ALPINE AND SUBALPINE VEGETATION IN THE SOUTHERN CHILCOTIN MOUNTAIN RANGELANDS OF BRITISH COLUMBIA

by

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Abstract:

An ecological classification of high elevation range provides a framework for proper resource management. Alpine and subalpine vegetation in the Southern Chilcotin Mountains was studied to characterize the plant communities of the high elevation rangelands in the southern interior of British Columbia. The impacts of grazing on the structure and composition of the vegetation were evaluated.

Two hundred and thirty-nine sites were sampled in a 10,000 ha area. Plots were selected randomly within homogeneous units delineated on 1:30,000 (40 chain) air photos prior to the field season. These were classified on the basis of physiognomy, dominant species and environmental conditions. The following nineteen community types were described: Picea engelmanii-Abies lasiocarpa forest, Pinus albicaulis-Juniperus communis forest, Salix barclayi-Carex aquatilis shrub wetland, Salix barrattiana alpine shrub wetland, Salix brachycarpa-Salix barclayi shrubland, Salix brachycarpa-Festuca spp. shrubfield, Salix brachycarpa-Phleum alpinum shrubfield, Arctostaphylos uva-ursi-Amelanchier alnifolia dry shrubland, Salix cascadensis dwarf willow shrubland, Dryas octopetala fellfield, Dryas octopetala-Festuca altaica alpine grassland, Carex aquatilis/rostrata wetland, Carex nigricans late snowbed meadow, Festuca altaica-Festuca brachyphylla meadow, Festuca brachyphylla meadow, Festuca brachyphylla-Phleum alpinum meadow, Phleum alpinum-Carex phaeocephala meadow, Koeleria cristata dry meadow, and crustose lichen rock-land or talus terrain unit.

Changes in the structure and composition of plant communities in response to grazing pressure were evident on the more heavily used valley bottom meadow

community types. After many years of use, Festuca altaica appears to have been eliminated from heavily grazed meadows, there is a decrease in the height of the vegetation, an increase in the exposed bare ground, and an increase in the abundance of weedy species in all community types.

Many of the community types described from this region are floristically and/or ecologically comparable with plant communities described from other high elevation areas in British Columbia, the southern Yukon, and the Pacific Northwest of the United States.

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CHAPTER 1

Introduction

British Columbia is a province of extremely diverse topography, varying in elevation from sea level to 4,666.5 m. at the top of Mt. Fairweather on the British Columbia-Alaska boundary. Mountainous terrain dominates the 94.7 million hectares of land and water that comprise British Columbia. Of that land base, 36% (34 million hectares) is classified by the British Columbia Forest Service as alpine forest, scrub, rock, and barren (Pearse, 1976).

This "alpine" land is considered by the B.C. Forest Service to be non-productive with little or no direct value to the forest industry. However, these lands do provide essential summer range to large numbers of wildlife and, in some areas, to domestic livestock as well. Recreational activity in the form of hunting, horse pack trips, and backpacking is another major use of our alpine resource. Furthermore, mineral potential is often high in mountainous terrain and considerable disturbance can result from mining activity.

Pressure on the alpine and subalpine natural resources will probably increase in the future, as their potential is more fully realized. The environment is extremely fragile and proper management is essential to its preservation and continued productivity. Toward this end coordinated resource planning is currently being used in at least one alpine area in British Columbia to help alleviate multiple use conflicts and to maximize benefits and minimize conflicts among the various resource users.

Sound management and planning decisions require a knowledge of the resource base. A vegetation study provides valuable information on wildlife habitat, abundance of key range species and recreation potential, and aids in the identification of vegetation types which are particularly sensitive to

human or grazing impact. Baseline data provide a benchmark against which to assess range trend and the success of the various management schemes which may be implemented. Thus an understanding of the vegetation ecology of an area facilitates proper land management. With this goal in mind, the objectives of this study were (1) to collect and identify the floral elements of an alpine-subalpine rangeland in the Southern Chilcotin Mountains (no extensive botanical collections had previously been made in this part of British Columbia); (2) to characterize and map alpine-subalpine vegetation units; and (3) to compare grazed and ungrazed sites as to species composition and community structure.

The study area is located in the Chilcotin Mountains on the eastern flank of the Coast Range, north of Carpenter Lake and SW of Gang Ranch at approximately 51°11'N latitude and 123°W longitude (Figure 1). Relay Valley or the Charlie Cunningham area (as it is known to nearby residents) is only 215 km due N of Vancouver. Relay Valley, Relay Basin, Graveyard Valley and Two Lakes Basin and the Dash Plateau were the main areas of study. They comprise four alpine-subalpine grazing units as defined by the B.C. Forest Service, Range Division in Williams Lake. A small part of the Paradise Valley grazing unit was also examined. The total area encompasses approximately 100 sq. km (10,000 ha) (Figures 1, 2 and 3).

The Charlie Cunningham Area was chosen as the study site for several reasons. It has a long history of range use but little or no management has been practiced until recently. Its accessibility and proximity to Vancouver make future recreational pressure inevitable and, in fact, the area was once considered as a potential Provincial Park site. Wildlife are plentiful and there is the potential for mineral development. Furthermore there is a remote

