'western' flora and includes some plants that are abundant farther

west where a damp climate prevails, as well as species adapted to the fairly dry climate of the Rockies. Outastanding of the former category is Heuchera glabra - Cavell is the only known locality for Alberta (Packer & Dumais, 1972). Most of the conifers and willows in the Cavell area, and half the sedges, are Cordilleran in origin. Other notable plants include western spring beauty (Claytonia lanceolata), partridge-foot (Luetkea pectinata), trailing raspberry (Rubus pedatus), sweet cicely (Osmorhiza), blue-bottle gentian (Gentiana glauca), Indian paint-brush (Castilleja spp), mountain valerian (Valeriana sitchensis), alpine harebell (Campanula lasiocarpa), Arnica spp, slender hawkweed (Hieracium gracile), Saussurea densa, arrowleaf ragwort (Senecio triangularis), false hellebore (Veratrum viride), heathers (Phyllodoce spp), Menziesia ferruginea, tall bilberry (Vaccinium membranaceum), grouse-berry (V. scoparium).

Boreal species, those that occur in the transcontinental taiga of Canada, comprise roughly 20% of the flora. These are boreal-forest plants that have moved down the cordillera, establishing themselves as regular and important components of the coniferous forests in the Northern Rocky Mountains. About 50 occur in the Cavell area, the most important being ground juniper (Juniperus communis), bunchberry (Cornus canadensis), twin-flower (Linnaea borealis), rock-cranberry (Vaccinium vitis-idaea), the winter-greens (Pyrola spp), bearberry (Arctostaphylos uva-ursi), and Labrador tea (Ledum groenlandicum).

Wide-ranging species, common across much of North America or Europe, make up about 25% of the flora. Common horsetail (Equisetum arvense), Kentucky bluegrass (Poa pratensis), wild strawberry (Fragaria virginiana), common yarrow (Achillea millefolium) and the ferns are in this category.

Also included here are the twelve species of exotics (foreign weeds)

that I found in the area. They are restricted mainly to the roadside and disturbed ground in the area of the horse corrals, and pose no immediate threat to natural ecosystems. Commonest along the roadside are dandelions (Taraxacum laevigatum, T. officinale) and alsike clover (Trifolium hybridum). There are lesser amounts of common plantain (Plantago major) and tall buttercup (Ranunculus acris). A small patch of disturbed ground just north of the Canadian Youth Hostel has an exceptional variety of native and introduced weedy species including nettle (Urtica dioica), stinkweed (Thlaspi arvense), wormseed mustard (Erysimum cheiranthoides), dock (Rumex occidentalis, R. salicifolius), caraway (Carum carvi), big chickweed (Cerastium vulgatum), smooth brome (Bromus inermis), quack grass (Agropyron repens), redtop (Agrostis alba), and timothy (Phleum pratense).

Ecologically one of the most interesting groups in the Cavell area is the sedges, which thrive in the large range of niches afforded by the broken topography and damp conditions. Undoubtedly the most noteworthy of these, and in a scientific context probably the single most valuable plant species, is Carex eurystachya. This distinctive, handsome sedge, unknown elsewhere in the park, flourishes in some of the wet meadows in the Cavell area. Hermann (1957) described the species based on material he collected here, i.e. the area represents the type locality.

A handful of the sedge species are restricted to dry alpine slopes. Outstanding among these is Carex glacialis, heretofore known only from subarctic areas (Greenland, Newfoundland, Yukon).

The Cavell area has a rich variety of not just vascular plants, but also of lichens and bryophytes. The 96 species of lichens listed in

Appendix 1 include easier-to-identify and more conspicuous forms. The total lichen flora might approach 200 species. Bryophytes are abundant all through the area. So far, 40 hepatics (Appendix 2a) and 122 mosses (Appendix 2b) are known from the study area and Tonquin Valley taken together, and the true total might be as much as 50% higher.

According to D.H. Vitt (pers. comm.) the study area has a quite remarkable bryophytic flora, one that is different from any others he has seen. It is difficult, apparently, to really characterize the flora. For one thing it is incompletely known. And then, the species groupings seem unnatural; many of the mosses found here are characteristic of calcareous habitats, though the Cavell area certainly is not calcareous. At least a partial explanation can be found in the high precipitation in the immediate area, creating moist conditions under which bryophytes flourish.

Aside from its basically rich flora, 'the area has a number of species which are of quite limited distribution in the Rockies', since the amount of silicate rocks, with which they are typically associated, is relatively small (Bird & Vitt, 1972).

ECOSYSTEMS & PLANT COMMUNITIES

Eight natural ecosystems are represented in the Cavell area. Their delineation and arrangement generally follows that of the Maligne Lake area ecosystems (Kuchar, 1972). Each ecosystem includes one or more plant communities, and these are briefly characterized in the section that follows.

1. LACUSTRINE ECOSYSTEM.

Cavell lake undoubtedly harbors planktonic communities, composed

mainly of microscopic algae; but they have not been characterized. The most comprehensive limnological study in the park was carried out at nearby Amethyst Lake by Rawson (1953).

There is some submergent macrophytic vegetation in the lake (evidenced by some strands of Potamogeton washed ashore), but I do not know if it is abundant.

The border between lake and mossy-hummock shoreline is abrupt, and there is essentially no emergent macrophytic vegetation such as reed beds or sedge meadow.

2. RIPARIAN ECOSYSTEM.

The streamside habitat is a distinctive and important one, here as elsewhere, from the standpoint of various animal organisms, although vegetationally it is rather heterogeneous. To set it off as a separate ecosystem is perhaps too liberal an approach, and partly artificial; but riparian habitats certainly cannot be ignored.

Some of the stream sections in the Cavell area run through damp forest and meadow, and have a solid border of mosses, especially Cratoneuron commutatum. This moss also occurs in thick patches over some of the more active seepage areas on the forested slope.

Some of the slower-flowing stretches have thick growths of aquatic moss, but usually the bouldery-sandy bed does not harbor any macroscopic plant growth. West from the teahouse a broad-fronted (30m) spring issues from the base of the scree slopes, and algal growth is abundant in the first 10m of flow. Small clumps of moss are abundant on the stream bed here and on downstream.

Many stream sections are flanked by naked gravelly surfaces, charac-

teristically unstable habitats, which support plants adapted to a role of primary colonizers. Common are willows, red willowherb (Epilobium latifolium), wild strawberry (Fragaria virginiana), and some others, along with small clones of bryophytes and lichens.

Outcrops along some stream sections have bryophytes and lichens on ledges and in crevices; small ferns in crevices; and other ledge and rock-associated plants such as spearleaf fleabane (Erigeron lonchophyllus), Draba, and saxifrages.

Upstream in the E-W trending gully which lies east and slightly south of the teahouse, there are some unique slopes made up of alternating strips of spruce and willow vegetation. Mountain heathers (Cassiope mertensiana & some Phyllodoce) are abundant beneath the spruce. The willow strips constitute a rather unstable-looking habitat of rocks and boulders with the fines washed out by continual seepage. Two willow species are prominent, 3m tall patches of Salix drummondiana, and shorter S. vestita. Under them are mats of moss, with colonies of red-stemmed saxifrage (Saxifraga lyallii).

Downstream from the bridge across Cavell Creek there are numerous boulders protruding above the surface of the water. They have a surprisingly varied plant assemblage, notably of bryophytes (Rhacomitrium, Aulacomnium, Mnium, Ptilidium), lichens (Cladonia spp, Umbilicaria spp, crustose forms), and some sedges (Carex atrata, C. bebbii, C. norvegica).

3. MEADOWS.

Meadows in the Cavell area can be characterized as damp to very wet, usually fairly level, treeless or virtually treeless, well-vegetated

topography that has one or more of the following elements:

a. willow shrubs
b. lush, variegated herbaceous vegetation
c. sedges &/or rushes &/or horsetails in essentially pure stands

There is usually also a profusion of mosses, typically forming a continuous or near-continuous ground cover. Lichens are rare or absent.

The patches of meadow do not amount to a very large percentage of the Cavell area, yet account for around half the vascular flora. As can be seen in table 2, there is a remarkable heterogeneity in vascular plants from stand to stand. Due to this, it does not seem possible to prepare a satisfactority natural classification of meadow vegetation. Other contributory problems are the small size of many of the stands, the relatively small size of the entire study area, and the fairly low level of intensity of field studies. Perhaps a key to classification here could be found in something like soil mineral nutrients, or composition of mosses.

An artificial but convenient breakdown of the meadow ecosystem yields three vegetation types:

A. alluvial-fan meadows
B. forest meadows
C. snowbed or/& variegated forest-tundra meadows

A. On the alluvial fan at the south end of Cavell Lake there is a braided stream network and some exposed sections of gravel and sand; but about 80% of the fan is covered with vegetation. All the communities are structurally and floristically very simple.

i. At the upper end there is some willow scrub: dense, $1\frac{1}{2}$-2m high shrubbery, mostly Salix barclayi. The ground is covered with willow leaves and about 30% cover of low moss mounds.

ii. Sedge-willow meadows make up the greater part of the fan's

TABLE 2. VASCULAR SPECIES PRESENT IN SOME MEADOW STANDS.

STAND NO.	31	18	29b	39b	26	39	28	39c	27b	12
Achillea millefolium	+									
Agoseris aurantiaca	+	+	+							
Agropyron trachycaulum	+	+	+	+						
Agrostis alba			+							
Agrostis ?scabra		+								+
Agrostis variabilis										+
Anemone parviflora		+		+						
Antennaria lanata		+								
Antennaria pulcherrima				+		+				
Aquilegia flavescens		+	+							
Arabis drummondii		+								
Arctostaphylos rubra								+	+	
Arenaria obtusiloba									+	
Arenaria rossii	+									
Arnica latifolia	+									
Arnica mollis		+	+		+	+				
Artemisia norvegica		+	+							
Betula glandulosa				+	+	+		+	+	
Botrychium lunaria		+								
Calamagrostis inexpansa	+	+		+						
Caltha leptosepala	+	+								
Carex aquatilis				+	+	+				+
Carex atrosquama		+	+			+				
Carex capillaris					+			+	+	
Carex dioica						+	+	+		
Carex eurystachya							+			+
Carex leptalea				+	+	+				
Carex limosa					+					
Carex nigricans		+	+							
Carex paysonis			+							
Carex rostrata										+
Carex saxatilis	+									
Carex scirpoides		+	+			+	+			
Carex spectabilis		+								
Carex vaginata				+	+				+	
Carex sp.	+	+						+		

TABLE 2 (continued)

STAND NO.	31	18	29b	39b	26	39	28	39c	27b	12
Cassiope mertensiana		+					+			
Castilleja occidentalis		+								
Castilleja rhexifolia			+							
Cerastium beeringianum		+								
Cornus canadensis				+						
Danthonia intermedia		+								
Deschampsia atropurpurea		+								
Draba lonchocarpa		+							+	
Empetrum nigrum				+						
Epilobium alpinum	+	+	+							
Equisetum arvense		+	+							
Equisetum variegatum	+			+	+	+	+	+		
Eriophorum polystachion		+								
Eriophorum scheuchzeri							+			
Fragaria virginiana	+	+	+							
Hedysarum alpinum							+			
Juncus castaneus							+			
Juncus drummondii		+	+							
Juncus mertensianus		+	+							
Juncus triglumis							+	+		
Kalmia polifolia				+	+			+		
Kobresia simpliciuscula							+			
Ledum groenlandicum				+						
Luetkea pectinata		+								
Luzula arcuata									+	
Luzula parviflora		+								+
Lycopodium selago									+	
Mitella pentandra		+								
Parnassia fimbriata		+	+		+					
Pedicularis bracteosa		+								
Petasites frigidus		+	+							
Phleum alpinum	+	+								
Poa alpina	+	+								

TABLE 2 (continued)

STAND NO.	31	18	29b	39b	26	39	28	39c	27b	12
Poa arctica	+	+								+
Polygonum viviparum	+	+		+	+	+				
Potentilla diversifolia		+	+			+				
Pyrola sp.			+	+				+		
Ranunculus eschscholtzii	+		+							
Salix barclayi		+	+							
Salix barrattiana		+	+	+		+	+	+	+	+
Salix glauca										+
Salix sp.			+		+				+	
Scirpus cespitosus				+	+	+				
Selaginella selaginoides		+	+	+	+			+	+	
Senecio pauciflorus	+					+				+
Senecio triangularis		+	+							+
Sibbaldia procumbens		+								
Stellaria longipes									+	+
Taraxacum ceratophorum	+	+								+
Tofieldia pusilla				+			+		+	
Trisetum spicatum	+	+	+							
Trollius laxus		+	+							
Vaccinium oxycoccos					+					
Vaccinium scoparium		+								
Valeriana sitchensis		+								
Veratrum viride		+	+							
Veronica wormskjoldii	+	+								
Total No. Species	21	52	29	19	15	14	12	11	13	13

vegetation (table 2, stand no.12). Although two species of 25-40cm high willow shrubs are abundantly and homogeneously dispersed in about a 10% cover, they were not very conspicuous in 1971 due to a severe infestation of leaf beetles (Chrysomela sp.) that reduced most of the leaves to red skeletal fragments.

The dominant stratum in these meadows is a 25-35cm high cover of sedges, in pure stands or as mixtures of two or three species. These are Carex rostrata, C. aquatilis, and C. eurystachya. The cover of these sedge tussocks is fairly low in some (upper) sections of the fan, but often approaches 100% medially. Luzula parviflora is fairly common through the meadows though its total cover is very small. A few other flowering plants are scattered throughout, including long-stalked chickweed (Stellaria longipes), ragworts (Senecio pauciflorus, S. triangularis), and some bent grass (Agrostis scabra, A. variabilis).

There is normally a 50-75% cover of moss in clones humped up to 15cm. The bulk of the moss is Aulacomnium palustre, although there is also some Tomenthypnum nitens, Bryum pseudotriquetrum, and Sphagnum warnstorfii.

iii. Sections of gravel and wet sand-flat are colonized by rushes (Juncus balticus, J. mertensianus, J. castaneus, J. drummondii, J. triglumis). J. balticus is particularly abundant toward the lake side of the fan. Here too are pure stands of cottongrass (Eriophorum scheuchzeri) and some small patches of sedges (Carex aurea, C. saxatilis).

iv. Colonies of horsetails (Equisetum variegatum, E. arvense) and red willowherb (Epilobium latifolium) occupy some patches of damp to wet gravelly alluvium. Long-stalked chickweed, sandwort (Arenaria rossii), some grass, and even the occasional cushion of moss campion (Silene acaulis) can be found here.

B. Small meadows of all sizes up to 1 ha ($2\frac{1}{2}$ acres) are dotted over the forested west-facing slopes. According to the wetland classification of Adams & Zoltai (1969) these meadows are nearest to fens, characterized as follows: variable thickness of peat; dominant vegetation usually sedge; often much shrub cover; water table at surface most of the time, and some standing water possible in the spring. The definition for topogenous fen, furthermore, appears well suited for them: 'A fen developed on slightly sloping depressions in which there is a restricted internal drainage. The laeral movement of water is not completely obstructed. The surplus water is drained off by open or restricted outlets.'

Some of the stands in table 2 represent topogenous fen. The low interstand similarity (i.e. the heterogeneity) of this fen vegetation is evident from table 3.

The smallest meadows, mere depressions in the forest floor, have an intergrading forest-meadow vegetation: there is often a good deal of Phyllodoce glanduliflora or Vaccinium scoparium, but sedges are also abundant particularly Carex vaginata. In some spots, Equisetum arvense is common. Mosses are always abundant and usually in thick solid masses.

The larger meadows have one or other, or combinations, of the following general patterns.

i. Very wet meadow dominated by thick tussocks of Scirpus cespitosus. Under optimal development the community has no other vascular species. The water table is very close to the surface and there may be some water-filled potholes, the bottom alga-covered. Usually there is a well-developed, sopping wet moss stratum of Fissidens adianthoides or of Drepanocladus revolvens + Campylium stellatum.

One particular stand (no.26) had small very slight depressions that were filled not with water but by Sphagnum warnstorfii along with some

TABLE 3. COMPARISON OF SOME MEADOW STANDS, USING INDEX OF SIMILARITY[1].

STAND NO.	31	18	29b	39b	26	39	28	39c	27b
18	37.3								
29b	23.5	56.1							
39b	14.6	16.7	16.7						
26	10.8	11.8	13.6	52.9					
39	16.7	11.9	14.0	48.5	48.3				
28	5.9	9.2	9.8	19.4	7.4	30.8			
39c	12.1	9.4	15.0	20.0	30.8	32.0	34.8		
27b	0	9.2	14.6	25.8	37.0	15.4	16.7	43.5	
12	17.6	18.5	9.8	12.9	7.4	23.1	16.7	8.7	16.7

[1]Percent similarity = $\frac{200w}{a+b}$, where w = number of species in common, a & b = number of species in each of the two stands respectively.

sedge (Carex limosa, C. leptalea).

ii. Slightly drier meadows, usually somewhat hummocky (micro-relief 15-20cm). Dotted about are very short willow shrubs, very rarely taller than 30cm and in some stands scarcely exceeding 20cm. Some shrubby cinquefoil (Potentilla fruticosa) and dwarf birch (Betula glandulosa) may also be present. There is abundant, varied herbage, sedges especially, the total cover around 50%. A complete moss cover is usually present. Very typical and abundant are the 'brown mosses' Drepanocladus revolvens and Campylium stellatum.

There are instances of intergradation between type i and ii meadows, usually seen as Scirpus cespitosus tussocks associated with scattered type ii vascular plants. The response of these two community types to water level is a remarkably sensitive one. As evidence for this can be cited the presence of Scirpus cespitosus tussocks on an old disused path leading out of one of the meadows, whereas the very slightly raised microrelief adjacent to the path, a mere difference of 5cm, is dominated by the type ii vegetation of small shrubs, forbs and mosses.

iii. Locally there are larger hummocks, to $\frac{1}{2}$m high, in these forest meadows. They are covered with ericads (Ledum groenlandicum, Kalmia polifolia, Empetrum nigrum, mountain heathers), dwarf birch, bunchberry (Cornus canadensis), and various mosses and lichens particularly cladinas at the very tops.

C. A confusingly variegated pattern of meadows dominates the forest-tundra zone. Time of snowmelt and seasonal water availability are probably key environmental factors responsible for the expression of these different plant patterns.

i. At the foot of the alpine slopes there are some flat areas with a two-part plant community: hummocks, vegetated with Cassiope mertensiana and Salix barrattiana along with some Hedysarum alpinum, grasses, and sedges; and watery bare-gravelly level surface colonized by clumps of sedges, rushes and cottongrass. Kobresia simpliciuscula is abundant in what seems as intermediate situations.

ii. Damp meadows (but drier than type B), with abundant vascular plants, and a well-develped moss layer dominated by Aulacomnium palustre.