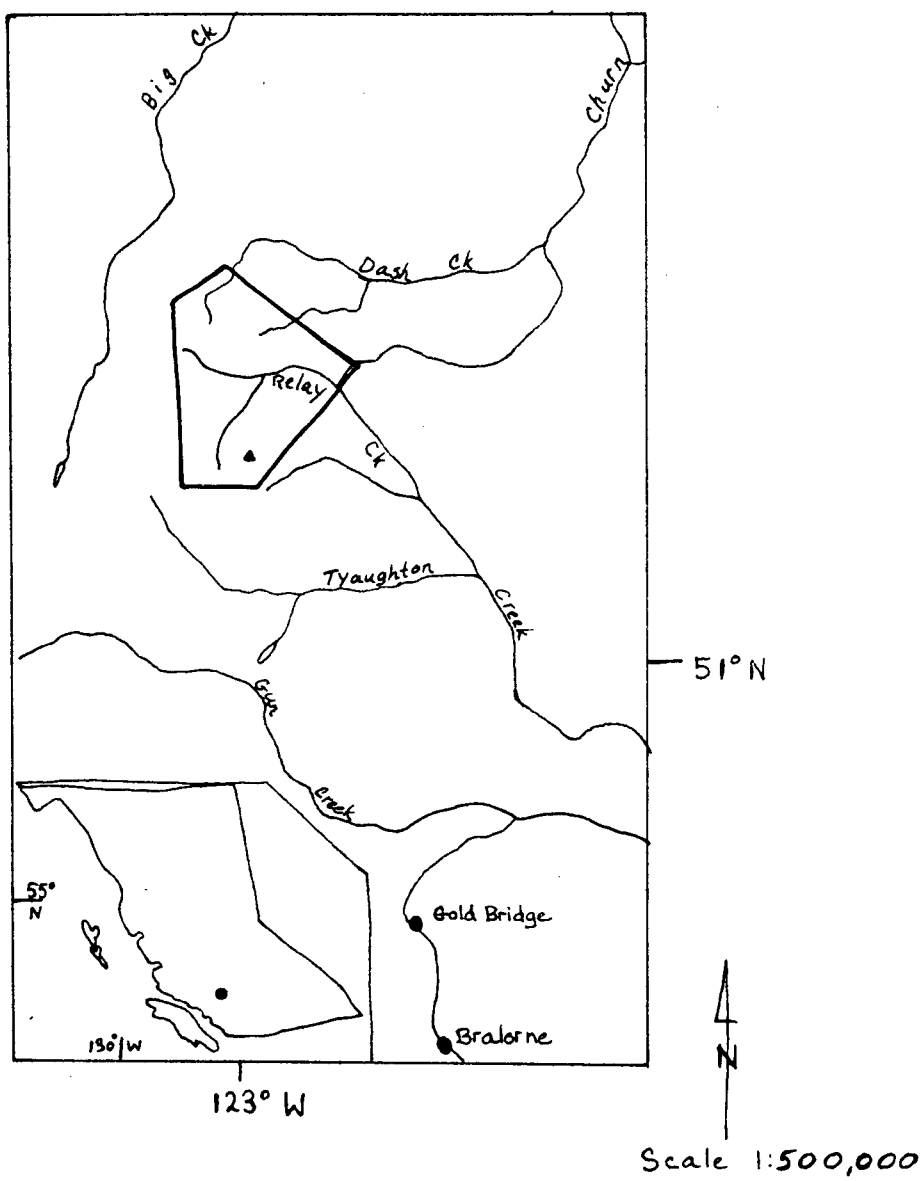


Figure 1: Location of study area

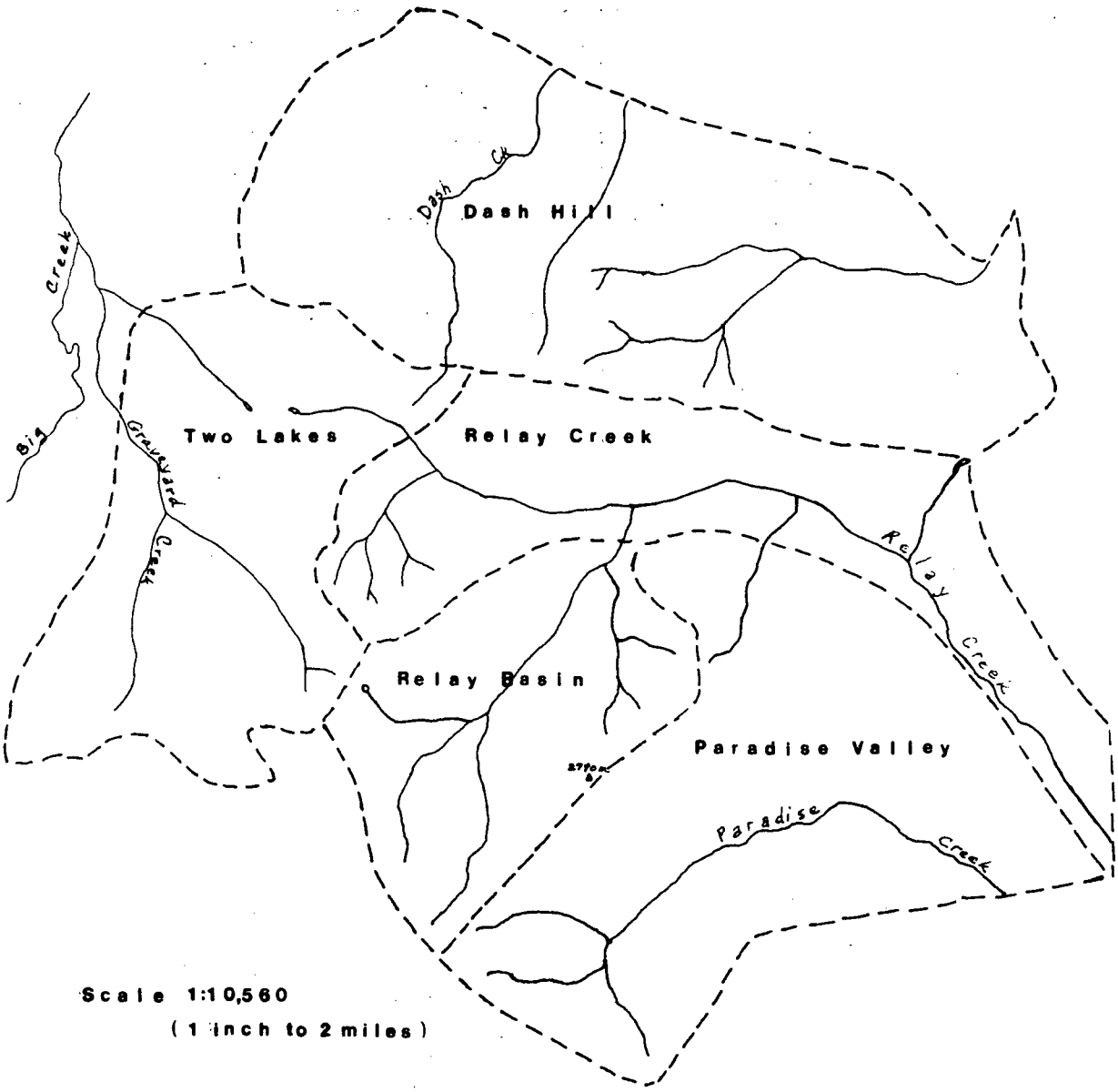
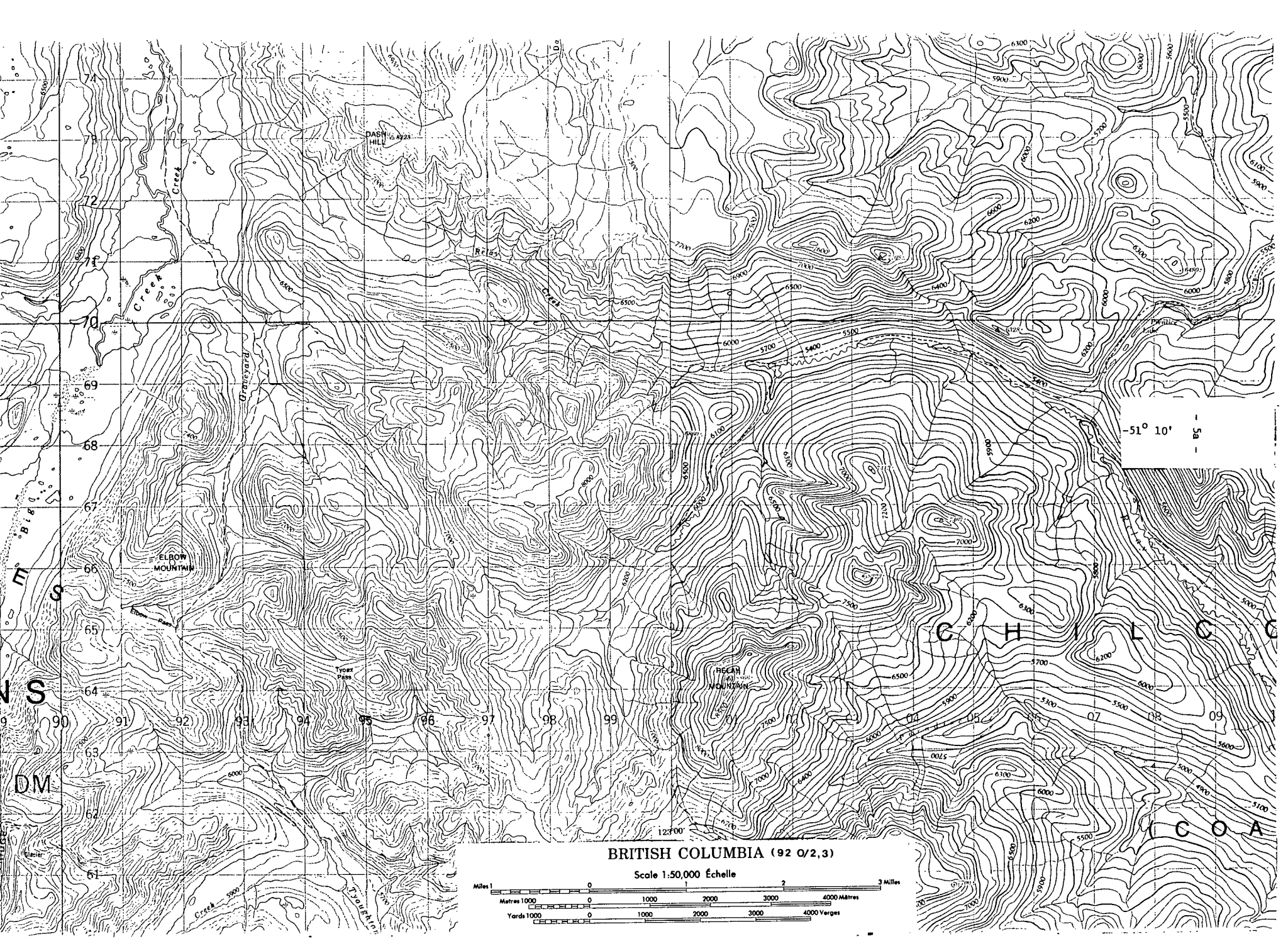


Figure 2: Grazing units included in the study area

Figure 3: Topographic map of the study area and vicinity


DASH HILL
Relay Creek
Graveyard Creek
ELBOW MOUNTAIN
Elbow Pass
Tyaughton Creek
Tyaughton Pass
REGAN MOUNTAIN
Prentice Lake
-51° 10'
CHILCOA
BRITISH COLUMBIA (92 O/2,3)
Scale 1:50,000 Échelle
Miles 1 0 1 2 3 Milles
Metres 1000 0 1000 2000 3000 4000 Mètres
Yards 1000 0 1000 2000 3000 4000 Verges

possibility that Relay Valley will some day be a part of a road system from Pemberton to Williams Lake. In 1977 the area was included in a Coordinated Resource Management Plan and more intensive management began. This study should provide useful information for planning and management policies in the high elevation rangelands of the Chilcotin Mountains.

Description of Study Area

1. History:

Relay Valley has been recognized as prime summer grazing land since 1939 when the Haywood Ranch first started driving sheep form the Tranquille Range to Relay Creek by way of French Bar Creek and Beaver Valley. The sheep grazed in what was then called the "Paradise grazing unit" before being trailed back to the Tranquille via Tyaughton and Mud Creeks. The Paradise grazing unit was considered to be the most productive in the area, possibly because of greater precipitation, and had an estimated carrying capacity of 2 ha (5 acres) per sheep. As many as 4300 head of sheep (3600 on the average) grazed in Relay Valley each summer until 1964 when the Haywood operation went out of business. The economics of trailing or trucking (which was done for several years) sheep such a long distance from the base ranch and of getting and keeping reliable shepherds at a minimal salary partly explain the demise of the Haywood sheep ranch.

From 1965 until 1967 Relay Valley was rested from domestic grazing. It would be very interesting to have some quantitative information on the range condition at this time for comparative purposes but, unfortunately, no data are available. We can assume that the rangelands were still considered relatively productive because in 1967 the Gang Ranch received a grazing permit

for this area from the B.C. Forest Service Range Division for 4500 cows and 1000 yearlings. The basis for determining the carrying capacity of the range is unknown.

The Gang Ranch moves cattle into Relay Valley by two main routes. One is up Big Creek to Two Lakes Basin and down Relay Creek. The other is through Hungry Valley into Beaver Valley, past Prentice Lake and down into Relay Valley. A third route that has been used led from Hungry Valley up Dash Creek, onto the Dash Plateau and then down into Two Lakes Basin. Cattle are herded (with the help of cowboys) throughout the study area from late July until early September when they are rounded up and herded back to the base ranch some 50 miles to the north. Some cattle may be left in the area until snow brings them down into the valleys.

Graveyard Valley apparently did not have an extensive period of sheep grazing but has been used by cattle for a longer time period than the Relay Creek drainage area. Cattle were grazing along Graveyard Creek in 1945 (Wood, 1949). Unfortunately all the records were lost in a fire.

The Western Canada Ranching Company Ltd., otherwise known as the Gang Ranch, has been owned by American interests (W.P. Studdert and F.E. Skelton) until recently (in 1978 it was purchased by Dale Alsager of Alberta). Management of the ranch has not always been based on the principles of sound range management. From 1966-1970, 5200-5600 head of cattle per year were grazed in the backcountry until October 31. This resulted in an estimated use of 22,500 AUMs* in 1969 and 1970 (the years of heaviest use). Such use placed

*An A(nimal) U(nit) M(onth) is the amount of forage required by one mature (450 kg.) cow or the equivalent for one month. Each AUM requires an average of 300 kg. of available forage (McLean and Marchand, 1968).

extreme pressure on the vegetation and soil resource base. As a result, the grazing season was reduced by one month and the number of cattle permitted west of the Fraser River was reduced to 4000 head (Fredell et al., 1974). Recommended use of these rangelands in 1975 was 6000 AUMs.

In 1974 the B.C. Forest Service Range Division in Williams Lake did a reconnaissance survey of Crown rangelands used by the main Gang Ranch, of which there are approximately 2,125 sq. km (Fredell et al., 1974). Based on this report a rest rotation grazing scheme for the summer rangelands was implemented in 1977. Stocking rates for the high elevation range units were reduced to 2,000 head in 1975, 1500 head in 1976 and in 1977 to 1000 head grazed under a rest-rotational system which allows for alternate year use of the range units. It is hoped that this level of use will allow for range rehabilitation. Some fencing has also been built to improve control of cattle distribution. Seeding of severely disturbed sites was begun in 1977, but the results are not known.

The Gang Ranch backcountry was included in a coordinated Resource Management Plan in 1977. It is to be re-evaluated each year until 1982.

2. Physiography and Geology:

The study area is located in the Southern Chilcotin Mountains (a subdivision of the Chilcotin Ranges) which lies along the eastern side of the Pacific Ranges physiographic unit of Holland (1976). It is west of the Yalakom River and north of Carpenter Lake and falls within the transition zone between the Coastal Mountains and the Chilcotin Plateau. The part of the Southern Chilcotin Mountains that is between Tyaughton and Relay Creeks has also been referred to as the "Red Mountains" (Wood, 1949). Relief ranges from

1600 m to 2790 m. The highest point within the study area is Relay Mountain (2790 m). Timberline lies between 2000 and 2100 m.

The Relay Area is underlain by a complex of seven bedrock types. They are predominantly Mesozoic and are of the Jurassic and Cretaceous periods. The Relay Mountain Group (comprised of 3 units) represents the oldest rocks followed by the more common Taylor Creek Group. The Kingsvale Group is the youngest unit in this area. All are sedimentary. The Cenozoic rocks are of two types: the plutonic rocks of the Eocene and the volcanic intrusions found in the Chilcotin group of the Upper Miocene or Pliocene (Tipper, 1978). Relay peak is an erosion remnant of these flat lying Tertiary volcanic rocks (Wood, 1949).

3. Soils

The development of soils is influenced by climate, topography, geology, hydrology, geomorphology, biological activity, and time (Retzer, 1974; Lavkulich and Sneddon, 1976). Conditions in the alpine and subalpine environments often result in a complex mosaic of soil types within a small area (Bamberg and Major, 1968); however, soil development is often limited. Low temperatures inhibit the physical and chemical weathering of soils (Bliss, 1966) and can limit root penetration into the soil. The translocation of silts, clays, sesquioxides and bases can occur only in sites where there is sufficient water moving through the solum to promote leaching (Sneddon, 1973). Precipitation is often low so that translocations are minimal. Where volcanic ash is present large quantities of mobile iron and aluminum are available on weathering and a podsolisation occurs even where rainfall is low (Sneddon, 1973; Valentine et al., 1978). Erosive factors are prominent in the alpine landscape as well.

Wind and water erosion, cryoturbation and solifluction are active processses wearing away the landscape and contributing to the immaturity of soils (Retzer, 1974). Furthermore, there has been a limited time (10,000 years) available for soil development as most mountainous areas in British Columbia are post-Pleistocene in age. The following discussion of soil types is based on the Environment and Land Use Committee Secretariat soils and landform map 920 (Figure 4).

Although there are no glaciers found in the study area, the effects of Pleistocene glaciation are evident. The valleys are characteristically U-shaped and the summits are rounded. Much of the soil parent material is of glacial origin - especially in the valleys where morainal deposits are predominant. Dystric brunisols are common on these landforms. According to Valentine et al. (1978), they are acidic and "have relatively thin, poorly decomposed organic surface layers with little incorporation of the organic matter in the mineral soil". These soils are sometimes modified by the addition of volcanic ash from the Bridge River ashfall of 2,120-2,670BP (Lavkulich and Sneddon, 1976).

In the steeper mountainous areas, colluvial processes have produced the primary soil parent material. The topography has resulted in unstable areas with little soil development. Regosols are predominant, although in level areas (e.g. Graveyard Valley) brunisols have developed and in rugged areas, rockland is found. Frost action results in patterned ground (especially rock stripes) in some of these alpine areas (Washburn, 1956). Rock stripes are common on the Dash Plateau.

An orthic regosol has developed on the large alluvial deposit at the base of the western slopes of Relay Mountain. Fluvial processes are responsible for this distinctive landform unit.