Where water is in abundant supply the moss layer is hummocky and thick, but where it is not so plentiful the moss cover is fairly thin and generally not quite continuous. Stand no.29b exemplifies the former, and no.18 the latter.

In stand no.18 there is a high (50-60%) vascular plant cover, made up of many different species. Most abundant is Artemisia norvegica, along with Senecio triangularis and Agrostis scabra. The other species are all well intermixed, so that the community looks reasonably homogeneous though the cover of each individual species is low. There is about a 5% cover of well-dispersed, very small willow shrubs. Another stand that was investigated proved fairly similar to no.18, although among the dominants Juncus drummondii replaced Senecio triangularis. In a slightly depressed section of stand no.18 Artemisia norvegica was totally absent, and the dominants were grasses along with more damp-loving species such as Caltha leptosepala.

Stand no.29b has about 50-60% vascular plant cover, but the herbage seems more profuse than in communities of the stand no.18 type; the herbage is, furthermore, taller and less homogeneous. Important species are Artemisia norvegica, globe-flower (Trollius laxus), Arnica mollis, Senecio triangularis, along with grasses and sedges. Some plants such as yellow columbine (Aquilegia flavescens) and broad-leaved paint-brush (Castilleja rhexifolia) are present in a low percent cover but are quite conspicuous. It is this meadow type that is responsible for much of the floral display at around timberline.

iii. In climatically moister mountain areas west of the continental divide and in the coastal ranges, mountain valerian (Valeriana sitchensis) and false hellebore (Veratrum viride) form a distinctive commu-

nity on steep south-facing slopes (e.g. Douglas, 1969). This community type is fragmentally developed in the Cavell area, on some steep south-west aspects at around timberline. It could probably be considered as a facie of the type ii lush meadow vegetation.

iv. In very late snow-release situations, the typical community consists of a thick cover of black alpine sedge (Carex nigricans). Other vascular species do not add up more than 5% cover, and there is a very thin discontinuous moss stratum.

4. MOUNTAIN HEATHERS.

Mountain heathers are a conspicuous element of the forest-tundra zone in the Cavell area and throughout the park. They extend up into the lower alpine zone, and invade the uppermost fringes of forest. Three major community types are involved.

a. The commonest type of mountain heather vegetation includes abundant white mountain heather (Cassiope mertensiana) along with yellow heather (Phyllodoce glanduliflora) and red heather (P. empetriformis). These species flourish on well-drained yet not excessively dry, 5-25 slopes. The ground surface is usually uneven due to the gradual buildup, as a consequence of frost action, of irregular earth hummocks.

In the south-eastern part of the study area, this ecosystem is dominated by Cassiope mertensiana which accounts for up to 80% of the cover, with yellow and red heather each about 10%. Very locally there are patches of P. intermedia, a natural hybrid between these two heathers. In the south-west part of the area, the Phyllodoce spp seem more abundant.

Associated with the heathers, often in slightly depressed micro-

habitats, are small numbers of a variety of plants especially alpine speedwell (Veronica wormskjoldii), smooth-leaved cinquefoil (Potentilla diversifolia), wooly pussytoes (Antennaria lanata), Carex spectabilis, and locally, abundant grouse-berry (Vaccinium scoparium). Lichens, and mosses in particular, are common as a low ground stratum.

b. Partridge-foot (Luetkea pectinata) is a low semi-shrubby plant which, though not a mountain heather, occupies the damper end of the same broad niche. It is ubiquitous through the forest-tundra zone in the coastal ranges, but it is not particularly common in most of the high-elevation areas that I have run across in Jasper Park. The one exception is the Cavell area where it flourishes, this undoubtedly a reflection of the more ample moisture supply. It can occur in pure patches, but is usually intermixed with mountain heathers.

c. Cassiope tetragona and Dryas octopetala form an easily recognized and fairly stable community, on exposed situations in the upper forest-tundra zone and lower alpine zone. The gravelly windswept habitat is intermediate between damper, normal mountain heather tundra, and unstable, xeric, poorly vegetated alpine situations. Cassiope tetragona, giving the community its distinctive brownish cast, forms an upper stratum (15-20cm) over the prostrate Dryas.

Common vascular associates include alpine goldenrod (Solidago multiradiata), moss campion (Silene acaulis), alpine harebell (Campanula lasiocarpa), alpine cinquefoil (Potentilla nivea), Anemone drummondii, and Castilleja occidentalis. Usually there is also some krummholz. The cover of lichens and mosses is not high but is fairly varied.

5. ALPINE TUNDRA.

Although some types of meadows (e.g. Carex nigricans) as well as mountain heathers can occur in the alpine zone, in the Cavell area they are mostly confined to the forest-tundra zone. The alpine zone in this area has a rich and quite distinctive flora of mosses, lichens and vascular plants in the main restricted to high elevations. The chief growth forms exhibited by the vasculars are mats, rosettes, cushions and small tussocks. These growth forms, as well as the perennial habit, are adaptations for survival in the so-called harsh alpine environment of strong winds, diurnal and seasonal temperature extremes, frost action especially needle ice formation, short growing season, and inadequate winter snow cover.

Two major types of alpine plant assemblages are represented in the Cavell area, mesic and xeric. The former resembles the Dryas - Salix arctica community described by Hrapko (1970) for Signal Mountain near Jasper town, and the latter her Dryas-lichen community. This vegetation is well developed along the ridge at the eastern edge of the study area, and eastward.

The Dryas - Salix arctica type occupies a wide, level, slightly hummocky terrace (just past the eastern edge of the photograph in plate 1). As implied, the dominant species are arctic willow (Salix arctica) and white dryad (Dryas octopetala). Tufted hairgrass (Deschampsia cespitosa) and the sedge Carex saxatilis are also abundant. Common but in lesser abundance are smooth-leaved cinquefoil (Potentilla diversifolia), alpine bistort (Polygonum viviparum), spike woodrush (Luzula spicata), Carex scirpoidea, Sibbaldia procumbens, and several grasses: bentgrass (Agrostis variabilis), alpine sheep fescue (Festuca ovina s.l.), alpine bluegrass (Poa alpina), arctic bluegrass (Poa grayana), spike trisetum (Trisetum spicatum). Mosses form a conspicuous stratum, mainly of Aulacomnium palustre and Hylocomium splendens. Floristically

this community is in some ways intermediate between xeric Dryas-lichen vegetation and damp meadows of the Cii type.

Dryas-lichen vegetation occupies most of the alpine ridge and slope. It is characterized by a gravelly-pebbly loose surface showing very little soil development (Regosol); by a small cover of very low vascular plants; and by an abundance and variety of lichens which thrive in this relatively competition-free and well-lit habitat.

Mats of Dryas octopetala provide most of the vascular plant cover. Locally there are small colonies of very stunted Cassiope tetragona. A secondary dominant is , surprisingly enough, grouseberry (Vaccinium scoparium). This low shrub, commonly associated with drier forests in the subalpine zone, is evidently thriving in the harsh alpine environment. In many spots it is no less abundant than Dryas, and at the time of investigation had large mature fruit, a not-so-common occurrence for any plant in this habitat.

Other prominent vasculars in the Dryas-lichen community are the sedges Carex nardina, C. rupestris, C. albonigra, and Kobresia bellardii. Also found here are snow willow (Salix nivalis), alpine cinquefoils (Potentilla nivea, P. uniflora), alpine pussytoes (Antennaria alpina), alpine goldenrod (Solidago multiradiata), alpine milk-vetch (Astragalus alpinus), late yellow loco-weed (Oxytropis campestris), alpine loco-weed (O. podocarpa), arctic lousewort (Pedicularis arctica), spike woodrush (Luzula spicata), alpine sweetgrass (Hierochloe alpina), and small bluegrasses (Poa grayana, P. rupicola).

Prominent lichens include Umbilicaria spp, Alectoria spp, Dactylina arctica, D. ramulosa, Cornicularia aculeata, Hypogymnia spp, Thamnolia subuliformis, Cladina mitis, Cetraria cucullata, C. nivalis, C. tilesii, C. ericetorum, C. commixta. There are also various crustose forms, the

commonest being Rhizocarpon geographicum.

More detailed typification of a broad spectrum of alpine vegetation can be found in Hrapko (1970). Color photographs of alpine plant communities, as well as mountain heathers, are in Hrapko (1970).

An interesting pattern of vegetation has developed in the ridge-swale topography below (i.e. west of) the alpine ridge. The gravelly surface of the ridges has Dryas mats and the normal plant associates. Also present are spotted saxifrage (Saxifraga bronchialis) and mats of crowberry and ground juniper. The swales have a thick cover of Phyllodoce glanduliflora and Cassiope mertensiana with abundant Cladonia spp, and fair amounts of Stereocaulon indicative of damp conditions (at least for the first part of the season). Mosses are also abundant.

6. BOULDER RUBBLE.

Areas of very rocky and bouldery terrain, both colluvial and morainal, fall into this category. Characteristic of these areas is an incomplete plant cover due to the virtual absence of soil. This in turn is due to the recent or unstable nature of the surficial deposits. Biological succession is in its primary stages here.

Some schemes of classification deal only with climax vegetation or potential climax, and according to these the boulder rubble areas at Cavell should be designated as spruce-fir forest. This would certainly not be a practical classification. True, climax spruce-fir forest is the ultimate vegetation type here, but the successional process is very slow and will take literally hundreds of years to approach completion.

Two areas of boulder rubble are involved, dissimilar both as to origin

and vegetation. They are the moraine complex deposited by recent advances of Angel Glacier; and colluvial slopes on the west side (Mt. Sorrow).

1. Moraine

The large, recently deglaciated moraine south of the teahouse is slowly being colonized by various plants. In some pockets where fines have accumulated, there are thin willow groves. But overall the plant cover is very low, certainly much less than 1%. Scattered about are mountain heathers (Phyllodoce spp, Cassiope spp), willows, mountain sorrel (Oxyria digyna), white dryad, occasional moss campion (Silene acaulis), bladder fern (Cystopteris fragilis), the rush Juncus drummondii, variegated horsetail (Equisetum variegatum), and conifer seedlings. The last four seem best to typify the vascular plant assemblage. The tree seedlings are in the main very small, and are made up almost entirely of alpine fir. Mosses and lichens are present only in minute quantities, the scarcity of crustose rock lichens being particularly striking.

It is difficult to discern the 'classical' successional sequence as delineated by Cooper (1916) in his pioneering studies in the Mount Robson area. He saw the sequence as initiated by scattered vascular plants, grading into a community dominated by dwarf shrubs notably white dryad (Dryas octopetala) and alpine bearberry (Arctostaphylos rubra), followed by a tall-shrub stage of willows and dwarf birch (Betula glandulosa), and climaxed with spruce-fir forest. In the Cavell area, the freshness of the deposits but particularly their coarseness accounts for the poor plant success.

2. Colluvium

Although they have a substrate similar to that of the moraines, some of

the colluvial slopes are much richer vegetationally. This is due to the more mesic nature of these slopes shaded as they are from early afternoon on and thus escaping extreme desiccation, as well as the fact that geomorphologically they are much older.

Vascular plants are very scarce over large sections of these slopes. This may be due to the absence of an adequate rooting medium. It does not reflect slope instability: the lower sections in particular are quite stable as reflected in the abundance of saxicolous lichens.

Exposed surfaces of most of the rocks are blackened from growth of crustose lichens. Rhizocarpon geographicum, a common green species, covers perhaps 10% of the surfaces. Small thalli of Umbilicaria spp and a grayish Parmelia(?) are prominent though their total cover is small. There are also species of Lecidea and Lecanora, and the red Xanthoria elegans. Some of the rocks have small cushions of Grimmia. In general the larger the rock face the greater the percent cover of this rock moss, and also the greater the frequency of invasion of it by various lichens.

The most important inter-rock plants are the hepatic Temnoma setiforme and the moss Rhacomitrium canescens. Both form clones 10-25cm across which serve as the matrix for establishment of mosses and lichens. Cladonia uncialis is particularly abundant here. Also common are C. coccifera, C. ecmocyna, C. gracilis, and Cladina mitis.

Mixed colonies of lichens and bryophytes are also developing slowly on level rock faces, generally in somewhat sheltered sites where erosional processes are not severe yet where light is adequate. Here they gradually accumulate wind-blown silt and grow on it.

Some sections of these rock rubble slopes have a good cover of dwarf

birch and alpine fir, but a snow-avalanche situation is usually implied here, and as such dealt with under Ecosystem #7.

There is an upslope gradation into fine-scree surface (because the larger the rock the farther it will tend to roll). This fine-scree situation is also found through the southern end of the Cavell area. But this very unstable surface with very good (too good) drainage has a very sparse and irregular scattering of vascular plants and does not really rate an ecosystem designation.

7. AVALANCHE SLOPES.

Some of the avalanche chutes in the area, notably toward the south end, are much too steep and active to harbor any vegetation at all, but toward the base of Mt. Sorrow a distinctive vegetation type has developed on some of the colluvium, and is being maintained by avalanching. It seems to intergrade both with the previous ecosystem (rock rubble) and with conifer forest northward along the slope.

The ecosystem is characterized by alternating or mixed patches of dwarf birch (Betula glandulosa) and appressed alpine fir (Abies lasiocarpa), the former mostly 1.5m tall and the latter 1m tall with leaders, dead in the majority of cases, to 1.5m or occasionally more. Where developed as patches purely of one species, each has a distinctive subordinate vegetation.

Under fir there is a thick damp cover of feather mosses with some lichens especially colonies of Peltigera canina and Cladonia spp. Other mosses, Polytrichum in particular, thrive on slight mounds and overhangs. On more open spots, notably where rock is outcropping strongly, reindeer lichens are prominent, commonest of these being the yellowish Cladonia

uncialis. Vascular vegetation includes fairly abundant crowberry and thin patches of grass.

Under birch the situation is reversed. Mosses, again mostly feather mosses, are present in about the same proportion that lichens were under fir, i.e. 10-15%. Light penetration and dryness are much greater under the birch, and reindeer lichens (Cladina spp) have assumed dominance on the ground surface. Again, plant cover is virtually complete.

As one moves alongslope toward forested sections, the avalanche influence obviously progressively diminishes. First there are some spruce, as small trees to 4m tall, along with an occasional lodgepole pine. The trees progressively increase in size and number. The most noticeable changes in subordinate vegetation are the gradually rising importance of Menziesia ferruginea, grass (e.g. Calamagrostis inexpansa), Stereocaulon, and wood-associating lichens (Cladonia cenotea, C. gonecha, C. pleurota) on logs. The ground surface has a mosaic of lichens (mostly Cladina arbuscula) and feather mosses (mostly Ptilium crista-castrensis), on highs and lows respectively of the microrelief.

Very locally at the base of the slopes there are abundant signs of snow avalanching. Trunks, branches, small red-leafy stems litter the ground. The strip of treeless ground at the base is no wider than 4-5m however.

8. SPRUCE-FIR FOREST.

More than three-fourths of the study area is covered in coniferous forest. The east-facing colluvial slope overlooking Cavell Lake is forested, and there are pockets of forest on alluvial deposits upstream from the lake. The bulk of the forestd area, however, includes the large expanses of west-

facing slopes.

In his study of subalpine spruce-fir forests in Banff and Jasper Parks, Beil (1966) considers them structurally and floristically simple. The top and bottom strata, trees and bryoids (bryophytes + lichens) are best developed, the herb - dwarf shrub stratum is less well developed, and the shrub stratum is poorly developed. The forests in the Cavell area more or less fir this generalization.

Although there is a wide range in relative dominance of spruce and fir (table 4), the general picture is one of spruce as the larger, emergent species with a somewhat greater crown cover than fir which, with its propensity toward layering, typically behaves as a tall shrub and small tree. In the single stand which he analyzed in the Cavell area, Beil (1966) found a maximum tree age of 345 years and height of 29.6m, the larger spruce trees infrequently attaining a dbh of 60cm. Sampling for tree density, Beil estimated 13.4 live stems and 1.6 dead stems per $100m^2$. In terms of basal area, he arrived at a value of $38.3m^2$/ha (167 ft^2/acre).

As one approaches timberline there is a fairly abrupt decrease in tree height, and the forest breaks up into the forest-meadow complexes. In a meadow close to timberline I found a spruce tree with the remarkable dbh of 90cm, though unfortunately I was unprepared to core it for age.

Most of the spruce in the Cavell area is Picea engelmannii. Below about 1800m (5500') or perhaps somewhat higher, Picea glauca genes begin infiltrating, though the resultant hybrids are definitely nearer P. engelmannii than P. glauca (cf. Evans & La Roi, 1964).

In the lower northern part of the study area, some of the slopes are subject to so much seepage that the vegetation is almost muskeg-like, with

TABLE 4. SPRUCE-FIR FOREST STANDS.

STAND NO.	1	2	3	4	5
ALTITUDE (m)	2070	1870	1870	1900	1750
SLOPE (in deg.)	23	30	25	5	6
ASPECT	W	WSW	WSW	N	W
AV. CROWN HT. (m)		14		8	
MAX. TREE HT. (m)	30	18	25?	10?	
TREES					
Picea engelmannii	?	1	4	4	2
Abies lasiocarpa	?	2	2	3	1
Picea mariana				+	1
Pinus contorta				+	2
CROWN COVER	4	2	5	5	4
SHRUBS					
Abies lasiocarpa	4	2	2		
Menziesia ferruginea	+	1	2		
Rhododendron albiflorum	+		+		
Vaccinium membranaceum	+	+	+	+	
Salix spp.[1]	+	+	+		+
Betula glandulosa			+		+
Ledum groenlandicum				3	3
DWARF SHRUBS					
Phyllodoce glanduliflora	1				
Cassiope mertensiana	+				
Cassiope tetragona	+	+			
Phyllodoce empetriformis	+	+			
Vaccinium scoparium	1	+	1	1	1
Empetrum nigrum	+	+	1	3	3
Vaccinium vitis-idaea		+	+	1	1
Vaccinium myrtillus		+			+
Linnaea borealis		+			1
HERBS					
Oxyria digyna	+				
Arnica cordifolia	+				
Pyrola virens	+	+			
Pyrola uniflora	+	+			
Rubus pedatus	+	+			
Listera cordata	+	+			
Equisetum scirpoides	+	+			
Lycopodium selago	+	+			

TABLE 4 (continued)

STAND NO.	1	2	3	4	5
Goodyera repens		+			
Calamagrostis neglecta			+		
Lycopodium annotinum	+	+	+		+
Pyrola secunda	+	+	+		+
Cornus canadensis	+	+		+	+
TERRESTRIAL BRYOIDS	5	5	5	?	?

[1]Mostly Salix drummondiana, some S. vestita.

NOTE: values represent cover classes. + = less than 1% cover, 1 = 1-5%, 2 = 5-15%, 3 = 15-25%, 4 = 25-50%, 5 = 50-75%.

1 Beil, 1966
2 Matthews, unpubl. data. On file at Office of Park Naturalist.
3 P. Kuchar
4 Evans & La Roi, 1964
5 "

abundant Labrador tea (Ledum groenlandicum) and even some black spruce. But this is not the case through most of the higher-elevation forest. Labrador tea is absent and the tall-shrub stratum, generally 1m high, has more of fir than anything else. There is a sprinkling of willows throughout, and locally quite abundant Menziesia ferruginea and Vaccinium membranaceum.

The presence of these latter two shrubs implies a moist climatic regime. Menziesia and tall bilberry are very abundant shrubs, indeed the understory dominants, in spruce-fir forests westward and southward (e.g. in Waterton Lakes Park). The annual precipitation is twice as high there as in Jasper

Park, thus the local abundance of these shrubs in the Cavell area implies annual precipitation intermediate between say 50 and 100 cm (20 and 40"). The presence of other such plants, e.g. Listera cordata and Tiarella unifoliata, as well as the abundance of Luetkea pectinata, lend strength to this argument.

From table 4 one might infer that there is a wide range in numbers and kinds of dwarf shrubs and herbs through the Cavell forests. There is some variability but not as much as the table would intimate. A greater number of species (stands 1&2) simply implies a larger stand and a higher sampling intensity, where even the rarest and most inconspicuous plants were tabulated.

The herb - dwarf shrub stratum adds up to a fairly low total cover, usually less than 15% and rarely greater than 30%. It is rather consistently dominated by crowberry (Empetrum nigrum), rock-cranberry (Vaccinium vitis-idaea) and grouse-berry (V. scoparium), with smaller amounts of groundpine (Lycopodium annotinum), one-sided wintergreen (Pyrola secunda) and bunchberry (Cornus canadensis). Mountain heathers enter the picture upslope, adding significantly to the low shrub cover, particularly near timberline. The isolated groves and patches of forest in the forest-tundra zone retain, despite the proximity of meadow vegetation, their characteristic understory components, and mountain heathers figure prominently here.

The ground stratum of bryophytes and lichens in the spruce-fir forest covers 50-75% of the surface. Three-quarters of this consists of feather mosses. Hylocomium splendens is most abundant, with some Pleurozium schreberi and fairly rare Ptilium crista-castrensis. Commonest of the other bryophytes are Dicranum spp and Barbilophozia lycopodioides. Thallose

lichens (Peltigera spp, Nephroma arcticum) account for around 10% cover. Other lichens, mainly Cladonia and Cladina species, amount to only around 5% cover. Logs have an abundant and varied bryoid cover. Epiphytic lichens are abundant, especially on some of the small (dead) trees.

From the above description of the spruce-fir ecosystem in the Cavell area, one might suppose a fairly homogeneous and predictable vegetational assemblage. In fact this is hardly the case. Topographically most of the forested west-facing slope is very irregular, and it is this, combined with a rather large supply of groundwater, that creates a complex of different habitats with diverse niches. Some of the main elements are:

1) Damp hollows and seepage spots with horsetails, sedges especially Carex vaginata and C. capillaris, small willows, and thick clumps of moss.

2) Many streamlets, over and undergorund, lined with mosses.

3) Tiny ponds and potholes, with mosses, also sedges and other vasculars adapted to such damp habitats.

4) Rocks protruding through the forest floor, and draped with lichens and mosses characteristic of such.

5) Abundant, crisscrossing logs, supporting corticolous-lignicolous lichens and bryophytes.

6) Small eroding sections on some steep slopes.

7) 'Normal' forest, the ground covered with needle litter and bryoids, and some dwarf shrubs. In very slightly more mesic sites, large clones of feather mosses.

The patches of forest on alluvium upstream from Cavell Lake are generally not too dissimilar structurally or floristically from the west-slope forests. The trees are mostly spruce, the tree seedlings almost all fir.

The subordinate vegetation varies a great deal depending on canopy cover and soil moisture regime. Spots that are quite damp support clumps of rushes, sedges and horsetails as well as abundant Campylium stellatum and other mosses. There is profuse algal growth in some of the small potholes. The plant cover of mesic sections is most akin to that of slope forests: a thin shrub stratum, about 20% cover of dwarf shrubs (Vaccinium scoparium, Phyllodoce, Cassiope) with some herbs such as Pyrola spp, Pedicularis bracteosa, Stellaria calycantha, and a well-developed bryoid stratum. Under a closed canopy the moss cover approaches 100%, with little else in the way of subordinate vegetation.

Toward the upstream end of this colluvial area, the forest is of a rather disturbed and xeric nature, and poorly developed. The irregularly channeled surface of coarse gravel supports a sparse ground cover, around 5%, predominantly of fir seedlings, some moss, and a smattering of shrubs and herbs. Some of the latter are evidently forest species, while others such as Epilobium latifolium are characteristic of disturbed and primary habitats.

OTHER VEGETATION.

Disturbance vegetation

As mentioned earlier, there are twelve or more species of weedy exotics in the Cavell area, rastricted mainly to the highway right-of-way. Dandelions and alsike clover seem the commonest of these. Native plants also occur here, but thinly dispersed at best. Yarrow (Achillea millefolium) and willows, notably grayleaf willow (Salix glauca), are commonest.

The horse corral on the east side of Cavell Creek seems to be in a

dampish location, and this may account for the churned-up, muddy surface with a great deal of the thallose liverwort Marchantia polymorpha along with some Drepanocladus uncinatus moss. The other corral, on the west side of the creek, is in a drier location and has mostly some weedy grasses and forbs along with some native forest vegetation.

Cliff vegetation

Ledges, crevices and rock walls along cliffs, particularly of Mount Edith Cavell itself, support some vascular and non-vascular plants. Although time and logistics were inadequate to handle these micro-ecosystems, they undoubtedly accommodate many species either restricted to these habitats, or ones that are rare elsewhere. The lichens and mosses would be of especial scientific interest.

Barren boulder field

About 1/3 km east from the north end of Cavell Lake, there is a small boulder field which is rather different from those included under ecosystem #6. Although it has apparently been intact for as long as the mature forest surrounding it, it is remarkably poor in plant growth. The limestone boulders, 5(2-12) dm in diameter, are sparsely (no more than 10%) covered by Rhizocarpon cf. geographicum and lesser amounts of other lichens especially species of Umbilicaria. There are also small clumps of Grimmia, particularly where irregularities on the rock faces afford a more secure hold. Down among the boulders, the sum total of the vegetation is represented by sparse clones of moss. Water can be heard flowing underneath. Any silt or other fines are evidently washed out before they have a chance to accumulate, hence the rather sterile inter-boulder environment.

PHENOLOGY

The finest displays of flowers are to be found in the forest-tundra zone and upward into the alpine zone. Three ecosystems here, meadows, mountain heathers, and alpine tundra, harbor a large variety of flowering plants including the majority of those with large, massed, or otherwise conspicuous blooms.

1. Meadows. In late June, globe-flower (Trollius laxus), mountain marsh marigold (Caltha leptosepala), and snow buttercup (Ranunculus eschscholtzii) are the first plants to come into flower. Other species succeed these in early July, but it is not until mid-July that the meadows can be considered to have reached the height of flower. Some of the finer and more conspicuous species include mountain valerian (Valeriana sitchensis), red paint-brushes (Castilleja miniata, C. rhexifolia), alpine speedwell (Veronica wormskjoldii), mountain bog laurel (Kalmia polifolia), and wood betony (Pedicularis bracteosa). Somewhat later come ragworts (Senecio triangularis, S. pauciflorus), hairy arnica (Arnica mollis), burnt-orange false dandelion (Agoseris aurantiaca), yellow columbine (Aquilegia flavescens), and fringed grass-of-Parnassus (Parnassia fimbriata). Some of the plants, for example yarrow (Achillea millefolium), are not well adapted for the fairly late snow-release, and in some years may not even have time to reach the flowering stage. The Carex nigricans community, latest to be freed of snow but adapted to this situation, comes into flower in late July, but it could hardly be described as showy.

2. Mountain heathers. Although individual plants of Phyllodoce spp and Cassiope mertensiana begin flowering as early as late June, phenologically the mountain heathers do not attain their peak until the middle of July,

maintaining it until the end of July. Practically all the plants associated with mountain heathers are also in flower through July. Some of the conspicuous ones are partridge-foot (Luetkea pectinata), alpine speedwell, smooth-leaved cinquefoil (Potentilla diversifolia), wooly pussy-toes (Antennaria lanata), and arnicas. There is approximately a two-week difference in stage of development between vegetation on north and south aspects.

Due to its exposed positions, usually snow-free by early June, the Cassiope tetragona - Dryas octopetala community is a couple of weeks earlier than the rest of the mountain heather vegetation. In early July most of the flowering plants here are in full bloom. Drummond's anemone (Anemone drummondii), the first to bloom, is near shedding its seeds by this time; and alpine goldenrod (Solidago multiradiata), the last to bloom, does not come into flower until late July.

3. Alpine tundra. Flowering here, as in most tundras (Bliss, 1971), is synchronous. The peak of bloom occurs in late June - early July. The flowers of many of the species are striking in the large size they attain in proportion to the whole plant. Some of the showier species include white dryad, alpine cinquefoil, alpine goldenrod, alpine milk-vetch, alpine loco-weeds, arctic lousewort, alpine harebell.

4. Other vegetation. Those visitors to Cavell who do not hike up to the forest-tundra zone are not deprived the sight of flowers, but these will be mostly roadside plants particularly weeds such as dandelions which in no way reflect the native flora. If they venture along the moraine trail to the point where it enters the forest, they will pass a small meadow as well as some mountain heather vegetation at the forest edge. There are also scattered individual flowering plants along the way.

At the perimeter of Cavell Lake there are various meadow-type plants that begin to come into bloom by mid-June. However, the zone is a narrow one and certainly not one of floral display. There are also fair numbers of flowers in disturbed situations at the forest edge and in clearings, but they cannot begin to compare in variety and overall effect with those in the forest-tundra zone.

As for the forests in the area, they cannot be said to have a real phenological peak. The dominant plants such as blueberries and crowberry have inconspicuous flowers, and those plants such as heart-leaved arnica which do have showy flowers are not at all common.

By early August the majority of the flowering plants in the Cavell area have set seed, but flowers can be found to the end of August and even into September.

ANIMAL LIFE

INTRODUCTION

Although the Mt. Edith Cavell and Tonquin Valley region have a fairly rich history of investigations of birds and mammals, at least compared to most areas in Jasper Park, the data do not add up to much in an absolute sense. In the early part of the century, mammals received some attention in the area. What these studies, if they could be called that, amounted to was the collection of specimens, mainly by Spreadborough, Taverner, Hollister, Anderson. A smattering of observations and collecting can be traced through the years up to the present time, but there were never any intensive investigations. Recently, a caribou study was initiated by the C.W.S. in this and tow other regions of the park. Soper (1970) presents a short review of mammal-oriented research in Jasper Park. In his four-summer intensive investigations of mammals in the park, 1960-63, he apparently did not cover the Cavell - Tonquin Valley region.

According to Cowan (1955), in the first half of the century nearly all ornithological work in the park was restricted to four localities one of which was the Cavell area. From about 1917 on, apparently most collectors appear to have spent at least some time there. Taverner (1918) camped at Cavell Creek and Cavell Lake for almost a month.

The resident/breeding vertebrate fauna of the Cavell and Tonquin Valley region (Appendix 4,5) includes a possible total of 67 species: 25 mammals, 40 birds, 2 fish, no reptiles or amphibians. An additional ten or so mammals occasionally wander into the area; and 20 bird species migrate through but probably do not nest here.

The area also supports a large variety of invertebrates of which practically nothing of an ecological nature is known. As far as I am aware, Cavell is one of just two areas in Jasper Park (the other being the Maligne area) in which anything vaguely resembling a general survey of invertebrate fauna has been conducted.

METHODS

No specific sampling procedures were used in obtaining field data on animal patterns and movements. During the course of field trips in the area notes were taken on anything of interest, usually any time birds or mammals or signs of their activity were encountered. The very few pages of field notes that I took attests to the unusual scarcity of animals through the area, except for the unnaturally high numbers of golden-mantled ground squirrels and Clark's Nutcrackers just south of the teahouse and memorial cairn.

Much of the information on birds and mammals was obtained through the scientific literature, and in conversation with the area warden and a few other people. The lists (Appendix 4,5) represent what I believe to be all the vertebrate species sighted and reported in the area. If there are one or two that have been missed, it is probably because they are very rare here and in all likelihood accidentals.

The one weak point in the vertebrate study lies with the small mammals. My very limited time allotment precluded live-trapping in the Cavell area. Snap-trapping would certainly have been more practical, and it is doubtful that it would have had a deleterious effect on populations. Although there were signs of microtines, their numbers may have been at a low level as in other areas of the park in this particular year (cf. Kuchar, 1972).

MAMMALS

For general comments on mammals in Jasper Park, refer to Soper (1970). In the Cavell area, mammals do not seem to figure prominently in any of the ecosystems except perhaps the boulder rubble ecosystem. At least part of the reason for the relative insignificance of mammals is suggested by the heavy winter precipitation which would hamper activity of most of the larger mammals. For example, even in the Maligne area, which receives appreciably less winter precipitation, there is a fall exodus of ungulates. Some of the small mammals, microtines in particular, might be favored by the rich variety of damp and wet habitats.

Four species of microtines, and seven or eight other species of small rodents, are recorded for the area (cf. Appendix 5). They are the most numerous of the Cavell mammals, in terms both of species as well as population numbers. Vole runways seem quite common in the little forest meadows and vegetation-mantled seepage slopes. Voles and mice may also be abundant in the forest-tundra zone, with its concentration of utilizable vegetation; however, I am not certain of their status here. According to Pattie & Verbeek (1967) who studied mammals in an area of the Central Rockies, this zone (krummholz-timberline) serves to concentrate mammals by virtue of the edge effect. Specifically mentioned were red-backed voles and deer mice.

Mountain heather tundra in this zone is inhabited by Columbian ground squirrels, though they are also recorded from near Cavell Lake (Anderson, 1918). These rodents did not seem particularly abundant, though Spreadborough (1919) considered them common in the area. He also noted marmots as common at Cavell, but this again did not appear to be the case, at least not in 1971. Marmots are restricted to colluvial slopes where the rocks are large to boulder-sized,

and this habitat type occupies only a small percentage of the area.

Although microtines are probably the most abundant rodents, the golden-mantled ground squirrel and the red squirrel are certainly the most conspicuous. The latter occurs through all forested sections, though not in particularly high numbers. The golden-mantled ground squirrel inhabits higher-elevation, open rocky terrain. Thus its distribution in the Cavell area is bimodal, namely in the alpine zone and down on the moraines. The golden-mantled ground squirrel is the mammal that visitors are likeliest to notice, for it is very abundant at the northern end of the fresh moraines, its numbers doubtless augmented by visitors' handouts.

The pika overlaps in its habitat with the golden-mantled ground squirrel, but it shuns areas that do not have abundant crevices and large rocks or boulders. Small 'hay piles' under boulders on the fresh moraines are a sure sign of its activity. I do not know the population status of the pika here. However, even if its numbers are quite low, this herbivore is probably creating a significant impact on the boulder rubble ecosystem. There is not much vegetation here to begin with, and the pika may well be decelerating plant succession.

Another lagomorph, the varying or snowshoe hare, is reasonably abundant in the forests in the area (T. Klettl, pers. comm.).

Carnivores are uncommon. The smaller ones, notably marten and ermine (short-tailed weasel), are rare resident species (T. Klettl, pers comm.). I saw marten tracks in the snow in the forest-tundra zone in late September 1971. This animal will wander upward well into the alpine zone, but the preferred habitat is coniferous forest. The wolverine, a very wide-ranging wilderness mammal, might occur in the Cavell area at irregular

intervals. I would not really expect it however, considering the high level of visitor activity in summer and deep snows the rest of the year.

T. Klettl would encounter the occasional coyote and timber wolf, and rarely cougar, but these animals are probably temporary transients from the main (Athabasca) valley. The red fox occasionally frequents high altitudes in the park, but has not been recorded from the Cavell area. The status of Canada lynx here is not known.

According to T. Klettl, there used to be grizzlies in the area, but have not been seen for years now, possibly due to the greatly escalated visitor use. I do not know the status of the black bear here. On 30 June 1971 I saw tracks of a medium-sized bear by the highway, several miles down from the tea house.

Some ungulates can be found in the area in season, but they are not abundant. There do not appear to be any signs of moose, and T. Klettl does not recall ever having seen moose here. Mule deer come into the area in spring, in small numbers; they occur at all altitudes in meadows, forest, and tundra terrain. Elk occur in the area mainly late in the season; September might see the greatest numbers of the animals here, in open areas as high as alpine. The occasional Rocky Mountain caribou shows itself in the Cavell area, but might simply be a straggler from the Tonquin Valley population. Rocky Mountain sheep might once have occurred in the area - for example, according to Klettl they would winter in the vicinity of the highway viewpoint (site 3 on map). There are some mountain goats in the area though I do not know the population status. Doubtless they are not restricted to the area but probably utilize it part of the year. East-centrally there is one fairly well used game trail angling up an alpine

slope, which is probably travelled by these animals.

There are other game trails in the area, notably at mid-higher elevations on the forested west-facing slope. However, most of these trails are faint, partly overgrown with vegetation, suggesting infrequent or curtailed use. Two reasons may be suggested for the relative paucity of big game in the area.

Firstly, big game may once have been abundant, indeed may once have thrived here, but man's greatly escalated activity may have interfered with the population patterns. This is probably the case with the Rocky Mountain caribou though less likely with other ungulates, for they are much less sensitive to man's presence. Today caribou in this region are practically restricted to the Tonquin Valley area, where a study of them has been initiated by J. G. Stelfox of the Canadian Wildlife Service. That they may once have been common in the Cavell area might be inferred (e.g. from Anderson, 1918).

Secondly, the peculiarly local climate may always have suppressed the numbers of ungulates. According to Stelfox & Taber (1969), a high percentage of wintering by native ungulates is on exposed west and south facing slopes where grass and shrub browse is greatest. There are many slopes of such aspect in the study area, in fact the whole eastern section is practically one large west exposure. Through winter however, it is under deep snow in the coniferous forest and forest-tundra zone. The alpine slopes and ridges which are exposed in winter have a gravelly windswept surface that supports very little plant biomass. The high annual precipitation has probably historically precluded the development of xeric shrubby-grassy slopes such as are common for example on south and west aspects in the Athabasca Valley.

There is a possibility that elk have, since coming into the Cavell area following their re-introduction and spread in the park, begun to displace other ungulates. According to Flook (1964) elk are very vigorous competitors with other ungulates. Unfortunately, ungulates have been studied more or less only superficially in the area, thus I cannot be sure what the true situation is.