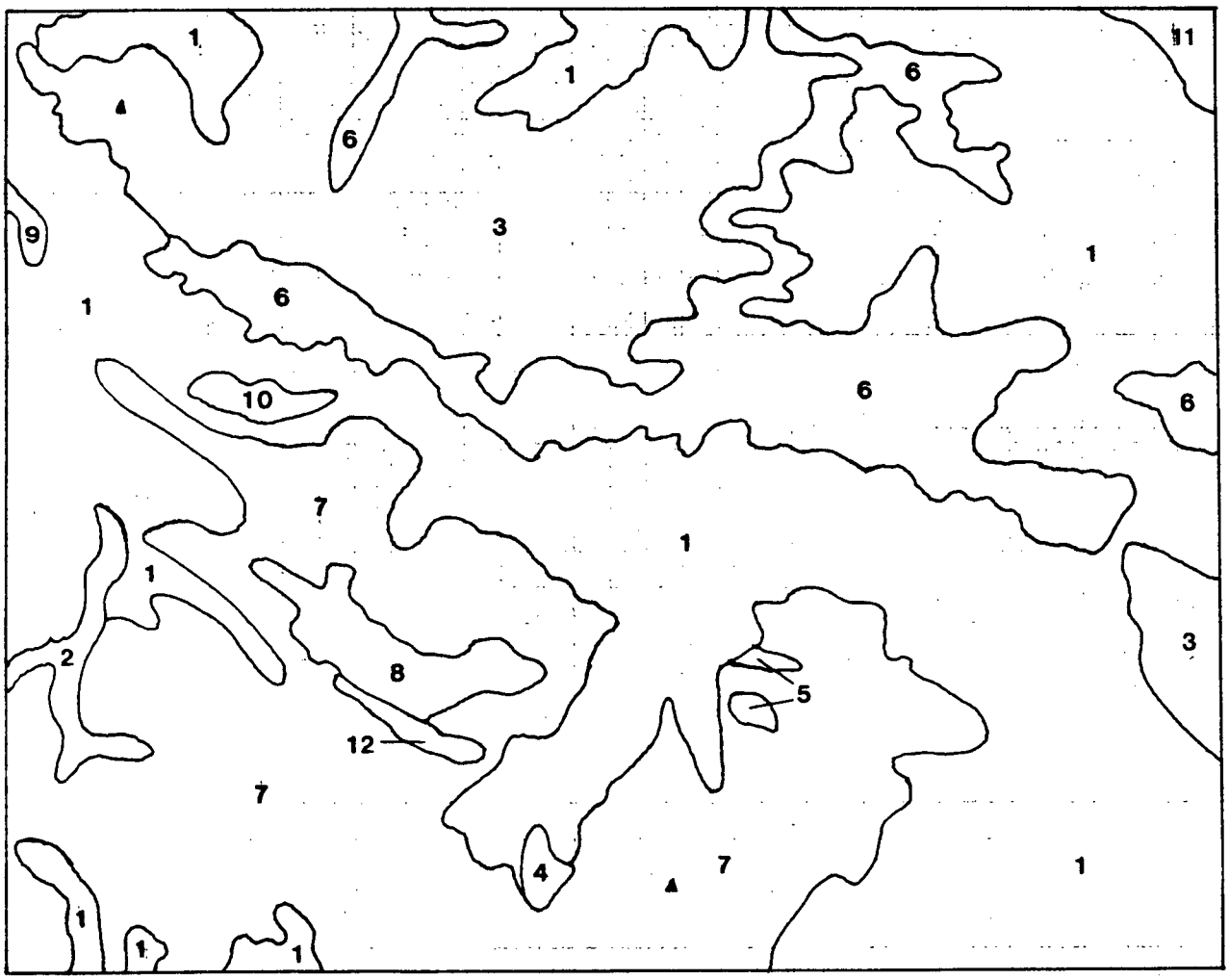


Figure 4: Preliminary soil map of the study area derived from E.L.U.C. Secretariat Map 920

Brunisols

(1) BI = Orthic Dystric Brunisol
(2) GC-MV = Orthic Dystric Brunisol-Orthic Regosol
(3) MY-YA-RO = Orthic Regosol-Sombric Brunisol-Rockland
(4) PU = Orthic Regosol (alluvial deposit)
(5) DP = Orthic Regosol (morainal deposit)
(6) RT-RO = Orthic Regosol-Rockland
(7) RT-BH-RO - Orthic Regosol-Lithic Regosol-Rockland
(8) BH-RT = Lithic Regosol-Orthic Regosol
(9) TG = Glayed Cumulic Regosol
(10) ND-DD = Rego Gleysol-Orthic Dystric Brunisol
(11) CL = Terric Humisol
(12) RO = Rockland

In valley bottoms or depressional areas with a high water table and poor drainage such as the Two Lakes Basin, rego gleysols have developed. Small areas with very poor drainage develop soils in which organic matter accumulates due to cold soil temperatures and low microbial activity.

4. Climate

The location and topography of Relay Valley play a major role in determining the climate. Although the study area lies in the Coastal Range, its position on the lee side results in a more continental climate than is characteristic of British Columbia's western mountains. July is the warmest month with a mean temperature of 15°C in Bralorne. January is the coldest, averaging -7.7°C. Mean annual temperature is 4.3°C. The study area lies in a rain shadow and receives roughly 500 mm precipitation with some falling in every month. Convectional summer showers, a continental feature, are characteristic and provide much of the annual rainfall. Midsummer days are generally sunny and warm but there can be frost during any month of the year.

There are no weather stations either within the study area or at ecologically comparable sites in the vicinity. In order to get an appreciation of the climate, 30 year norms from Bralorne (1016 m; 50°47'N, 122°49'W) to the south have been tabulated along with 1977 data from Upper Big Creek (1693 m; 51°15'N, 123°07'W) to the N (Figures 5 and 6). Of course the values given need to be adjusted for the elevation of the study site (1600 m-2790 m). On the average there is a decrease of about 5.5°C for each 1000 m increase in elevation (Daubenmire, 1974, page 165). Temperature is modified by slope and aspect (a 5° slope toward the pole reduces soil temperature approximately equivalent to 300 miles of latitude toward the pole, Daubenmire, 1974,