Unless developments in the Cavell area proceed on a massive, unprecedented scale, a quite unlikely situation, much of a shift in animal patterns is implausible. Major changes (if they have occurred) are behind us: decimation of caribou and grizzly populations, re-introduction and spread of elk, increased numbers of golden-mantled ground squirrels. The present populations are probably fairly stable, unless visitor use climbs tremendously; and this would cause a much more noticeable deterioration to vegetation and soil than to animal life. The real concern which is being expressed for the region's caribou, intolerant as they are of man's activity, is not really within the scope of this particular study, since these animals are about 10 miles westward (cf. Yonge & Scotter, 1972).

BIRDS

About 20 species of birds live year-round in the Cavell area, and another 20 are summer residents. An additional 15 species have been seen in the general area, Tonquin Valley included, but represent migrants and accidentals. A further ten or so species can be expected to occur here although I have no verifying records. Appendix 4 summarizes the available data on birds in this region.

From what I saw in my field trips to the area in 1971, and the few

earlier times that I had come here, there does not seem to be a real abundance or variety of birds. There are birds here, to be sure, but they seem less common than elsewhere through the park. This apparent relative impoverishment, both in numbers of individuals as well as species, may be tied in with the damp cool environment.

Clark's Nutcracker is a glaring exception to this general scarceness of birds. Through the summer, dozens of adults and juveniles flaunt themselves in the vicinity of the tea house, memorial cairn, and lower viewpoint trail, where they seem to thrive on visitors' handouts. It is a distinct possibility that the unnaturally high numbers of these birds may be depressing the populations of other birds especially the smaller songbirds. Although Clark's Nutcracker is characterized as a bird dependent on conifer seeds, it will supplement its diet with a variety of other food, including eggs and nestlings (cf. French, 1955). The higher numbers of Nutcrackers suggests greater chance for discovery by them of other nests.

These birds probably do not stay here in winter but move down into the larger valleys (cf. Cowan, 1955). On 26 Sept 1971, I could see no sign of these birds in the moraine area, though the occasional one could be encountered in the forest.

The birds in the Cavell area may be conveniently split into four groups: alpine, forest-tundra, forest, and water.

i. As in most alpine areas throughout the park and Northern Rockies in general, four species of birds breed in the alpine zone in the Cavell area though none remain in this zone through the winter. The Gray-crowned Rosy Finch nests in high cliffs. In spring it forages as the edges of melting snowbanks, but later in the season moves onto drier alpine slopes and ridges. The White-tailed Ptarmigan nests on dryas tundra.

In July it moves down into mountain heather and meadow vegetation, but toward the end of the summer returns to rocky, xeric terrain. The Horned Lark nests and restricts its summer activity to dryas tundra and fairly dry alpine slopes. Water Pipits breed in hummocky, sometimes rocky, but generally mesic tundra, particularly mountain heather tundra. The Golden Eagle, a bird of rough open terrain at all elevations, can sometimes be seen soaring over the area, though with its huge territory of several tens of square kilometers, it is doubtful that it nests within the study area proper.

ii. The forest-tundra zone, with its mosaic of tree islands and mesic tundra, is a habitat favored by a number of sparrows and a few other birds. The Golden-crowned Sparrow is probably the commonest bird in this zone, at Cavell and elsewhere through the Northern Rockies. The Fox Sparrow and Brewer's Sparrow occur in smaller numbers. The White-crowned Sparrow may nest in this zone in the Cavell area, though it also frequents open, hetergeneous-habitat areas at lower elevations. Soper (1960) did not see much of it in the area. In September 1971, I found little flocks of these birds throughout the forest.

In some areas in the park, for example the Maligne area (Kuchar, 1972), the Robin prefers the forest-tundra zone and thrives in it (though this bird does occur through tremendous range of habitats and elevations). I did not notice any nesting birds in the Cavell area, but it probably does breed here. The Hermit Thrush, another bird typical of open forest, can be found in the forest-tundra zone here. Townsend's Solitaire, a bird typically of drier, rough terrain, has been recorded for the area by Taverner (1918). I did not see any Mountain Bluebirds, but they would be expected to occur in open areas,

more likely in the open fresh-moraine section rather than the lushly-vegetated forest-tundra zone.

Cowan (1955) considered Wilson's Warbler as characteristic of the forest-tundra zone, and reported it nesting at Cavell. Lincoln's Sparrow has been reported at timberline in Tonquin Valley. Willow Ptarmigan occur in the Cavell area and Tonquin Valley, though I do not know how common they actually are. These birds are of exceptional interest since they, along with the population in the Maligne area, constitute the southern-most extensions of the Willow Ptarmigan's breeding range in North America.

iii. Forest birds in the Cavell area form a varied although not particularly abundant assemblage, of resident and seasonal species. Here as elsewhere, the cool damp high-altitude forest supports fewer birds than does more open country, at lower elevations. The abundant lichens and bryophytes are floristically and vegetationally very important components of the spruce-fir forest, but are essentially useless in terms of utilization by birds. Practically all the forest birds in the area depend on the trees (seeds and insects) for their sustenance.

Resident species include fringillids (finches), corvids, raptors, grouse, and small insectivores. Pine Siskins are the commonest fringillid here as in most areas of the park. Pine Groskeaks also occur here, but I do not know their status. I have no records of occurrence of either White-winged or Red Crossbill, but would expect them here on an irregular basis.

Corvids include the Gray Jay, Clark's Nutcracker, and Raven. The Gray Jay, 'the most universally distributed species in the park' (Cowan, 1955), ranges through all forested terrain. Clark's Nutcracker, as mentioned, is

locally very abundant through the summer but rare or absent in winter. The Raven is a rare but probably resident species.

Raptors have very infrequently been sighted in the region. Two Cooper's Hawks were seen by Cowan (1955). Prairie Falcon has been seen in Tonquin Valley (Cowan, 1955). The Goshawk and Great Grey Owl might occur in the area.

Grouse are infrequently encountered here as elsewhere through the park except in the lower Athabasca Valley. There is the occasional small family group or individual of Spruce Grouse. There are no records of Blue Grouse here. The Northern Three-toed Woodpecker is an uncommon resident species. Taverner (1918) noted three near the bridge over Cavell Creek. I saw one in spruce trees a little below timberline.

Small flocks of insectivorous birds can be encountered most times of year in the forest. They are typically composed of chickadees (Mountain and/or Boreal),one or two Red-breasted Nuthatches, sometimes Golden-crowned Kinglets, and, in late summer and fall, Ruby-crowned Kinglets and warblers. A Brown Creeper might occasionally accompany a flock. This bird is very rare in Jasper (Cowan, 1955), and the only one I ever saw in the park was in the Cavell forest on 26 September 1971. Ruby-crowned Kinglets, with their loud songs, are heard commonly early in the season (Hrapko, 1969).

The commonest summer birds are warblers. Predominating here as elsewhere in the park are Myrtle and Audubon's Warblers. Other species are much less common. Taverner (1918) noted the occasional Orange-crowned Warbler; and a Townsend's Warbler in early September.

The Junco, according to Cowan (1955) one of the most abundant birds

in the park, in all areas and at all elevations to timberline, is common in open forest and edge situations in the Cavell area. The Winter Wren, a fairly scarce species in the park, evidently nests in the Cavell area: on 29 August 1971 I saw two adults and two juveniles in brushy forest edge on the east side of Cavell Lake. Forest thrushes, notably the Varied Thrush, Swainson's Thrush, and Veery, have not been noted as breeding in the Cavell area, but I would expect this. In September 1971, Varied Thrushes were quite common through the forested west-facing slopes. The Olive-sided Flycatcher has nested in the area: Cowan (1955) saw four juveniles at Cavell Lake. This bird prefers solitude, and is only thinly scattered through the park, thus it is not surprising that I saw none during my field investigations.

iv. Flocks of waterfowl rest on Amethyst Lake during migration (Cowan 1955); though how important this body of water is for migrating waterfowl I do not know. Ducks are rare on Cavell Lake possibly because, situated high as it is in the mountains, this lake is extremely oligotrophic and unable to support submergent vegetation and therefore ducks. Cowan (1955) reported one Lesser Scaup on the lake in 1944. I saw a female Goldeneye on the lake on 30 June 1971. For his month-long stay at Cavell Lake, Taverner (1918) had only one waterfowl record, surprisingly enough that of a Harlequin Duck with young.

The Dipper, a bird of fast-flowing mountain streams, seems not to have been reported from the Cavell area proper. The Spotted Sandpiper is a common (and only) shorebird along Cavell Lake. Occasional other shorebirds as well as passerines stop off at Cavell Lake, e.g. Northern Phalarope and

Savannah Sparrow (Taverner, 1918).

In summary then, the Cavell area has a bird fauna normal for the region, with no extraordinary features save the seasonally large numbers of Clark's Nutcrackers. A few birds, for example Harlequin Duck and Olive-sided Flycatcher, may once have been more abundant, or at least present in the area, though not so today probably due to the stress imposed on initially low population numbers by the influx of visitors. The Nutcracker's numbers have doubtless increased due to visitor attentions, and they may be depressing other bird populations.

FISH

Two of Jasper Park's 16 species of fish (Paetz & Nelson, 1970) occur at Amethyst Lake. They are the rainbow trout (Salmo gairdneri Richardson) and brook trout (Salvelinus fontinalis (Mitchill)), and were introduced there beginning in 1931 (table 5). I do not know if there are any fish at Cavell Lake, though I suspect not.

TABLE 5. NUMBERS OF FISH STOCKED AT AMETHYST LAKE.

YEAR	KIND OF FISH	NUMBER
1931	rainbow trout	46633
1933	"	83437
1934	"	95646
1961	"	7000
1961	brook trout	2000
1965	"	60000
1970	rainbow trout	225

INVERTEBRATES

According to W.G. Evans[1] (pers. comm.), the Cavell area holds great interest in terms of invertebrate animals. Faunistically, it is in many ways similar to other areas in Jasper Park. However, it is particularly rich in plant life, thus it is logical to assume that it is rich in animal life, since many of these are directly dependent on one or a small group of species of plants for food or shelter. Furthermore, it is the first area in the park where any amount of entomological work has been carried out. Sites such as this contribute substantially to our very limited

[1]Dept. of Entomology, U. of Alberta, Edmonton.

knowledge of the Rocky Mountain invertebrate fauna.

The 1964 field trip of the ecology/entomology course at the U. of Alberta was conducted in the vicinity of the highway to Mt. Edith Cavell (Evans & La Roi, 1964). A general survey of the insect and spider fauna was carried out, though the lateness of the season and short span of investigations placed obvious limitations on the study's exhaustiveness.

The most important insect groups found were flies and beetles. A number of the specimens of these and other insects appeared to be species new to science, and were consequently given to the appropriate experts. Most of the new descriptions are still forthcoming. Some of the insects belong to long-unrevised groups, making it difficult to say just how unique they and the fauna in general are.

The Cavell area has the distinction of being the type locality for some new species of insects that have been and will be described. The holotypes of two species of caddisflies, Limnephilus valhalla and Philocasca thor, are specimens that were collected at Cavell (Nimmo, 1971). For several other caddisflies, this area is one of a small handful of collection sites. Griffiths (1972a,b) has designated some specimens of a leaf-miner fly from Cavell as the paratypes of a new species, Phytomyza hypophylla. At Cavell he has also collected larvae and puparia of P. deirdreae, another new species. In the near future he will be describing and publishing further new species, based on the abundant material he has obtained in the alpine zone and forest-tundra meadows at Cavell (pers. comm.).

The Cavell area is rich in ground beetles (Carabidae), particularly in the riparian ecosystem with its 'mixed' habitats of gravel, shrubs, herbs

and water (H. Goulet, pers. comm.). Tonquin Valley has a remarkable variety of ground beetles. The cold/wet habitat diversification in particular is responsible for the insect diversity.

As in the Maligne area (Kuchar, 1972), at Cavell there are distinctive snow insects: Boreus californicus Packard (snow scorpionfly), Chionea alexandriana Garret (snow fly), Grylloblatta campodeiformis Walker, and the ubiquitous springtails. The abundance of Grylloblatta (Evans & La Roi, 1964), an unusual and otherwise rare snow insect, is not surprising, since its preferred and in fact critical habitat requirement of cold (near freezing) and humid microenvironments is admirably met in the area.

HUMAN ACTIVITY

INTRODUCTION

According to B. Reeves[1] (pers. comm.), the Cavell area is lacking any archaeological sites. But in terms of 'white man', it has been and remains one of the outstanding focal points of activity of the entire Jasper region. Drapell (1969) considers it one of the most popular tourist attractions in Jasper Park. As mentioned earlier, it is the fourth most visited place in the park, third in total and average man-hours of recreation, and second in length of stay of visitors (53 min.). It is also the chief departure point for trips to Tonquin Valley, which is seeing rapidly escalating use, particularly by backpackers (Yonge & Scotter, 1972).

According to a survey carried out in 1964 (Drapell, 1969), July and August of that year saw an average of 223 vehicles per day to Cavell. Allowing 3.5 persons per vehicle, this amounts to around 48,400 people. Including a further 10-15% by bus, that particular summer saw around 55,000 people at Cavell. Assuming visitor use to have doubled since then (by no means an immoderate estimate), it appears that well over 100,000 people now visit Mt. Edith Cavell annually. This is perhaps a tenth the total number recorded as entering the park.

Although overall Jasper Park is or at any rate contains large tracts of wilderness, the Cavell area cannot be viewed as wilderness. As they hike along a trail at Cavell or gaze at the mountain, visitors here might momentarily experience what a backpacker might call the wilderness feeling

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or experience, but this would probably not persist. One is usually within sight or hearing range of other people, and even in remoter parts of the forest or other out-of-the-way spots, one retains the knowledge of proximity of man's activity.

The area entails a readily accessible day use situation, hence recreationally a different proposition entirely from neighboring Tonquin Valley for example, which caters more to backpackers' rather than average tourists' needs. Whereas the backpackers' primary motives for a trip, to Tonquin Valley at any rate, are the viewing of wildlife and landscape, wilderness camping, and escaping civilization (Yonge & Scotter, 1972), most visitors to Cavell come to view Angel Glacier and Mount Edith Cavell, as well as, secondarily, to see some other of the spectacular geological features, wildlife, and plant life. Or, as Drapell (1969) puts it, 'The general activities provided for are enjoyment of scenic attractions, nature study, hiking and picnicking'.

The Cavell area is a favorite stop on ecology field trips from the U. of Alberta, for it represents an accessible (unless snowed in early), attractive series of higher-elevation vegetation and habitat types.

Winter at Cavell sees a small but constant degree of use by man. There are winter ski trips to Tonquin Valley, and winter climbs of Mount Edith Cavell. I do not know the actual numbers of people involved though suppose it is fairly low, in the dozens rather than the hundreds.

AESTHETICS

Adjectives such as 'spectacular' and 'breathtaking' would quite adequately complement the scenery of the Cavell area. Angel Glacier and towering Mount Edith Cavell are the two most obvious features, but aesthe-

tically there are a number of other prominent units:

1. Recent morainal deposits. The remarkable thing is not the mere presence of moraines, but their conspicuousness and freshness.
2. Series of lateral moraines.
3. Ice-cored moraine.
4. Periglacial features such as hummocks and solifluction terraces.
5. Cavell Lake, its alluvial fan, and its peculiar pea-green color.
6. Accessible alpine tundra.
7. Richly vegetated forest-tundra zone.
8. Forests and other ecosystems.
9. Numerous Clark's Nutcrackers and golden-mantled ground squirrels.

According to Yonge & Scotter (1972), the major aesthetic features of Tonquin Valley should be viewed as a collective unit, the whole being much greater than the separate sum of the parts. The whole might then be the 'wilderness experience' which backpackers seek. In the Cavell area on the other hand, one may profitably view the disparate elements of the landscape on their own, almost as objets d'art. Angel Glacier constitutes a great attraction in its own right. So too the height and size of Mount Edith Cavell ipse, or moraines ipse.

Actually, there might be a logical three-part sequence through which a normal visitor to Cavell could view the landscape:

i. All features in an aesthetically pleasing blur.

ii. Concentration on individual features.

iii. Mental integration of the features, on a natural-history

type of framework, i.e. tying together the individual features into their natural (historical) relationships. Thus: the glacier has eroded part of the mountain, resulting in a cirque basin, moraines, stream forming a delta (with wet meadows) at the small blocked lake; forest on long deglaciated terrain, etc. Dynamic considerations are implicit in such a scheme such as this.

The best overview of the Cavell area can probably be attained at about the end of the present trail in the forest-tundra zone. Here one can see the mountain, the glacier with its cirque, the valley and surrounding ranges; also mountain heathers and meadows rich in flowers, stringers of alpine, forest groves. There is no one exact spot that could be designated as the viewpoint par excellence, though some of the spots along the end of the trail come close toward one's realization of maximum possible diversity of landscape elements.

There are some natural as well as anthropogenic features that could be termed unaesthetic or at any rate undesirable. These include pollution in its broad sense, as well as weather and insect pests.

For most visitors, probably the single greatest detractor to enjoyment of their sojourn would be inclement weather. The unpredictable nature of the weather, the possibility of cold rain or snow practically any day, might deter potential hikers from travelling up to above timberline wherein they could maximize their enjoyment of the area. Regarding insect pests, I did not notice unduly large numbers of mosquitoes or black flies, though they could pose a secondary though not unanticipated problem.

The proximity of other people, or indeed crowding during peak use

periods, does not seem to be a real detractor from enjoyment of the visit, possibly because one is prepared to see other people here. Visitors to Cavell are not nearly as exacting in their demands for undisturbed, 'natural' landscape as are for example backpackers.

Littering might be the most serious overall pollution problem, but a good supply of waste receptacles and some signs might help. In the Cavell area at any rate, the problem is more one of aesthetics than of actual ecological impact (i.e. ecosystem disturbance). When she was a seasonal naturalist in the park, Hrapko (1969) had ample opportunity to observe this common phenomenon, and she commented that 'The worst offenders, however, are not the tourists but the local residents, including Park personnel. Although we preach to the visitors about litter at our evening programs and on our walks, the message does not reach Park people. A set of general information lectures, held jointly with other government services in the Park, might help to remedy this to some extent.'

FRAGILITY

In this report, fragility refers to the ease with which ecosystems or parts thereof can be altered, anthropogenically but unintentionally. For in-depth treatment of the concept and rating of fragility, refer to Kuchar (1972).

The major effect of park visitors on the ecosystem is a direct one namely trampling of vegetation. Different kinds of vegetation can withstand different degrees of trampling. A given intensity of trampling may only temporarily (for one season) change the appearance of one plant community, substantially alter the plant composition and cover of a second community,

and possibly initiate irreversible degradative changes in a third. Clearly, some sort of equal-basis rating is desirable for the range of vegetation types that occur at Cavell and other areas.

The fragility scale (table 6) brings together into a synthetic index (a 1-5 scale) the parameters or attributes of vegetation as it relates to 'tramplability'. The main parameters include degree of trampling per unit time, vulnerability of trampled surface to erosional processes, and recovery potential of the vegetation.

Three assumptions are implicit in the fragility scale:

i. Trampling is on an equal-rate basis between different plant communities.

ii. Trampling is 'moderate' in degree (very roughly quantified as a few people, wandering over a small area say 1 ha or 2½ acres, for perhaps an hour each day).

iii. No trampling immediately following spring snow-melt for any given ecosystem or community, nor for a small subsequent period (generally 1-2 weeks) during which the ground surface is water-saturated and soft and therefore most vulnerable.

Illustrative of the concepts of moderate and equal-rate trampling (the first two assumptions) are for example the studies of Willard & Marr (1970) in Colorado. They found that random strolling over natural alpine tundra by a few visitors caused little or no change, but heavy visitor use resulted in rapid deterioration. They concluded that trampling by fewer than five persons every few days over a period of many years would have no persistent effects, but that trampling by hundreds in one area could destroy a snowbed ecosystem in 1-3 weeks and a turf ecosystem in 8 weeks. In the fragility scale (table 6), I am assuming a trampling rate somewhere between these two extremes of use.

TABLE 6. FRAGILITY SCALE FOR PLANT COMMUNITIES AND ECOSYSTEMS.

RATING	POTENTIAL CHANGES IN VEGETATION/ECOSYSTEM	GENERAL ATTRIBUTES OF VEGETATION/ECOSYSTEM	EXAMPLES
1	Not forseeably changeable with visitor use.[1] Total plant cover = 100% of natural. Not erodable. No compaction of surface.	One or more of the following: a) very stable, durable, & trample-resistant plant cover. b) plants thriving through trampling. c) a very low natural plant cover, therefore chances very low that the extant vegetation will be walked upon. d) slope nil.	Some weedy ground.
2	Lightly changeable. Visitor use will cause moderate changes in the appearance (plant cover = 90% of natural). No permanent shift in ecosystem structure: arresting visitor use would result in a reversion to 100% of natural cover of the original vegetation. Erosion potential nil or extremely low (i.e. negligible). Very little or no surface compaction.	On level terrain or gentle slopes, (or exceptionally on steep but very stable slopes); on rock substrata or stable soil. Mesic or xeric habitat.	Dryas-lichen tundra; recent morainal deposits.
3	Moderately changeable. Visitor use will cause noticeable but not serious or irreversible changes in plant cover and structure (plant cover = 50-90% of natural). Erosion nil or mild, or not much greater than natural erosion. Some soil compaction possible.	On level terrain or stable slopes. Mesic or xeric habitat (exceptionally, dampish habitat). Usually a well-developed sod structure.	Spruce-fir forest; mountain heathers.

TABLE 6. (continued)

RATING	POTENTIAL CHANGES IN VEGETATION/ECOSYSTEM	GENERAL ATTRIBUTES OF VEGETATION/ECOSYSTEM	EXAMPLES
4	Rather fragile. Visitor use will rather easily disturb the normal plant patterns, and either shift them permanently or else not permit re-establishment of vegetation for a long time. Plant cover will probably become very low relative to natural condition. Erosion may be a problem, but usually not a permanent one.	Usually on steep slopes that are damp most of season, &/or large percentage of silt present. Or on level areas, but vegetation easily crushed.	Damp meadows on steeper slopes.
5	Extremely fragile. Visitor use, even in moderate amounts, will destroy the plant patterns irreversibly (in our time anyway), and either a different vegetation will eventually arise (a seral stage, often of weedy-type colonizers), or no vegetation at all due to active erosion or chemical/nutritional problems for plants trying to establish there. Erosion serious or snowballing: artificial measures might be necessary to arrest erosion.	On steep, usually water-saturated or damp slopes; vegetation very easily dislodged. Or vegetation very easily crushed and destroyed.	At some seepage areas.

[1]A saturation point can be reached in any vegetation or ecosystem, beyond which changes will become manifested. That is, extremely heavy visitor use will drastically affect all ecosystems. The use of the fragility scale involves the assumption that visitor use is moderate, not extremely heavy (handfuls rather than hundreds of people).

TABLE 7. FRAGILITY RATING OF VEGETATION IN THE MT. EDITH CAVELL AREA.

ECOSYSTEM	PLANT COMMUNITY	FRAGILITY RATING[a]	TRAIL DURABILITY
LACUSTRINE	plankton	-	-
	shoreline	3-4	4?
RIPARIAN	stream beds, springs	1-4	4
MEADOW	alluvial-fan willow scrub	2	3
	alluvial-fan sedge-willow	3-4	3-5
	alluvial gravel & sand flats	2	4-5
	Scirpus cespitosus	3	3-4
	low-herb meadows	3	3
	lush, tall-herb meadows	4[b]	3(-4)
	Carex nigricans	2-3	2(-3)
MOUNTAIN HEATHER	*Cassiope tetragona* - *Dryas*	2	1-2
	Cassiope mertensiana - *Phyllodoce* spp.	2-3	2
	Luetkea pectinata	2-4	2-3
ALPINE TUNDRA	*Dryas* - *Salix arctica*	3	2?
	Dryas - lichen	2	1
BOULDER RUBBLE	morainal	1-2	1
	colluvial	4	2?
	xeric (site 1 on map)	1	1
AVALANCHE SLOPE	alpine fir - dwarf birch	3?	3?
SPRUCE-FIR FOREST	on west-facing slopes	3	2[c]
	on mesic colluvium	3	3
	on xeric colluvium	1-2	1-2
	on xeric alluvium	1-2	1

[a] Note that no #5 ratings (extremely fragile) are given. But locally, particularly at seepage sites, disturbance could bring about irreversible changes.

[b] Possibly an excessively high rating. Although the vegetation is easily trampled and crushed, the thick turf and moss cover generally impede further deterioration.

[c] Assuming that damp spots are strictly avoided.

Re. assumption iii, there is as great a range in fragility within most of the ecosystems as between them, if we include spatial and temporal considerations. Soil moisture plays an exceedingly important role, and as a rule, the greater the soil moisture the greater the fragility. The fragility of a given community can be much higher at the start of the season than toward the end. Also, some spots (depressions, hollows) will be more fragile than the community in general.

Slopes are naturally more fragile than level areas due to the greater likelihood of erosion. It follows then, that wet soils on steep slopes are one of the most fragile situations possible. This is unfortunately a rather common situation in the Cavell area.

In the field I rated each stand of vegetation on the fragility scale. Table 7 presents fragility ratings for all major plant communities in the Cavell area. For some vegetation types the scale might have value merely as a theoretical concept. For example, most of the spruce-fir forest has a value of 3. But how many people would actually move through on an equal-use basis? They would in actual fact tend to follow game trails, or with continued use form their own trails, rather than bushwhack randomly. Hence a rating also of trail durability (the durability, to a moderate amount of pedestrian traffic, of an unimproved trail).

It should be noted that fragility ratings imply shifts from what occurs normally, rather than deterioration from stasis. A good example here is the gravel and sand flats up from Cavell Lake. The fragility rating is 2, presupposing a rather low degree of impact to moderate trampling. This would seem odd in view of the damp and truly easily alterable nature of the habitat. However, natural forces of erosion and deposition are rapidly altering the

habitat, therefore it would be difficult to justify a rating of 3 or 4.

Although fragility ratings have predictive value, there are some hidden pitfalls. For example, Carex nigricans meadow has a trail durability rating of 2(-3), which indicates that a trail would stand up quite well here. But what it does not say is that the season is so short in this type of meadow (i.e. snow-free only $1\frac{1}{2}$-2 months) that it would simply not be practical to put a trail through.

As I have indicated in the section on animals, there does not seem to be any real danger to the present populations. Any major changes are past, and it would take drastically increased visitor use to cause any appreciable dents in present animal life. The possibility of serious but hidden changes should not be overlooked however: birds and mammals would not be affected much, but invertebrate populations, about which we presently know very little here or elsewhere, might suffer unnoticed but tremendous changes through destruction or modification of habitat.

Though I have no real proof, it appears that the golden-mantled ground squirrels and Clark's Nutcrackers entail unnaturally augmented populations; and furthermore, that curtailing the practice of giving handouts could precipitate population crashes. Hrapko (1969) had some interesting comments regarding the feeding of these animals: 'The selling by area operators of nuts for feeding to ground squirrels is a rather contentious point... My personal feeling is that people will feed the animals anyway, and the nuts, provided they are unsalted, are mich better for the squirrels than are salted peanuts, chocolate, bits of sandwiches, etc., they would otherwise be fed. During the last two summers when I was able

to observe them frequently, the ground squirrels appeared to be in good condition and there were young ones in the spring. There was no direct evidence of adverse effect, other than the teaching of the animals to look for food at the end of a hand rather than out in the field. I therefore see no reason for trying to stop the shops from advertising "squirrel nuts". Perhaps the shops could be provided with a note to include in their advertising the reason why only unsalted nuts should be fed to animals, and to birds as well.'

The small amount of winter activity by man would imply impact limited to whatever mammals he might encounter, caribou in particular, though I am not sure that any large mammals reside in the Cavell area in winter.

DEVELOPMENTS AND IMPACT

The present situation at Cavell is this:

- a paved highway from the main valley to the edge of the fresh moraines at Cavell
- tea house (chalet)
- memorial cairn
- parking area between tea house and cairn
- toilets east of parking area
- trails: a 2/3 km (almost ½ mile) asphalt trail to lower viewpoint; and a 1½ km (1 mile) trail to just above timberline
- picnic area
- two corrals, at north end of Cavell Lake
- Canadian Youth Hostel

According to the provisional master plan for Jasper Park, the following developments are slated for the Cavell area:

- basic reconstruction of highway
- on-site exhibits, displays and signs
- manned information kiosk

Further developments and recommendations are entailed in the report of Drapell (1969):

- increased parking facilities
- new chalet
- trail by Cavell Lake
- day shelter at upper end of hiking trail
- trail markers

clean-up or relocation of picnic site

The main developments shall be treated in turn.

1. Basic reconstruction of the highway leading to Cavell is proposed in the provisional master plan of Jasper Park. Drapell (1969) does not feel this is necessary or indeed desirable. She considers the drive to Cavell as part of the whole experience (the feeling of gaining altitude, of driving on a mountain road, into a less accessible secluded area). She says that 'in the final analysis the visitor would be deprived of an experience - the experience of reaching an off-the-beaten-track area high in the mountains.'

There are serious ecological implications to a major road reconstruction. The west-facing forested slopes which the road traverses, particularly those in the north-west section of the area, hold a great deal of water. Sites of groundwater discharge are common in this section, and give rise to the most fragile sort of terrain (Root & Knapik, 1972). Further cutbanks would create serious erosional problems. It is virtually impossible to stabilize such banks due to their continual subjection to groundwater discharge.

Drapell does suggest minor improvements including some road widening, alignment adjustment, improvement of the viewpoints, regrading of steep cutbanks and planting with grasses, native shrubs, trees and ground cover. It

is doubtful if there are any sorts of plants that could stabilize some of the worse cutbanks.

2. The present tea house (chalet) and its location do not present any especial problems of ecological impact. Drapell suggests the erection of a new chalet, based on the premise that a better view from the chalet is important. First of all, it is the purpose of the asphalt trail rather than the chalet to accommodate people interested in the view. A chalet located to give an excellent view would not necessarily discourage walking, but would certainly not encourage it either. The new location would be farther up the moraine, and in principle not a good move. The substrate is certainly stable enough, but this remarkable, fresh depositional feature of glaciation should be preserved rather than gradually encroached upon.

The new chalet (probably = the manned information kiosk of the provisional master plan) would entail the following:

- restaurant
- souvenir shop
- restrooms
- historical interpretation
- natural history interpretation
- guide to trails and areas of interest in the form of a large topographic map
- education of the public toward better behavior in the mountains (e.g. fragility, personal safety, pollution)

There is no real reason to discourage any one of these facets of the new chalet/interpretive centre. One possible problem is the restrooms. If these imply the use of flush toilets, this would mean a much greater volume of waste than there presently is. Two main questions are implicit. First, what would the source of water be? (If either of the two major streams is channeled into reservoirs, this would probably change the ecosystem balance

downstream particularly in the wet meadows on the alluvial fan.) Second, what is the waste disposal method? There is probably not enough room anywhere for a sewage lagoon, and the disposal of the liquid fraction directly onto any area had better not be considered at all. Habeck (1972), scrutinizing an intensive-use, high-altitude area in the Rockies in Montana, discusses some of the problems involved with large quantities of raw sewage.

3(a). The present location of the Tonquin Valley parking lot, on the enlarged shoulders of the highway, is dangerous to traffic (Drapell, 1969; Klettl, 1970). According to Klettl, 'It could be relocated very easily between the road and the private corral where there is a flat area large enough to accommodate the parking from the Tonquin Valley horse and foot traffic.' He adds: 'I do not agree...that the Tonquin Valley traffic should start from the Cavell teahouse area, because this would add another $1\frac{1}{2}$ miles to the trip. Climbers after a long 15 hour day traversing Edith Cavell would not appreciate an extension of their day by a mile and a half, as the majority of the climbers return via the West Ridge and the Tonquin trail.'

3(b). At least as far back as 1966 the parking lot (south & east of the tea house) has been filled to capacity at peak use hours (Drapell, 1969). Drapell considered the maximum accommodable number of cars to be 59, and at the maximum use period (1200-1600 hrs) an average of 22 cars in the lot. These figures seem too low according to Klettl (1970). He has counted as many as 97 cars in the parking lot. During the busiest days there would be an average of 87 cars in the lot, as well as 109 cars in the picnic area and 80-140 parked along the highway.

Figures as high as these might raise doubts in one's mind as to the

effectiveness or lasting value of additional parking lots such as Drapell has proposed. These sites would include some of the gravelly, thinly vegetated alluvium just downstream from the terminus of the recent moraines (i.e. more or less the present picnic site), as well as some thin forest just down from the tea house. The ecological impact would certainly not be serious. At maximum development the two new lots could accommodate 200 cars. In terms of peak use, this figure was evidently being exceeded as much as five years ago.

Even more parking facilities than this would clearly be needed. But now we run into the problem of what could be termed the very restricted mobility of planners at Cavell. There just don't seem to be any further suitable sites. The west-facing slopes are steep and in areas waterlogged (though not nearly so bad here as toward the north end of the area); the east side consists of cliffs and very steep colluvium; the lake and damp alluvial fan are not utilizable; the fresh moraine is a distinct possibility from an engineering standpoint but there are aesthetic and scientific (geological) objections; some of the forest between Cavell Lake and the fresh moraines could be removed, but this seems an unduly drastic measure.

A viable alternative mentioned by Drapell is to ban private traffic and use some other means of transportation such as buses. This would allow large numbers of people to visit the Cavell area yet would circumvent the problem of traffic jams and continued gradual expansion of parking facilities.

Another possibility would be to limit the volume of private traffic to a predetermined total car capacity (to equal the Cavell lot capacity). This could be on a first-come, first-served basis, monitored from the foot of the Cavell highway. A parking lot could be constructed here (in lodgepole

pine forest, the most widespread ecosystem in the park), with buses transporting the overflow. This system would encourage earlier visits to Cavell, and would therefore ease the problem of early afternoon peaks. It might also teach some visitors that morning is a better time for observation than mid-afternoon when animals are least active.

Some visitors and others might consider the above system an arbitrary and capricious whim of administration. But this sort of managerial measure is quite in line with the growing need for restrictions on the ever-expanding use of certain recreational areas. The carrying capacity of any area has definite limits in terms both of ecology and aesthetics. If this system were used, a posted or otherwise available explanation would definitely be in order. Better yet, even the activity centre could be relocated to the foot of the highway. Visitors could stop by here and get an inkling of what to expect and what to look for at Cavell; and, at Cavell itself, the virtual absence of any developments might enhance a wilderness feeling ('wilderness experience').

It seems strange, in the final analysis, that the construction of further parking facilities in the Cavell area should be condoned. It simply sets back the date of ultimate confrontation with the fact that there is no more room for parking lots, and that alternatives must be sought. Why should these alternatives not be sought already?

4(a). Drapell (1969) recommends a trail around Cavell Lake, but as I see it there are three drawbacks:

i. The trail would not traverse a particularly large variety of ecosystems or vegetation types, and the views are not much compared to those from the existing upper trail.

ii. The shoreline habitat is a rare interface situation. The area involved is very small

area involved is very small and for this very reason worth preserving. It is a rather fragile area and would not take heavy use, particularly if one followed the recommendation of staying as close as possible to the lake edge.

iii. There is a small albeit real danger from rock slides off the west shoulder of Mt. Sorrow (cf. Klettl, 1970).

4(b). There is only one main trail in the Cavell area. It has two parts, a lower asphalt section along fresh lateral moraines, and an upper gravel section to the forest-tundra zone.

According to a 1964 survey (Drapell, 1969), 36,000 of the 48,000 July and August visitors used the lower viewpoint trail: on an average day, 580 used the trail. It is indeed fortunate that most visitor activity is funnelled onto an extremely durable trail, which in turn traverses an extremely durable ecosystem namely morainal boulder rubble.

Only a small percentage (no figures available) of visitors utilize the upper trail. However, even these relatively small numbers have a relatively serious impact. The problem is not with the trail itself, which is well-constructed though it could use slight upgrading. Rather, it is that of the trail's simply ending just above timberline. Hikers normally do not turn back at this point but continue on, and this has resulted in some fanning out and the beginnings of degradation of vegetation. Locally, where people sit down to rest or eat lunch (in mountain heather tundra), trampling is fairly severe, such that many of the plants have been abraded off, though not so severe that mineral soil has been extensively exposed. On the dryas ridges trampling has not shown up yet due to lower plant cover and the pebbly, drier surface. However, one has as much to fear from heavy trampling here and on higher in alpine tundra, for this sort of vegetation is very slow to

recover. Growth increments are small, and the combination of needle-ice action and wind could prevent re-establishment of the original plant cover. Also, the soil at these high altitudes has a weak or non-existent structure and tends to break down easily (Root & Knapik, 1972). A well-developed turf is important in controlling soil erosion, but in the Cavell area most of the alpine and much of the forest-tundra vegetation (the mountain heathers) is not the turf type.

Discussing this very trail in their Canadian Rockies trail guide, Patton & Robinson (1971) state: 'From the initial viewpoint, the hiker can wander through verdant alpine meadows...' And, later: 'Though the trail ends at the two mile mark, the hiker is free to wander upward through the extensive alplands above.' This is precisely what must be prevented. Visitor activity must be channelled onto terrain able to stand the impact of trampling, viz. a durable trail.

The original trail plans would have solved this problem. They called for a loop, but according to Webster (1968) a suitable route was still being sought two years after construction of the forest segment. He concisely summarized the trail situation as follows: 'To reduce this random travel and attendant wear and deterioration of the fragile Alpine cover, there is an urgent need to mark out, if not construct a trail, across these meadows. In time it will probably be found necessary to build spur trails to higher points and other viewpoints to accommodate the increasing number of hikers.'