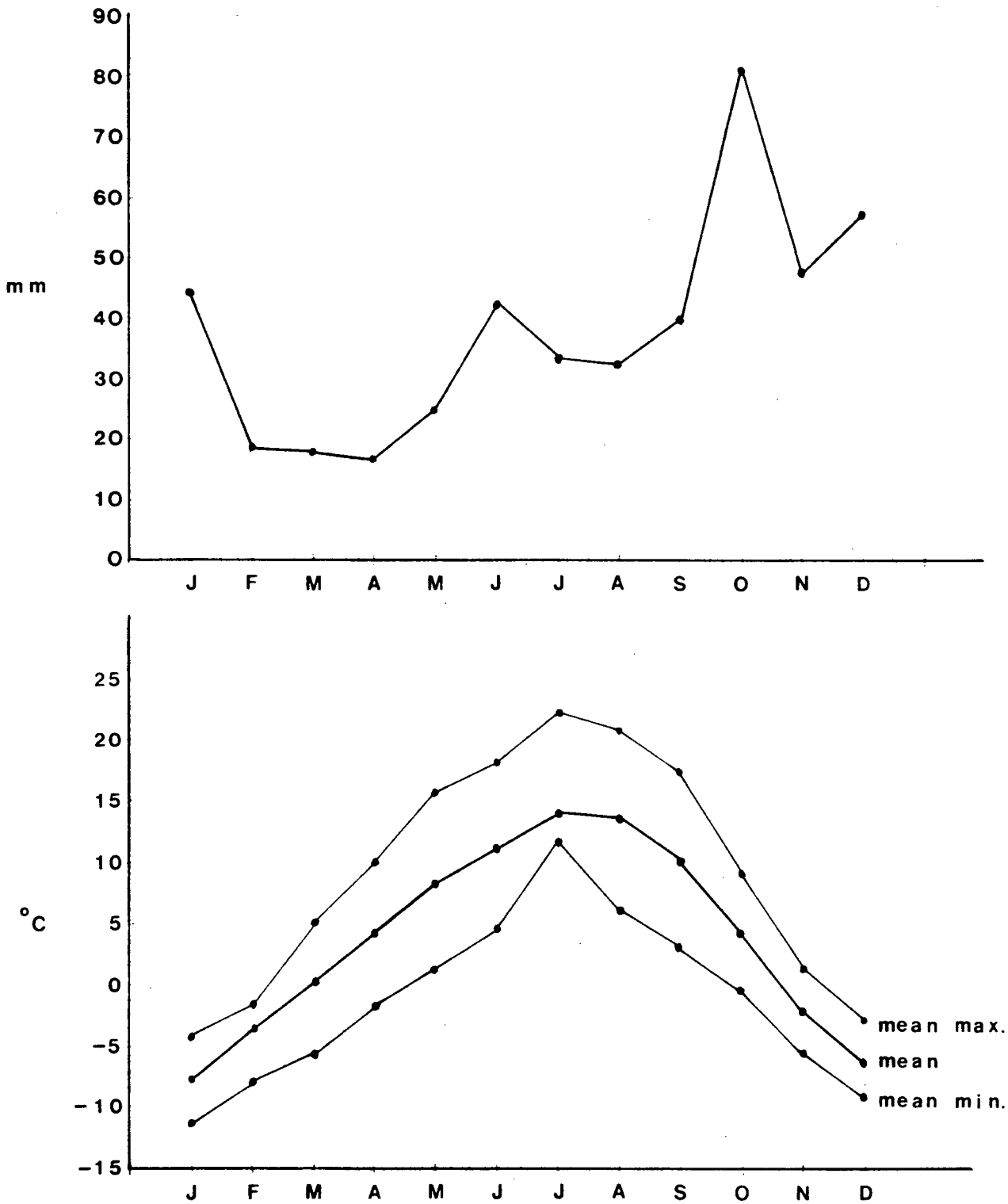


Figure 5: Precipitation (adjusted 30 year means) and temperature at Bralorne, B.C.