In the map of the Cavell area, I have delineated a trail segment that would connect with the existing segment, creating a loop trail. If one correlates the map with the aerial photograph stereo pair which displays the 'lie of the land', he can see that this trail would entail a gentle grade,

down a series of slight gullies or depressions. The very bottoms of these should be avoided, as they tend to collect water. The whole trail could be constructed on a very reasonable constant grade, and I would suggest that trail users travel up this segment, then down the steeper and faster existing forest segment.

Webster proposed a trail segment that would have extended farther north through the forest, past the large gully; but this does not seem necessary, and would require an undue amount of switchbacking. He noted that it would be ill-advisable to locate it parallel to the creek with its steep grades and excessive erosion (cf. table 7).

The exact location would have to be determined in the field, by someone experienced at trail construction. and with proper trail-building procedures in mind (cf. Root & Knapik, 1972). The round trip would be around 3.5 miles, certainly not unreasonable and well worth it for the overall perspective.

Drapell recommends use of color-coded trail markers. This might be useful in an area with a trail complex (possibly Tonquin Valley), but in the Cavell area it would suffice to have a sign at the foot of the trail giving the distance (or distances to diffferent points on the trail) and possibly altitude.

5. A day shelter is envisaged for the upper end of the trail (Drapell, 1969), to provide shelter and a place to eat lunch in case of sudden precipitation. There are pros and cons for such a shelter.

True, weather at Cavell is probably somewhat worse than in most other areas in the park, and hikers might welcome such a shelter. But it could ultimately prove impractical. If it is raining or snowing, it will be about as cold inside the shelter as out - presumably

as cold inside the shelter as out - presumably no fires would be permitted. Most enterprising hikers know how to escape at least the full brunt of foul weather, by standing under trees or hiding in krummholz higher up. Thus they might not wish to go to the shelter. If it is cold in the shelter, it would not be a particularly good place to remain in, relatively inactive, for a longer period of time. It might be advisable simply to head back. Klettl (1970) feels that the short distance back negates the value of the shelter. He also mentions a very important point, namely fragility of the high-elevation vegetation.

The vegetation in the immediate vicinity of the shelter would suffer at least some degradation, though proper planning of the precise location and access could minimize damage. Setting the shelter at the edge of a krummholz thicket would discourage people from going behind it. Located right by the trail, it would preclude the necessity of a spur trail and possibly extra trails angling over to it.

If a shelter is not built, some sort of viewpoint spot should still be structured, at least a sign or plaque with the altitude; and possibly a simple map indicating the highlights of the Cavell area.

6. The present picnic site is a logical one from the standpoint of fragility, but not aesthetically. The coarse, thinly vegetated colluvium withstands visitor use very well, but is not pleasant to walk on compared to for example a slightly spongy forest floor; and there is a relatively poor view. According to Drapell this site is little used; it actually appears to be used more for parking rather than picnicking.

I do not see any definite solution here. Moving onto the forested

slope, one would have much pleasanter but at the same time much more fragile surroundings. If use were low, then relocation onto the forested slope could be recommended. But I suspect that there is a relationship between type of surroundings and degree of use of picnic grounds.

7. There are two horse corrals at the start of the Tonquin Valley trail at the north end of Cavell Lake. Unsightliness of the premises is the problem here according to Drapell (1969). She feels that these corrals could be done away with if the Astoria-Portal trails were separated in terms of backpacker and horse traffic. Otherwise, 'some kind of planting screen should be placed between the corral and the trail'.

I have no comment to make on this particular section of the area.

8. The Canadian Youth Hostel is located in the forest edge by the highway, opposite the north end of Cavell Lake. Drapell believes that it should stay there, and perhaps even expand accommodation if necessary. 'The location at the beginning of the Tonquin Valley Trail is very convenient for hikers and climbers alike.'

There does not seem to be serious environmental impact here. The patch of weeds just north of the hostel is probably not spreading.

RECOMMENDATIONS

1. If further developments are planned, a survey is needed to determine why people come to Cavell, and what they would like or not like to see in the way of developments.

2. Further studies particularly those with a natural-sciences slant should be encouraged in one way or another. Much can yet be learned, ecologically and biologically, in the Cavell area. The advantages of choosing this area are obvious: accessibility, past history of investigations, wide range of habitats.

Possibly the greatest information can be gained in invertebrate surveys and detailed life-history studies; as well as in more detailed studies of the rich non-vascular vegetation.

Studies of Clark's Nutcrackers and golden-mantled ground squirrels could demonstrate and document the interaction of visitors and these animal populations.

3. Major highway reconstruction is not really warranted, and is ecologically unsound. There is no objection to minor improvements where necessary.

4. There are no serious objections to construction of a new chalet/interpretive centre. But there should be a reassessment of plans to relocate the chalet farther up on fresh moraine: best possible view is a poor criterion of location. Especial consideration should be given to possible problems of sewage pollution.

5. No further parking lots should be planned. This is not so much from concern for any real fragility or impact, but in principle: what would occur when capacity use is reached? Alternatives, such as restricted access to

Cavell, should be seriously considered, and implemented at least on a trial basis.

6. If present no-restrictions policy on private traffic continues, then the Tonquin Valley parking area should be relocated as suggested by Klettl.

7. A trail around Cavell Lake would not ultimately be an asset to the area.

8. The main trail should be completed without delay, so that degradation of tundra ceases. The addition of a new forest segment as described would complete the whole trail as a loop.

The trail should be gravelled: an unimproved trail could not handle the load of pedestrian traffic. Some thought might be given to paving (cold-asphalt) of the entire loop; but the cost might be prohibitive, and I am not sure how the forest-tundra environment, frost action in particular, might affect it.

9. Some signs are necessary: one at the foot of the trail, and the occasional 'STAY ON TRAIL'. Also, a site at the head of the trail should be designated as the upper viewpoint, with at least a sign giving altitude.

10. There are pros and cons for a day shelter in the forest-tundra zone, and I am not sure which carry more weight. A survey could be conducted of those hikers who reach the end of the present trail, for their opinion on a day shelter.

11. There are pros and cons for keeping or relocating the picnic site, and again, there does not appear to be any clear-cut solution.

12. The Canadian Youth Hostel is conveniently located and the impact on the environment is small. The nearby weed patch is probably not spreading.

EVALUATION AND SUMMARY

In Jasper Park, as in other wilderness type areas set aside by the Canadian government. our dual aim is to preserve and interpret - in other words, to prevent anthropogenic change or maintain it at the lowest possible level. It is not a matter of permitting some gradual continual changes (aside from strictly circumscribed intense-use zones) to accommodate supposed shifts in visitor use and recreation. Thus, in the Cavell area, the aim is to allow and indeed encourage visitors to come see the marvellous natural history of the area and enjoy a high-mountain experience, yet at the same time prevent these same visitors from substantively altering any preexisting facet of the area.

As it so happens, such a course is not at all difficult to implement in the Cavell area. Visitors will generally not venture into the forests which cover a large percentage of the area, and they will not markedly alter the (ecology of the) moraines and bare talus slopes. In the places where visitors will tend to concentrate, their activity can be channelled. Included here are the east and north-east side of the fresh moraines, the upper gravelly part of the alluvial fan (the lower portion is wet and will be avoided), Cavell Lake (a view from the bridge at its north end will suffice for most people), and the forest-tundra and alpine zone in the east part of the area.

In order that minimum (negligible) impact is maintained, designated routes should be used at all times. The importance of staying on trails cannot be overemphasized. Signs, brochures and other means should be used to explain why it is so important to remain on the trail.

Overcrowding by cars at Cavell is an intolerable situation. An expansion of present parking facilities is merely a stop-gap measure (and, based on the present plans, would be filled to overcrowding anyway at peak use hours). Barring all traffic seems an extreme solution, but possibly the only ultimately viable one.

Ecologically Cavell is a prime area. The richly diverse west-facing slope complex is especially to be noted. What the area lacks in dry-slope communities such as occur at lower elevations, it more than makes up for in its moisture-loving biota.

The area is exceptional botanically and scientifically valuable. It contains a rich flora of bryophytes and vascular plants. Species have been found here that are unknown elsewhere in the Rocky Mountains, or which are uncommon at these latitudes. The lichens of the area are incompletely known, and further work may bring to light interesting species both of epiphytic and terrestrial/saxicolous forms.

The area is unremarkable in its vertebrate fauna, aside from the large numbers of golden-mantled ground squirrels and Clark's Nutcrackers. It does have exceptional promise in terms of invertebrates however. Already, some new species of insects have been found here. It is at any rate one of the pitifully few collecting localities in the Rocky Mountains.

In terms of geology, particularly glaciation, the Cavell area is probably equal to any area in North America. The record of glaciation is remarkably clear and complete.

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APPENDIX 1. LICHENS OF THE MT. EDITH CAVELL AREA.

ORDER LECANORALES

PLACYNTHIACEAE

Psoroma hypnorum (Vahl) S. Gray 2,4,7

PANNARIACEAE

Pannaria pezizoides (G. Web.) Trev. 2

PELTIGERACEAE

Peltigera aphthosa (L.) Willd. 1,2,6
P. canina (L.) Willd. 2,6
P. horizontalis (Huds.) Baumg. 2
P. leucophlebia (Nyl.) Gyeln. 1,2
P. malacea (Ach.) Funck 3
P. rufescens (Weis.) Humb. 2
P. venosa (L.) Baumg. 2,3

Solorina crocea (L.) Ach. 2,7

NEPHROMATACEAE

Nephroma arcticum (L.) Torss. 1,2,4,6
N. expallidum (Nyl.) Nyl. 2

STICTACEAE

Lobaria linita (Ach.) Rabenh. 2,4

LECIDEACEAE

Lecidea assimilata Nyl. 7
L. auriculata Th. Fr. 7
L. dicksonii (Gmel.) Ach. 2
L. granulosa (Ehrh.) Ach. 2

Rhizocarpon geographicum (L.) DC. 2
R. grande (Flörke ex Flot.) Arn. 2

STEREOCAULACEAE

Stereocaulon alpinum Laur. 1,2,7
S. subalbicans Lamb 7
S. tomentosum Fr. 2,6

CLADONIACEAE

Cladina arbuscula (Wallr.) Hale & W. Culb. 1,2,3
C. mitis (Sandst.) Hale & W. Culb. 1,2,6
C. rangiferina (L.) Harm. 1,2

Cladonia amaurocraea (Flörke) Schaer. 1
C. cariosa (Ach.) Spreng. 2
C. cenotea (Ach.) Schaer. 1,2,7
C. chlorophaea (Flörke ex Somm.) Spreng. 1,2,4
C. coccifera (L.) Willd. 1,2
C. coniocraea (Flörke) Spreng. 2
C. cornuta (L.) Hoffm. 6
C. deformis (L.) Hoffm. 2,6,7
C. ecmocyna (Ach.) Nyl. 1,2,7
C. fimbriata (L.) Fr. 2
C. gonecha (Ach.) Asah. 1,2
C. gracilis var. dilatata (Hoffm.) Schaer. 1,2
C. macrophyllodes Nyl. 2
C. phyllophora Hoffm. 2
C. pleurota (Flörke) Schaer. 1,2
C. pyxidata (L.) Hoffm. 1,2
C. uncialis (L.) Wigg. 1,2

UMBILICARIACEAE

Omphalodiscus virginis (Schaer.) Schol. 7

Umbilicaria cylindrica (L.) Del. 2
U. hyperborea (Ach.) Ach. 1,2,7
U. polyphylla (L.) Baumg. 1
U. proboscidea (L.) Schrad. 1,5
U. torrefacta (Lightf.) Schrad. 1

PERTUSARIACEAE

Varicellaria kemensis Räs. 3

LECANORACEAE

?Haematomma lapponicum Räs. 4

Icmadophila ericetorum (L.) Zahlbr. 2,3,4,6

Lecanora cadubriae (Mass.) Hedl. 2
L. coilocarpa (Ach.) Nyl. 2

PARMELIACEAE

Cetraria commixta (Nyl.) Th. Fr. 1,7
C. cucullata (Bell.) Ach. 1,5
C. ericetorum Opiz 1
C. halei W. Culb. & C. Culb. 2
C. hepatizon (Ach.) Vain. 2
C. islandica (L.) Ach. 4
C. merrillii Du Rietz 2
C. nivalis (L.) Ach. 1
C. pinastri (Scop.) S. Gray 1,2,3
C. platyphylla Tuck. 2
C. tilesii Ach. 1,4

Hypogymnia austerodes (Nyl.) Räs. 2
H. enteromorpha (Ach.) Nyl. 2,3,6
H. intestiniformis (Vill.) Räs. 1
H. physodes (L.) W. Wats. 6,7
H. vittata (Ach.) Gas. 7

Parmelia sulcata Tayl. 6

Parmeliopsis ambigua (Wulf.) Nyl. 2,7
P. hyperopta (Ach.) Arn. 2,3

USNEACEAE

Alectoria chalybeiformis (L.) S. Gray 2
A. fremontii Tuck. 2
A. glabra Mot. 1,2,7
A. miniscula Nyl. 2
A. ochroleuca (Hoffm.) Mass. 1
A. pubescens (L.) R.H. Howe 1,2,7
A. sarmentosa (Ach.) Ach. 2

Cornicularia aculeata (Schreb.) Ach. 1

Dactylina arctica PD+ (Hook.) Nyl. 1
D. ramulosa (Hook.) Tuck. 1

Letharia columbiana (Nutt.) Thoms. 2
L. vulpina (L.) Hue 2,4,7

Thamnolia subuliformis (Ehrh.) W. Culb. 1

Usnea cavernosa Tuck. 5

BUELLIACEAE

Buellia triphragmoides Anzi 2

Rinodina mniaraea (Ach.) Körb. 2

PHYSCIACEAE

?Physconia muscigena (Ach.) Poelt 1

TELOSCHISTACEAE

Fulgensia bracteata (Hoffm.) Räs. 4

Xanthoria elegans (Link.) Th. Fr. 5

ORDER OSTROPALES

GRAPHIDACEAE

Xylographa abietina (Pers.) Zahlbr. 2

ORDER SPHAERIALES

VERRUCARIACEAE

Dermatocarpon hepaticum (Ach.) Th. Fr. 4

ORDER CALICIALES

CALICIACEAE

Calicium pusillum Flörke 2

ORDER MYRANGIALES

ARTHONIACEAE

Micarea melaena (Nyl.) Hedl. 2

FUNGI IMPERFECTI

Lepraria neglecta (Nyl.) Lett. 2

1 P. Kuchar
2 Bird & Vitt 1972
3 M. Ostafichuk, U of A herbarium
4 P. Seymour, U of A herbarium
5 A.W.L. Stewart, U of A herbarium
6 Matthews, unpubl. data
7 Scotter 1968

Taxonomy follows Hale & Culberson (1970).

APPENDIX 2a. HEPATICS OF THE MT. EDITH CAVELL AREA.

PTILIDIACEAE

Anthelia juratzkana (Limpr.) Trevis. 1,5
Pleuroclada albescens (Hook.) Spruce 1
Ptilidium sp. 6
Blepharostoma trichophyllum (L.) Dumort. 1,5,6

CEPHALOZIACEAE

Cephalozia bicuspidata (L.) Dumort. 1
C. lammersiana (Hüb.) Spruce 1
C. pleniceps (Aust.) Lindb. 1,5
Cladopodiella fluitans (Nees) Joerg. 5

HARPANTHACEAE

Harpanthus flotowianus Nees 1

JUNGERMANNIACEAE

Lophozia alpestris (Schleich.) Evans 1
L. gillmanii (Aust.) Schust. 1
L. incisa (Schrad.) Dumort. 1
L. longidens (Lindb.) Macoun 5
L. longiflora (Nees) Schiffn. 1
L. porphyroleuca (Nees) Schiffn. 1
L. ventricosa (Dicks.) Dumort. 1
Leiocolea heterocolpa (Thed.) Buch 1
Gymnocolea inflata (Huds.) Dumort. 1
Tritomaria quinquedentata (Huds.) Buch 1,5
Orthocaulis floerkei (Web. & Mohr) Buch 1,5
O. kunzeanus (Hüben.) Buch 1
*Temnoma (Chandonanthus) setiforme (Ehrh.) M.A. Howe 4,6
Saccobasis polita (Nees) Buch 5
Barbilophozia hatcheri (Evans) Loeske 1,5
B. lycopodioides (Wallr.) Loeske 5,6
Jamesoniella autumnalis (DC.) Steph. 1
Nardia geoscyphus (DeNot.) Lindb. 1,5
Solenostoma triste (Nees) K. Müll. 1

SCAPANIACEAE

Diplophyllum obtusifolium (Hook.) Dumort. 5
D. taxifolium (Wahlenb.) Dumort. 1
Scapania curta (Mart.) Dumort. 5
S. undulata (L.) Dumort. 1

PORELLACEAE

Porella cordaeana (Hüben.) Evans 1

RADULACEAE

Radula complanata (L.) Dumort. 1

PELLIACEAE

Pellia neesiana (Gottsche) Limpr. 1

PALLAVICINIACEAE

**Moerckia blyttii (Moerck) Brockm. 5

RICCARDIACEAE

Riccardia latifrons Lindb. 5
R. pinguis (L.) S.F. Gray 5

MARCHANTIACEAE

Marchantia polymorpha L. 5,6

Preissia quadrata (Scop.) Nees 1,5

Taxonomy follows Evans (1940).

APPENDIX 2b. MOSSES OF THE MT. EDITH CAVELL AREA.