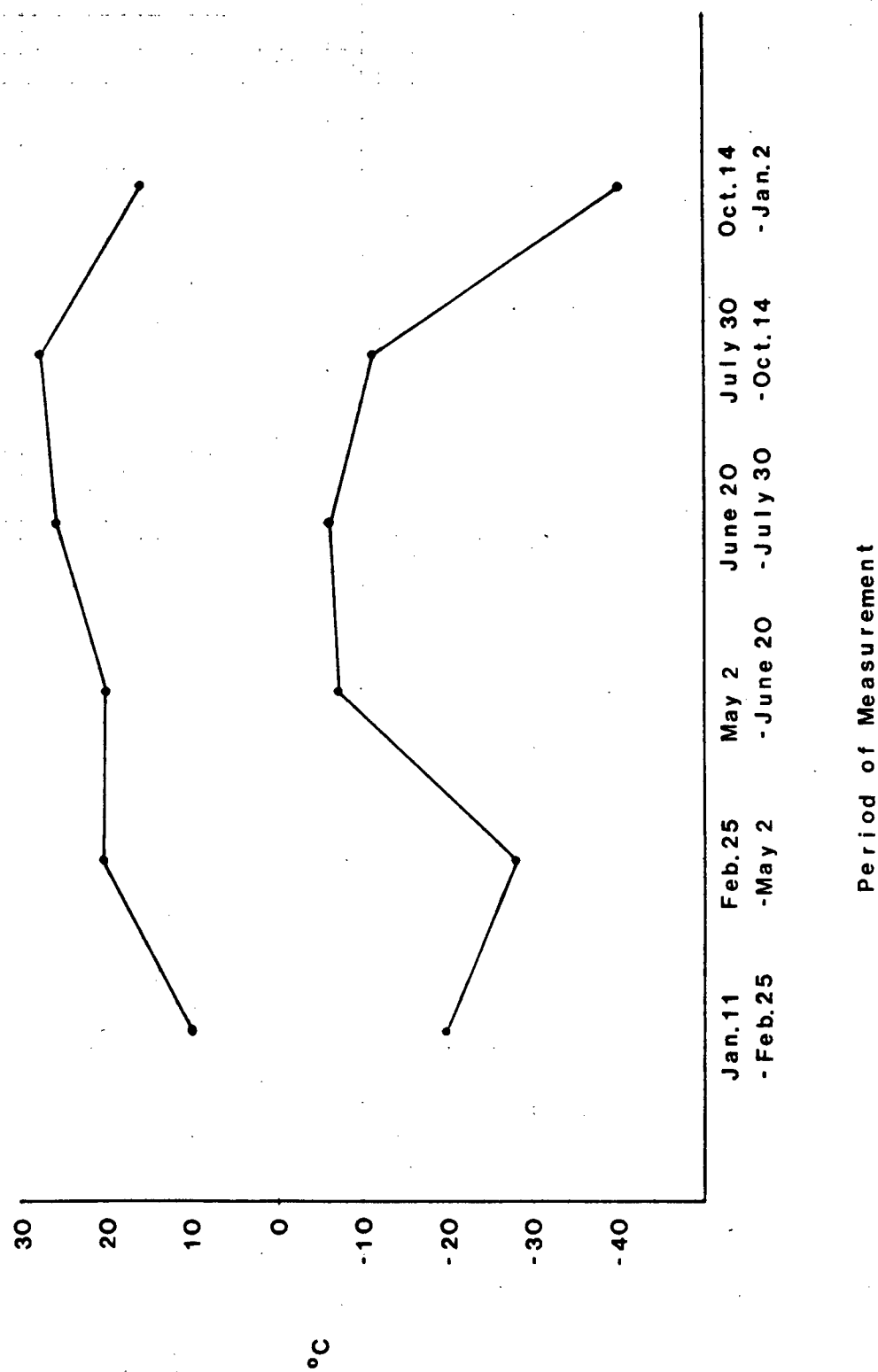


Figure 6: Maximum and minimum temperatures at Upper Big Creek, 1977

page 165) however, and microclimatic data are not available. Summer precipitation generally increases with elevation (Buttrick, 1978) and winter snowfall is greater in higher elevations than in valley bottoms. Strong winds affect the snow distribution pattern which in turn influences vegetation. All of these factors complicate the extrapolation of climatic data from lowlands to mountainous terrain. However, a general picture of climatic conditions can be gleaned from available data. The temperature and precipitation data from Bralorne and the snow survey data from Green Mountain (Figure 7) are particularly useful. They indicate a relatively light winter snow pack but adequate summer rainfall to prevent drought. The temperature data from Upper Big Creek illustrate the extreme temperature fluctuations that can occur at high elevations.

5. Vegetation

The vegetation of the study areas lies within two biogeoclimatic zones as described by Krajina (1965;1969). These zones are separated primarily on the basis of climate (Beil et al., 1976). The Engelman Spruce Subalpine Fir (ESSF) zone has been divided into a wet and dry subzone by the B.C. Forest Service (Annas and Coupe, 1979). The study area lies in the ESSF a or dry subzone.

The ESSF zone is found in the interior of B.C. where a continental climate predominates (Dfc after Koppen). It has a lower mean annual temperature (1-4^{o}C) than the coastal subalpine zone (3-7^{o}C) and has greater temperature extremes. The annual total precipitation is 410-1830 mm with approximately 43 percent falling as snow. Cold winter temperatures, high summer temperatures, and low precipitation result in a high probability of frozen ground in the winter and the potential for summer drought (Krajina, 1965; Fraser, 1970). This zone ranges in elevation from 1200-2100 m. in southwestern B.C.

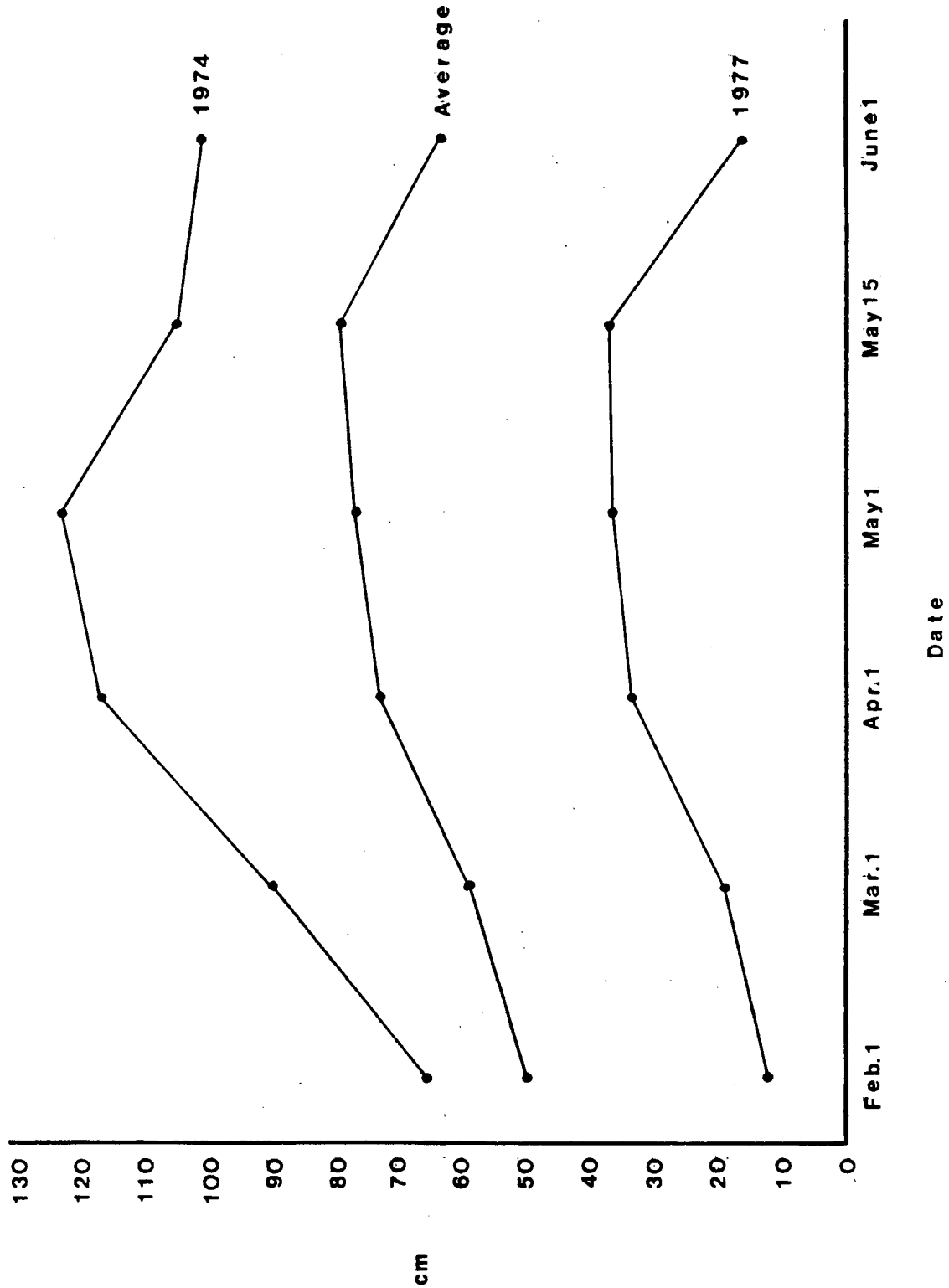


Figure 7. Snow Survey from Green Mountain (elevation 1710 m; 50°47', 122°55') 1960-1978. Values recorded are the snow depth water equivalent.