SPHAGNOBRYA

SPHAGNACEAE

Sphagnum capillaceum var. tenellum (Schimp.) Andrews (MacFadden No 4134, Tonquin Valley)
*S. compactum Lam. et Cand. 2
S. fimbriatum Wils. in Hook. (MacFadden No 4141, Tonquin Valley)
*S. girgensohnii Russ. 2
*S. recurvum P. Beauv. 2
S. russowii Warnst. 2
*S. warnstorfii Russ. 2,5,6

ANDREAEOBRYA

ANDREAEACEAE

Andreaea obovata Thed. 1
*A. rupestris Hedw. 2

EUBRYA

FISSIDENTACEAE

Fissidens adianthoides Hedw. 6
*F. osmundioides Hedw. 2

DITRICHACEAE

Ceratodon purpureus (Hedw.) Brid. 1
Distichium capillaceum (Hedw.) Brid. 1

DICRANACEAE

*Aongstroemia longipes (Sommerf.) B.S.G. 2
Dicranella subulata (Hedw.) Schimp. 5
D. varia (Hedw.) Schimp. 1
*Paraleucobryum enerve (Thed. ex C.J. Hartm.) Loeske 2
*Cynodontium strumiferum (Hedw.) Lindb. 2
Dicranoweisia crispula (Hedw.) Lindb. ex Milde 1,5,6
Oncophorus virens (Hedw.) Brid. 1,2,5
Kiaeria blyttii (Schimp.) Broth. 1
K. starkei (Web. & Mohr) I. Hag. 1
Dicranum bonjeanii De Not. ex Lisa 1
D. elongatum Schleich ex Schwaegr. 1
D. fuscescens Turn. 1,5
D. undulatum Brid. 1

ENCALYPTACEAE

Encalypta rhaptocarpa Schwaegr. 1

POTTIACEAE

Tortella fragilis (Hook. ex Drumm.) Limpr. 5
T. tortuosa (Hedw.) Limpr. 5
*Bryoerythrophyllum recurvirostrum (Hedw.) Chen 2
*Barbula acuta (Brid.) Brid. 2
Desmatodon latifolius (Hedw.) Brid. 1
Tortula ruralis (Hedw.) Gaertn., Meyer & Scherb. 1,2,6

GRIMMIACEAE

Grimmia agassizii (Sull. & Lesq. ex Sull.) Jaeg. & Sauerb. 1
G. apocarpa Hedw. 1
G. atricha C. Müll. & Kindb. ex Mac. & Kindb. 1
G. calyptrata Hook. ex Drumm. 5
G. donniana Sm. ex Sm. & Sowerby 1
Rhacomitrium canescens (Hedw.) Brid. 1,6
R. canescens var. ericoides (Brid.) B.S.G. 5
R. fasciculare (Hedw.) Brid. 1
R. heterostichum (Hedw.) Brid. 1,5
R. heterostichum var. alopecurum (Schkuhr) Hüb. 1
R. heterostichum var. sudeticum (Funck) G. Jones 5
R. lanuginosum (Hedw.) Brid. 1
R. microcarpum (Hedw.) Brid. 1
R. patens (Hedw.) Hüb. 1

FUNARIACEAE

Funaria hygrometrica Hedw. 1

SPLACHNACEAE

Tayloria lingulata (Dicks.) Lindb. 5
T. serrata (Hedw.) B.S.G. 2
Tetraplodon mnioides (Hedw.) B.S.G. 1
Splachnum sphaericum Hedw. 1

TETRAPHIDACEAE

*Tetraphis pellucida Hedw. 2

BRYACEAE

Pohlia annotina (Hedw.) Lindb. 5
P. cruda (Hedw.) Lindb. 1,5
*P. nutans (Hedw.) Lindb. 1,2
Bryum argenteum Hedw. 5
*B. pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb. 2,6

MNIACEAE

Mnium andrewsianum Steere 5
M. pseudopunctatum Bruch & Schimp. 5
M. punctatum Hedw. 1

AULACOMNIACEAE

Aulacomnium palustre (Hedw.) Schwaegr. 1,5,6
*A. turgidum (Wahlenb.) Schwaegr. 2

MEESEACEAE

Paludella squarrosa (Hedw.) Brid. 1,5
Meesea uliginosa Hedw. 1,5

BARTRAMIACEAE

Plagiopus oederiana (Sw.) Limpr. 1
Bartramia ithyphylla Brid. 1,2
Conostomum tetragonum (Hedw.) Lindb. 5
Philonotis fontana (Hedw.) Brid. 1,5
P. fontana var. falcata Brid. 1

TIMMIACEAE

Timmia austriaca Hedw. 1

ORTHOTRICHACEAE

Orthotrichum laevigatum Zett. 1
*Ulota curvifolia (Wahlenb.) Brid. 3

FONTINALACEAE

Dichelyma falcatum (Hedw.) Myr. 1

CLIMACIACEAE

Climacium dendroides (Hedw.) Web. & Mohr. 1,5

HEDWIGIACEAE

Hedwigia ciliata (Hedw.) P. Beauv. 1

NECKERACEAE

Neckera menziesii Hook. ex Drumm. 1

LESKEACEAE

Lescuraea incurvata (Hedw.) Lawt. 1
L. radicosa var. denudata (Kindb. ex Mac. & Kindb.) Lawt. 1

AMBLYSTEGIACEAE

Cratoneuron commutatum var. falcatum (Brid.) Mönk. 6
*C. filicinum (Hedw.) Spruce 2

Campylium stellatum (Hedw.) C. Jens. 1,5,6

Leptodictyum riparium (Hedw.) Warnst. 1

Platydictya jungermannioides (Brid.) Crum 2

Drepanocladus exannulatus (B.S.G.) Warnst. 5
D. exannulatus var. alpinus (Grav.) Wijk & Marg. 1
D. fluitans (Hedw.) Warnst. 1
D. revolvens (Sw.) Warnst. 5,6
D. uncinatus (Hedw.) Warnst. 1,5,6
D. vernicosus (Lindb. ex C. Hartm.) Warnst. 1

Hygrohypnum dilatatum (Wils. ex Schimp.) Loeske 1
H. luridum (Hedw.) Jenn. 1
H. smithii (Sw. ex Lilj.) Broth. 1

Calliergon stramineum (Brid.) Kindb. 1
C. trifarium (Web. & Mohr) Kindb. 6

Scorpidium scorpioides (Hedw.) Limpr. 1

BRACHYTHECIACEAE

Tomenthypnum nitens (Hedw.) Loeske 1,5,6

Homalothecium pinnatifidum (Sull. & Lesq.) Lawt. 1

Brachythecium albicans (Hedw.) B.S.G. 1
B. plumosum (Hedw.) B.S.G. 1

Eurhynchium pulchellum (Hedw.) Jenn. 1

ENTODONTACEAE

Pterigynandrum filiforme Hedw. 1

Orthothecium chryseum (Schwaegr. ex Schultes) B.S.G. 5

Pleurozium schreberi (Brid.) Mitt. 1,5,6

HYPNACEAE

Hypnum callichroum Funck ex Brid. 1
H. revolutum (Mitt.) Lindb. 1

Ptilium crista-castrensis (Hedw.) De Not. 1,6

RHYTIDIACEAE

Rhytidium rugosum (Hedw.) Kindb. 1,5

Rhytidiadelphus loreus (Hedw.) Warnst. 1
*R. squarrosus (Hedw.) Warnst. 2
R. triquetrus (Hedw.) Warnst. 1

HYLOCOMIACEAE

**Hylocomium pyrenaicum (Spruce) Lindb. 5
H. splendens (Hedw.) B.S.G. 1,5,6

BUXBAUMIACEAE

Buxbaumia aphylla Hedw. 1

POLYTRICHACEAE

Atrichum undulatum (Hedw.) P. Beauv. 1

Oligotrichum aligerum Mitt. 1
**O. hercynicum (Hedw.) Lam. & DC. 5

Pogonatum alpinum (Hedw.) Röhl. 1
*P. capillare (Michx.) Brid. 2
P. urnigerum (Hedw.) P. Beauv. 5

Polytrichum commune Hedw. 1
P. juniperinum Hedw. 1
*P. norvegicum Hedw. 2
P. piliferum Hedw. 1,5

Polytrichadelphus lyallii Mitt. 6

1 MacFadden 1927 (includes Tonquin Valley).
2 Bird 1962
3 Bird 1968
4 Bird & Ogilvie 1964
5 Bird & Vitt 1972
6 P. Kuchar

Some names have been changed to agree with present-day nomenclature.

* First Alberta record when published.

** Recent (1971-2) first Alberta record.

Nomenclature for Sphagnum follows Van der Wijk et al (1967).

Rest of nomenclature, and taxonomy, follows Crum, Steere & Anderson (1965).

APPENDIX 3. VASCULAR PLANTS OF THE MT. EDITH CAVELL AREA.

LYCOPODIACEAE

Lycopodium alpinum L.	alpine club-moss
L. annotinum L.	stiff club-moss, groundpine
L. selago L.	fir club-moss

SELAGINELLACEAE

Selaginella selaginoides (L.) Link	spike-moss, little club-moss

EQUISETACEAE

Equisetum arvense L.	common horsetail, field horsetail
E. scirpoides Michx.	sedgelike horsetail
E. variegatum Schleich.	variegated horsetail

OPHIOGLOSSACEAE

Botrychium lunaria (L.) Swartz	moonwort

POLYPODIACEAE

Athyrium distentifolium Tausch ex Opiz (A. alpestre) 9	lady fern
Cryptogramma crispa (L.) R. Br. ex Hook. 9	rock brake, parsley fern
Cystopteris fragilis (L.) Bernh.	bladder fern, brittle fern
Dryopteris austriaca (Jacq.) Woynar ex Schinz & Thell.	shield fern
Polystichum lonchitis (L.) Roth. 7	northern holly fern
Woodsia glabella R. Br. 9	smooth woodsia

CUPRESSACEAE

Juniperus communis L.	ground juniper, common juniper

PINACEAE

Abies lasiocarpa (Hook.) Nutt.	alpine fir
Picea engelmannii Parry ex Engelm.	Engelmann spruce
P. mariana (Mill.) BSP 2	black spruce
Pinus albicaulis Engelm. 2	whitebark pine
P. contorta Dougl. ex Loud.	lodgepole pine

POTAMOGETONACEAE

Potamogeton ?pectinatus L.	pondweed

JUNCACEAE

Juncus balticus Willd.	wire rush
J. biglumis L. 8,9	rush
J. castaneus J.E.Smith	
J. drummondii E.Meyer	
J. mertensianus Bong.	
J. parryi Engelm.	
J. triglumis L. (J. albescens)	
Luzula arcuata (Wahlenb.) Wahlenb.	woodrush
L. parviflora (Ehrh.) Desv.	
L. spicata (L.) DC.	spike woodrush
L. wahlenbergii Rupr.	

CYPERACEAE

Carex albonigra Mack.	
C. aquatilis Wahlenb.	water sedge
C. atrata L.	black sedge
C. atrosquama Mack.	
C. bipartita All.	
C. bebbii Olney ex Fern.	
C. capillaris L.	
C. concinna R. Br. 9	
C. dioica L. (C. gynocrates)	
C. eurystachya F.J.Hermann (C. enanderi, C. eleusinoides ?)	
C. glacialis Mack.	
C. leptalea Wahlenb.	
C. limosa L.	mud sedge
C. microptera Mack.	smallwing sedge
C. nardina Fries	
C. nigricans C.A.Meyer	black alpine sedge
C. norvegica Retz. (C. media)	
C. pachystachya Cham. ex Steud.	chamisso sedge

C. paysonis Clokey (C. tolmiei)	
C. phaeocephala Piper	dunhead sedge
C. praticola Rydb.	
C. pyrenaica Wahlenb.	
C. rostrata Stokes ex With.	beaked sedge
C. rupestris All.	
C. saxatilis L. (C. physocarpa)	
C. scirpoidea Michx.	
C. spectabilis Dewey	
C. supina Wahlenb. 9	
C. vaginata Tausch	
Eriophorum polystachion L. (E. angustifolium)	cottongrass
E. scheuchzeri Hoppe	
Kobresia bellardii (All.) Degl.	
K. simpliciuscula (Wahlenb.) Mack.	
Scirpus cespitosus L.	

GRAMINEAE

Agropyron latiglume (Scribn. & Smith) Rydb.	
A. repens (L.) Beauv.	quack grass
A. trachycaulum (Link) Malte	slender wheatgrass
Agrostis alba L.	redtop
A. humilis Vasey 9	alpine bentgrass
A. idahoensis Nash 9	Idaho bentgrass
A. scabra Willd.	hairgrass, ticklegrass
A. variabilis Rydb.	
Bromus inermis Leys.	smooth brome, awnless brome
Calamagrostis canadensis (Michx.) Beauv. 9	bluejoint, marsh reedgrass
C. inexpansa Gray	northern reedgrass
C. neglecta (Ehrh.) Gaertn., Mey., & Scherb.	slimstem reedgrass
C. purpurascens R. Br.	purple reedgrass
Danthonia intermedia Vasey	timber oatgrass
Deschampsia atropurpurea (Wahlenb.) Scheele	mountain hairgrass
D. cespitosa (L.) Beauv.	tufted hairgrass
Elymus glaucus Buckl.	smooth wild rye, blue wild rye
E. innovatus Beal	hairy wild rye, fuzzyspike wild rye
Festuca ovina L. (incl. F. brachyphylla)	sheep fescue

Hierochloe alpina (Sw.) R. & S.		alpine sweetgrass
Phleum alpinum L.		mountain timothy
P. pratense L.		timothy
Poa alpina L.		alpine bluegrass
P. grayana Vasey	(P. arctica)	arctic bluegrass
P. leptocoma Trin.	9	bog bluegrass
P. pratensis L.		Kentucky bluegrass
P. rupicola Nash		timberline bluegrass
Trisetum spicatum (L.) Richter		spike trisetum

LILIACEAE

Tofieldia pusilla (Michx.) Pers.		false asphodel
Veratrum viride Ait.	(V. eschscholtzii)	false hellebore

ORCHIDACEAE

Goodyera repens (L.) R. Br.	6	rattlesnake plantain
Listera cordata (L.) R. Br.	1,6	heart-leaved twayblade

SALICACEAE

Salix arctica Pall.		arctic willow
S. barclayi Anderss.		
S. barrattiana Hook.		
S. commutata Bebb	9	
S. drummondiana Barratt		silver pussy-willow
S. farriae Ball		
S. glauca L.		grayleaf willow
S. nivalis Hook.		snow willow, low alpine willow
S. vestita Pursh		rock willow

BETULACEAE

Betula glandulosa Michx.		dwarf birch, bog birch
B. x arbuscula Dugle	(B. papyrifera x B. glandulosa) 8	(hybrid birch)

URTICACEAE

Urtica dioica L.	(U. gracilis)	nettle

POLYGONACEAE

Koenigia islandica L.	8,9	
Oxyria digyna (L.) Hill		mountain sorrel
Polygonum viviparum L.		alpine bistort
Rumex occidentalis Wats.		western dock
R. salicifolius Weinm.	(R. mexicanus)	willow dock, narrow-leaved dock

PORTULACACEAE

Claytonia lanceolata Pursh	western spring beauty

CARYOPHYLLACEAE

Arenaria obtusiloba (Rydb.) Fern.		alpine sandwort
A. rossii R. Br.		
Cerastium beeringianum Cham. & Schlecht.		mouse-ear chickweed
C. vulgatum L.		big chickweed
Lychnis apetala L.	5	
Sagina saginoides (L.) Britt.	9	pearlwort
Silene acaulis L.		moss campion
Stellaria calycantha (Ledeb.) Bong.		starwort
S. crispa Cham. & Schlecht.		
S. longipes Goldie		long-stalked starwort

RANUNCULACEAE

Anemone drummondii Wats.		Drummond's anemone
A. occidentalis Wats.		chalice flower, western anemone
A. parviflora Michx.		northern anemone, few-flowered anemone
A. richardsonii Hook.	3,4	Richardson's anemone
Aquilegia flavescens Wats.		yellow columbine
A. formosa Fisch.	3	Sitka columbine
Caltha leptosepala DC.		mountain marsh marigold

Ranunculus acris L.		tall buttercup, common European buttercup
R. eschscholtzii Schlecht.		snow buttercup
R. gelidus Kar. & Kir.	3	
R. pygmaeus Wahlenb.		
Trollius laxus Salisb.	(T. albiflorus)	globe-flower

PAPAVERACEAE

Papaver kluanensis D.Löve	3,5	alpine poppy

CRUCIFERAE

Arabis drummondii Gray		Drummond's rock cress
A. holboellii Hornem.		Holboell's rock cress
Cardamine bellidifolia L.		bitter cress
Draba crassifolia R.Grah.	McCalla 7105	
D. incerta Payson		
D. lonchocarpa Rydb.	(incl. D. nivalis)	
D. nemorosa L.	Turner 5170	
Erysimum cheiranthoides L.		wormseed mustard, blister cress
Thlaspi arvense L.		stinkweed, pennycress

SAXIFRAGACEAE

Heuchera glabra Willd. ex R. & S.	8	alum-root
Leptarrhena pyrolifolia (D.Don) R. Br. ex Ser.		leather-leaf saxifrage
Mitella pentandra Hook.		bishop's cap, miterwort
Parnassia fimbriata Konig		fringed grass-of-Parnassus
P. palustris L.		meadow grass-of-Parnassus
Saxifraga adscendens L.	5	pygmy saxifrage
S. aizoides L.	5	yellow mountain saxifrage
S. arguta D.Don	(S. punctata)	brook saxifrage
S. bronchialis L.		spotted saxifrage
S. caespitosa L.		
S. cernua L.		bulbous saxifrage, nodding saxifrage

S. debilis Engelm. ex Gray	(S. rivularis)	7,9	weak-stemmed saxifrage
S. ferruginea Graham	7,9		rustyhair saxifrage
S. lyallii Engler			red-stemmed saxifrage
S. nivalis L.	3		alpine saxifrage, snowball saxifrage
S. oppositifolia L.	5		purple saxifrage
Tiarella unifoliata Hook.	9		foamflower, laceflower, false miterwort

ROSACEAE

Dryas octopetala L.	(D. hookeriana)	white dryad, mt. avens
Fragaria vesca L.	7	woodland strawberry
F. virginiana Duchesne		wild strawberry
Geum macrophyllum Willd.		yellow avens
Luetkea pectinata (Pursh) Kuntze		partridge-foot, Alaska spiraea
Potentilla diversifolia Lehm.		smooth-leaved cinquefoil
P. fruticosa L.		shrubby cinquefoil
P. gracilis Dougl. ex Hook.		graceful cinquefoil
P. nivea L.		alpine cinquefoil
P. norvegica L.		
P. uniflora Ledeb.		singleflower cinquefoil
Rosa acicularis Lindl.		prickly rose
Rubus pedatus J.E.Smith		trailing raspberry
Sibbaldia procumbens L.		

LEGUMINOSAE

Astragalus alpinus L.		alpine milk-vetch
A. frigidus (L.) Gray		
Hedysarum alpinum L.		alpine sweet-vetch
Oxytropis campestris (L.) DC.		late yellow loco-weed
O. podocarpa Gray		alpine loco-weed
Trifolium hybridum L.		alsike clover

EMPETRACEAE

Empetrum nigrum L.		crowberry

VIOLACEAE

Viola adunca J.E.Smith	early blue violet, western sand violet
V. orbiculata Geyer ex Hook.	evergreen violet, yellow violet

ONAGRACEAE

Epilobium alpinum L.	alpine willowherb
E. alpinum var. lactiflorum (Hausskn.) C.L.Hitchc. (E. lactiflorum)	
E. alpinum var. nutans (Hornem.) Hook. (E. hornemannii) 9	
E. angustifolium L.	fireweed
E. glandulosum Lehm.	glandular willowherb
E. latifolium L.	red willowherb, broadleaved willowherb

UMBELLIFERAE

Carum carvi L.	caraway
Osmorhiza sp.	sweet cicely

CORNACEAE

Cornus canadensis L.	bunchberry

ERICACEAE

Arctostaphylos rubra (Rehder & Wils.) Fern.	alpine bearberry
A. uva-ursi (L.) Spreng.	common bearberry
Cassiope mertensiana (Bong.) D.Don	white mountain heather
C. tetragona (L.) D.Don	white mountain heather
Kalmia polifolia Wang.	mountain bog laurel, dwarf mountain laurel
Ledum groenlandicum Oeder	Labrador tea
Loiseleuria procumbens (L.) Desv. 8,9	alpine azalea
Menziesia ferruginea Smith (M. glabella)	menziesia, false azalea, skunk bush

Phyllodoce empetriformis (Sw.) D.Don			red heather
P. glanduliflora (Hook.) Coville			yellow heather
x P. intermedia (Hook.) Camp			hybrid pink heather
Pyrola asarifolia Michx.	(incl. P. bracteata)	3,9	common pink wintergreen[1]
P. minor L.			lesser wintergreen
P. secunda L.			one-sided wintergreen
P. uniflora L.	(Moneses uniflora)		one-flowered wintergreen
			star-flowered wintergreen
P. virens Schweig.			green-flowered wintergreen
Rhododendron albiflorum Hook.			white-flowered rhododendron
Vaccinium membranaceum Dougl. ex Hook.			tall bilberry
V. myrtillus L.	2		low bilberry
V. oxycoccos L.	(Oxycoccus microcarpus)		small bog cranberry
V. scoparium Leiberg			grouse-berry
V. vitis-idaea L.			rock-cranberry

PRIMULACEAE

Androsace septentrionalis L.		4	fairy candelabra

GENTIANACEAE

Gentiana glauca Pallas			blue-bottle gentian
G. propinqua Richards.	(Gentianella propinqua)		four-parted gentian
G. prostrata Haenke	(Gentiana fremontii)		moss gentian

BORAGINACEAE

Myosotis sylvatica Hoffm.	(M. alpestris)	5	alpine forget-me-not

SCROPHULARIACEAE

Castilleja miniata Dougl. ex Hook.			common red paint-brush
C. occidentalis Torr.			
C. rhexifolia Rydb.			broad-leaved paint-brush
Mimulus guttatus DC.		5	yellow monkey-flower

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[1] Not the true aromatic wintergreens (genus Gaultheria).

Pedicularis arctica R. Br.		arctic lousewort
P. bracteosa Benth.		western lousewort, bracted lousewort, wood betony, Indian warrior
P. capitata Adams	5	
P. contorta Benth.	9	alpine lousewort
P. lanata Cham. & Schlecht.	5	
Penstemon ellipticus Coult. & Fisher	7	alpine beard-tongue
P. fruticosus (Pursh) Greene	9	
Veronica serpyllifolia L.		thyme-leaf speedwell
V. wormskjoldii Roem. & Schult.	(V. alpina)	alpine speedwell

PLANTAGINACEAE

Plantago major L.	common plantain

CAPRIFOLIACEAE

Linnaea borealis L.	twin-flower

VALERIANACEAE

Valeriana sitchensis Bong.	mountain valerian

CAMPANULACEAE

Campanula lasiocarpa Cham.	alpine harebell
C. uniflora L. 5	alpine harebell

COMPOSITAE

Achillea millefolium L.	common yarrow
Agoseris aurantiaca (Hook.) Greene	orange-flowered false dandelion, burnt-orange false dandelion
Anaphalis margaritacea (L.) Benth. & Hook. 9	pearly everlasting
Antennaria alpina (L.) Gaertn.	alpine pussytoes
A. lanata (Hook.) Greene	wooly pussytoes
A. parvifolia Nutt.	
A. pulcherrima (Hook.) Greene	showy everlasting
A. racemosa Hook.	

Arnica alpina (L.) Olin	3	alpine arnica
A. amplexicaulis Nutt.	9	acute-bracted arnica
A. cordifolia Hook.		heart-leaved arnica
A. latifolia Bong.		broad-leaved arnica
A. louiseana Farr	9	
A. mollis Hook.		hairy arnica
A. rydbergii Greene	7	
Artemisia biennis Willd.		biennial sagewort
A. norvegica Fries		
Aster sibiricus L.	7	violet-colored aster
Crepis nana Richards.	3,5	alpine hawksbeard
Erigeron acris L.	3	blue fleabane, bitter fleabane
E. acris var. debilis Gray	3,7	
E. humilis Graham	3,5	
E. lonchophyllus Hook.		spearleaf fleabane
E. peregrinus (Pursh) Greene		showy fleabane, aster fleabane
Hieracium gracile Hook.		slender hawkweed
Petasites frigidus (L.) Fries		coltsfoot
Saussurea densa (Hook.) Rydb.	3	
Senecio pauciflorus Pursh		
S. pauperculus Michx.	7	
S. triangularis Hook.		tall brook ragwort, arrowleaf ragwort, arrowleaf groundsel
Solidago multiradiata Ait.		alpine goldenrod
Taraxacum ceratophorum (Ledeb.) DC.		alpine dandelion, rough dandelion
T. laevigatum (Willd.) DC.		redseed dandelion, smooth dandelion
T. lyratum (Ledeb.) DC.		dwarf alpine dandelion
T. officinale Weber		common dandelion

1 Beil (1966)
2 Evans & La Roi (1964)
3 Griffiths, G.C.D. (coll.)
4 Hrapko (1969)
5 Macoun (1918). Authenticity of some of the records is rather dubious.
6 Matthews (unpubl. data)
7 Packer, J.G. (coll.)
8 Packer & Dumais (1972)
9 Porsild (1959)

NOTE: Species followed by numbers (1-9) were not seen in Cavell area by P.Kuchar.

Unrecorded but to be expected: Arabis lyrata, Arenaria rubella, Erigeron aureus, E. compositus, Pedicularis groenlandica, Poa spp., Ribes spp., Sedum stenopetalum, Selaginella densa.

Nomenclature and taxonomy follow Hitchcock et al. (1955-1969).

Common names from various sources, particularly Kelsey & Dayton (1942), Moss (1958), Nelson (1961), Stirrett (1965), Hrapko (1969).

APPENDIX 4. BIRDS OF THE MT. EDITH CAVELL AND TONQUIN VALLEY AREA.

ANATIDAE

Lesser Scaup Aythya affinis (Eyton) 2

Common Goldeneye Bucephala clangula (Linnaeus) 1

Barrow's Goldeneye Bucephala islandica (Gmelin)

Harlequin Duck Histrionicus histrionicus (Linnaeus) 2,B

White-winged Scoter Melanitta deglandi (Bonaparte) 1

Surf Scoter Melanitta perspicillata (Linnaeus) 1

ACCIPITRIDAE

Goshawk Accipiter gentilis (Linnaeus) 2,(B)

Cooper's Hawk Accipiter cooperii (Bonaparte) 2,(B)

Golden Eagle Aquila chrysaëtos (Linnaeus) (B)

Bald Eagle Haliaeetus leucocephalus (Linnaeus) 2

FALCONIDAE

Prairie Falcon Falco mexicanus Schlegel 1

TETRAONIDAE

Blue Grouse Dendragapus obscurus (Say) e

Spruce Grouse Canachites canadensis (Linnaeus) B

Willow Ptarmigan Lagopus lagopus (Linnaeus) 3,B

White-tailed Ptarmigan Lagopus leucurus (Richardson) B

SCOLOPACIDAE

Spotted Sandpiper Actitis macularia (Linnaeus) B

PHALAROPODIDAE

Northern Phalarope Lobipes lobatus (Linnaeus) 2

PICIDAE

Red-shafted Flicker Colaptes cafer (Gmelin)

Northern Three-toed Woodpecker Picoides tridactylus (Linnaeus) B

TYRANNIDAE

Olive-sided Flycatcher Nuttallornis borealis (Swainson) 2,B

ALAUDIDAE

Horned Lark Eremophila alpestris (Linnaeus) B

CORVIDAE

Gray Jay Perisoreus canadensis (Linnaeus) B

Steller's Jay Cyanocitta stelleri (Gmelin) 2

Common Raven Corvus corax Linnaeus B

Clark's Nutcracker Nucifraga columbiana (Wilson) B

PARIDAE

Black-capped chickadee Parus atricapillus Linnaeus e

Mountain chickadee Parus gambeli Ridgway (B)

Boreal Chickadee Parus hudsonicus Forster B

SITTIDAE

Red-breasted Nuthatch Sitta canadensis Linnaeus B

CERTHIIDAE

Brown Creeper Certhia familiaris Linnaeus B

CINCLIDAE

Dipper Cinclus mexicanus Swainson B

TROGLODYTIDAE

Winter Wren *Troglodytes troglodytes* (Linnaeus) B

TURDIDAE

Robin *Turdus migratorius* Linnaeus B

Varied Thrush *Ixoreus naevius* (Gmelin) B

Hermit Thrush *Hylocichla guttata* (Pallas) 3,B

Swainson's Thrush *Hylocichla ustulata* (Nuttall) e

Mountain Bluebird *Sialia currucoides* (Bechstein) e

Townsend's Solitaire *Myadestes townsendi* (Audubon) B

SYLVIIDAE

Golden-crowned Kinglet *Regulus satrapa* Lichtenstein (B)

Ruby-crowned Kinglet *Regulus calendula* (Linnaeus) B

MOTACILLIDAE

Water Pipit *Anthus spinoletta* (Linnaeus) B

BOMBYCILLIDAE

Bohemian Waxwing *Bombycilla garrulus* (Linnaeus) e

PARULIDAE

Orange-crowned Warbler *Vermivora celata* (Say) 2

Yellow Warbler *Dendroica petechia* (Linnaeus) 3

Myrtle Warbler *Dendroica coronata* (Linnaeus) 2,B

Audubon's Warbler *Dendroica auduboni* (Townsend) B

Townsend's Warbler *Dendroica townsendi* (Townsend) 2

MacGillivray's Warbler *Oporornis tolmiei* (Townsend) e

Wilson's Warbler *Wilsonia pusilla* (Wilson) B

FRINGILLIDAE

Pine Grosbeak Pinicola enucleator (Linnaeus) (B)

Gray-crowned Rosy Finch Leucosticte tephrocotis (Swainson) B

Pine Siskin Spinus pinus (Wilson) B

Red Crossbill Loxia curvirostra Linnaeus e

White-winged Crossbill Loxia leucoptera Gmelin e

Savannah Sparrow Passerculus sandwichensis (Gmelin) 2

Slate-colored Junco Junco hyemalis (Linnaeus) 2,B

Oregon Junco Junco oreganus (Townsend) (B)

Brewer's Sparrow Spizella breweri Cassin 1,B

White-crowned Sparrow Zonotrichia leucophrys (Forster) (B)

Golden-crowned Sparrow Zonotrichia atricapilla (Gmelin) B

Fox Sparrow Passerella iliaca (Merrem) B

Lincoln's Sparrow Melospiza lincolnii (Audubon) 1,3,B

Lapland Longspur Calcarius lapponicus (Linnaeus) 2

1 Amethyst Lake or Tonquin Valley only (Cowan, 1955; Taverner; 1918)
2 Cowan (1955) or Taverner (1918)
3 Deirdre Griffiths

B judged to be nesting in Cavell area
(B) possibly nesting
e expected to occur

Birds followed by e,1,2, or 3 were not seen by author.

Nomenclature follows A.O.U. checklist (1957).

APPENDIX 5. MAMMALS OF THE MT. EDITH CAVELL AND TONQUIN VALLEY AREA.

SORICIDAE

Masked shrew Sorex cinereus cinereus Kerr 1,3

Vagrant shrew Sorex vagrans obscurus (Merriam) 1

OCHOTONIDAE

Pika Ochotona princeps princeps (Richardson) 1,2,3,4

LEPORIDAE

Varying hare Lepus americanus columbiensis Rhoads 2

SCIURIDAE

Hoary marmot Marmota caligata oxytona Hollister 1,2,3,4

Columbian ground squirrel Citellus (Spermophilus) columbianus columbianus (Ord) 1,4

Golden-mantled ground squirrel Citellus lateralis tescorum (Hollister) 1,2,3,4

Least chipmunk Eutamias minimus borealis (Allen) e?

Yellow-pine Chipmunk Eutamias amoenus ludibundus Hollister 1

Red squirrel Tamiasciurus hudsonicus columbiensis Howell 1,3,4

CRICETIDAE

Deer mouse Peromyscus maniculatus borealis Mearns 1

Bushy-tailed wood rat Neotoma cinerea drummondii (Richardson) 1

Lemming vole Synaptomys borealis chapmani Allen 1

Red-backed vole Clethrionomys gapperi athabascae (Preble) 1

Heather vole Phenacomys intermedius levis Howell e

Water vole Microtus (Arvicola) richardoni richardsoni (DeKay) 1

Meadow vole *Microtus pennsylvanicus drummondii* (Aud. & Bach.) 1

Long-tailed vole *Microtus longicaudus vellerosus* Allen e

ZAPODIDAE

Jumping mouse *Zapus princeps saltator* Allen 1

ERETHIZONTIDAE

Porcupine *Erethizon dorsatum nigrescens* Allen 2

CANIDAE

Coyote *Canis latrans incolatus* Hall 2

Timber wolf *Canis lupus columbianus* Goldman 2

Red fox *Vulpes fulva abietorum* Merriam e?

URSIDAE

Black bear *Euarctos americanus americanus* Pallas 4

Grizzly *Ursus arctos latifrons* (Merriam) (2)

MUSTELIDAE

Marten *Martes americana abietinoides* Gray 2,4

Ermine *Mustela erminea invicta* Hall 1,2

Wolverine *Gulo luscus luscus* (Linnaeus) 2

FELIDAE

Cougar *Felis concolor missoulensis* Goldman 2

Canada lynx *Lynx canadensis canadensis* Kerr e?

CERVIDAE

Elk *Cervus canadensis nelsoni* Bailey 2,3,4

Mule deer	Odocoileus hemionus hemionus (Rafinesque)	3,4
Rocky Mountain caribou	Rangifer tarandus caribou (Gmelin)	1,3,4

BOVIDAE

Mountain goat	Oreamnos americanus missoulae Allen	1
Rocky Mountain sheep	Ovis canadensis canadensis Shaw	(2)

1 Soper (1970)
2 T. Klettl
3 Deirdre Griffiths
4 P. Kuchar
e expected to occur

Nomenclature follows Soper (1964, 1970).

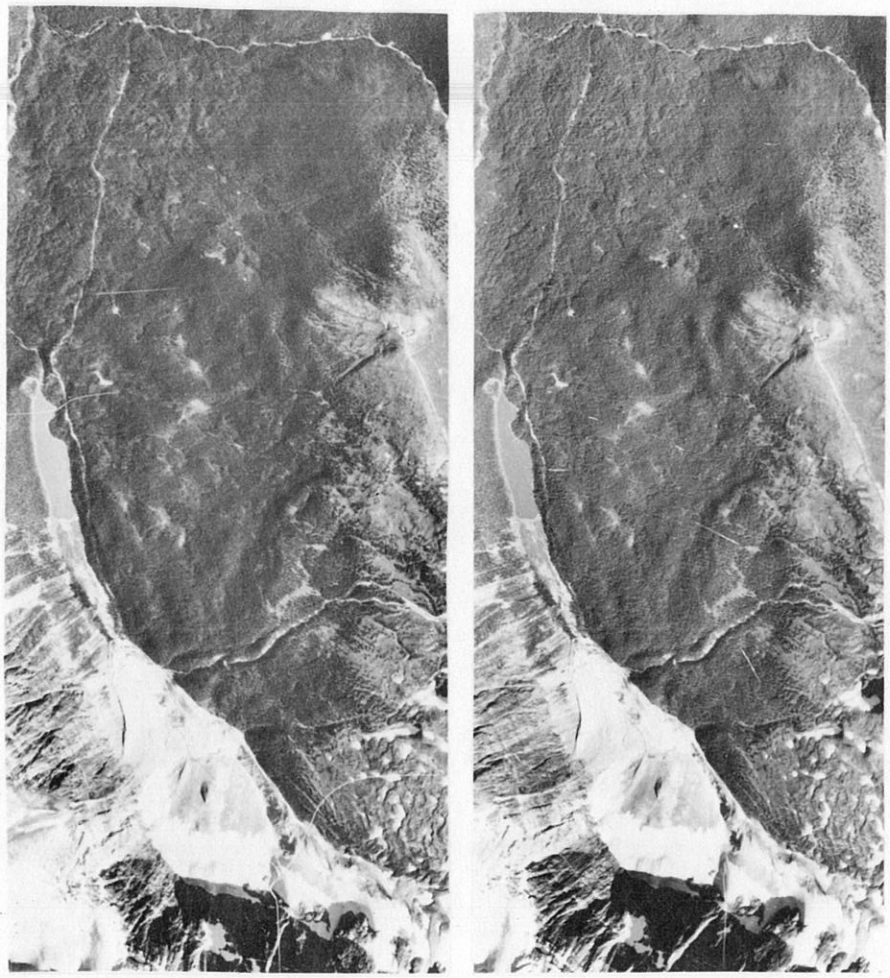

PLATE 1. Stereoscopic pair, aerial photographs of the Mt. Edith Cavell area.

POND

ALPINE RIDGE

MT.
EDITH
CAVELL

ICE-CORED
MORAINE

ANGEL GLACIER

MT. SORROW

CAVELL LAKE

HIGHWAY RIGHT-OF-WAY

CAVELL CREEK

TO TONQUIN VALLEY

RIPARIAN ECOSYSTEM

MEADOWS

SPRUCE-FIR FOREST

FOREST-TUNDRA ZONE

ALPINE ZONE

AVALANCHE AND
COLLUVIAL-RUBBLE VEG.

BARREN TALUS

MORAINAL BOULDER RUBBLE

1 BARREN BOULDER FIELD
2 CANADIAN YOUTH HOSTEL
3 HIGHWAY VIEWPOINT
4 HORSE CORRALS
5 PICNIC SITE
6 TEA HOUSE
7 OUTHOUSES
8 MEMORIAL CAIRN
9 LOWER VIEWPOINT
10 UPPER VIEWPOINT
11 PROPOSED VIEWPOINT

PRESENT TRAILS
PROPOSED TRAIL

E

MT. EDITH CAVELL AREA

SCALE 1:11500

0 ½ 1 KM

0 ½ 1 MILE

POND

ALPINE RIDGE

MT.
EDITH
CAVELL

ICE-CORED
MORAINE

ANGEL GLACIER

MT. SORROW

CAVELL LAKE

HIGHWAY RIGHT-OF-WAY

CAVELL CREEK

← TO TONQUIN VALLEY

RIPARIAN ECOSYSTEM

MEADOWS

SPRUCE-FIR FOREST

FOREST-TUNDRA ZONE

ALPINE ZONE

AVALANCHE AND
COLLUVIAL-RUBBLE VEG.

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------- PRESENT TRAILS
-.-.-.- PROPOSED TRAIL

E

MT. EDITH CAVELL AREA

SCALE 1:11500

0 ½ 1 KM

0 ½ 1 MILE