Several tree species are able to tolerate the relatively severe winters of the ESSF zone. Those found within the study area are Picea engelmanii*, Abies lasiocarpa, Pinus albicaulis and Pinus contorta. Dominant shrubs are Salix spp. and Betula glandulosa. The latter species is more characteristic of the northern subzone. According to Dr. V.J. Krajina (personal communication), the more extensive willow-birch shrub areas might be considered as a southern extension of the Spruce-Willow-Birch Zone where summer night temperatures are higher than in the ESSF zone.

The lower elevations of this zone are characterized by a continuous forest, while a parkland has developed at higher elevations. Tree islands are found in areas of heavy snow accumulation where there is an adequate moisture supply during the growing season (Beil et al., 1976). At the upper limits for tree growth krummholz is found. Extensive herb and shrub meadows lie in the transition from subalpine forest to the alpine areas (Plates 1 and 2).

At higher elevations (above 2000 m) in the study area, the vegetation is representative of the Alpine Tundra Zone, which lies above the area of continuous forest and parkland. The continental climate places it in the Interior Subzone where there is a relatively lighter snowfall and a somewhat wetter summer than in the Coastal Subzone (Beil et al., 1976). The mean annual temperature is -0.4 to -1.5^{o}C and the mean monthly temperature is less than 0^{o}C for 7-11 months of the year. This results in a short growing season limited by frost. Annual total precipitation is 700-2800 mm with nearly three-fourths falling as snow (Krajina, 1965).

*authorities for species collected in the study area are given in Appendix A.

Plate I. Photograph of Relay Basin grazing unit

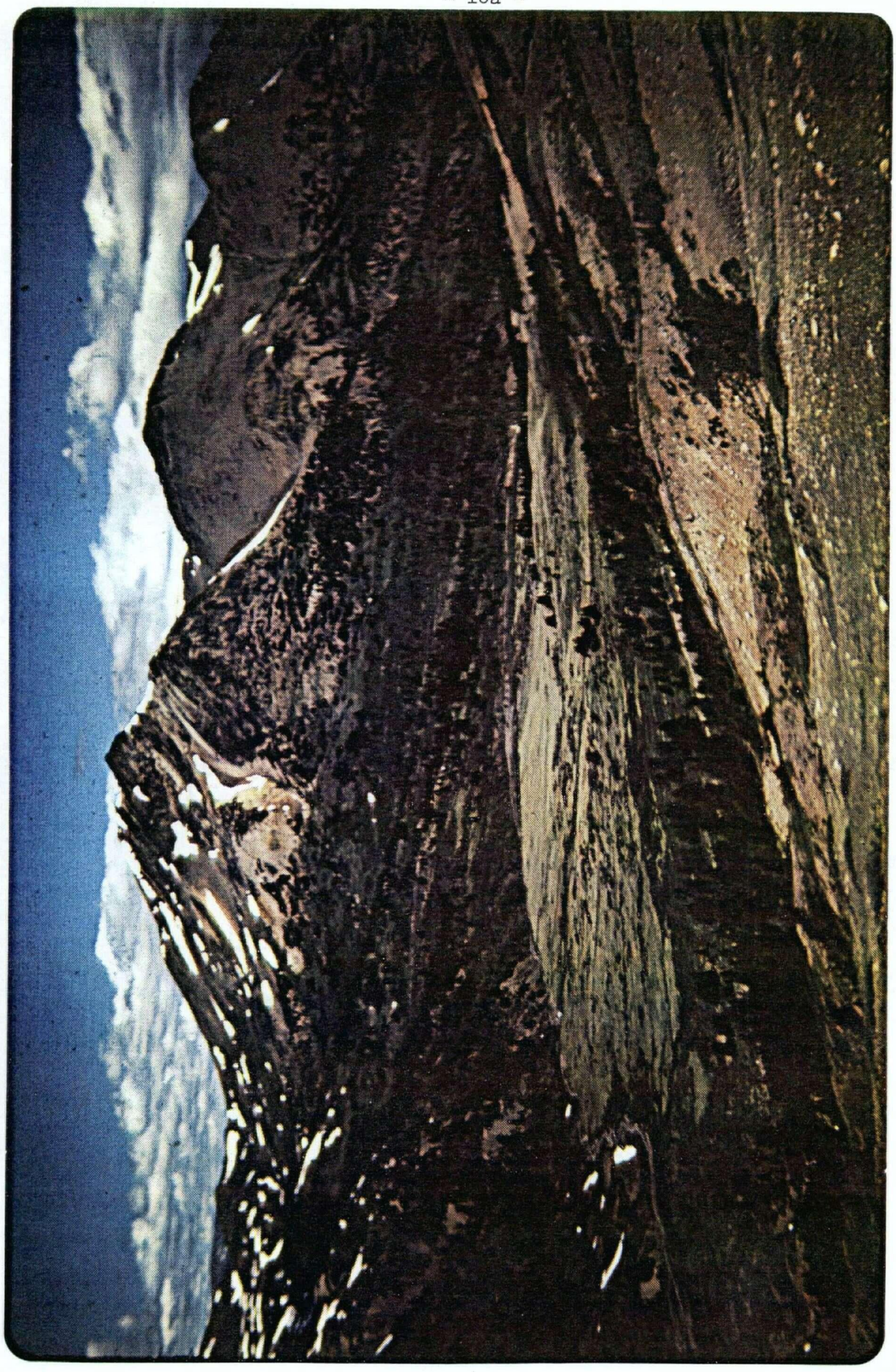
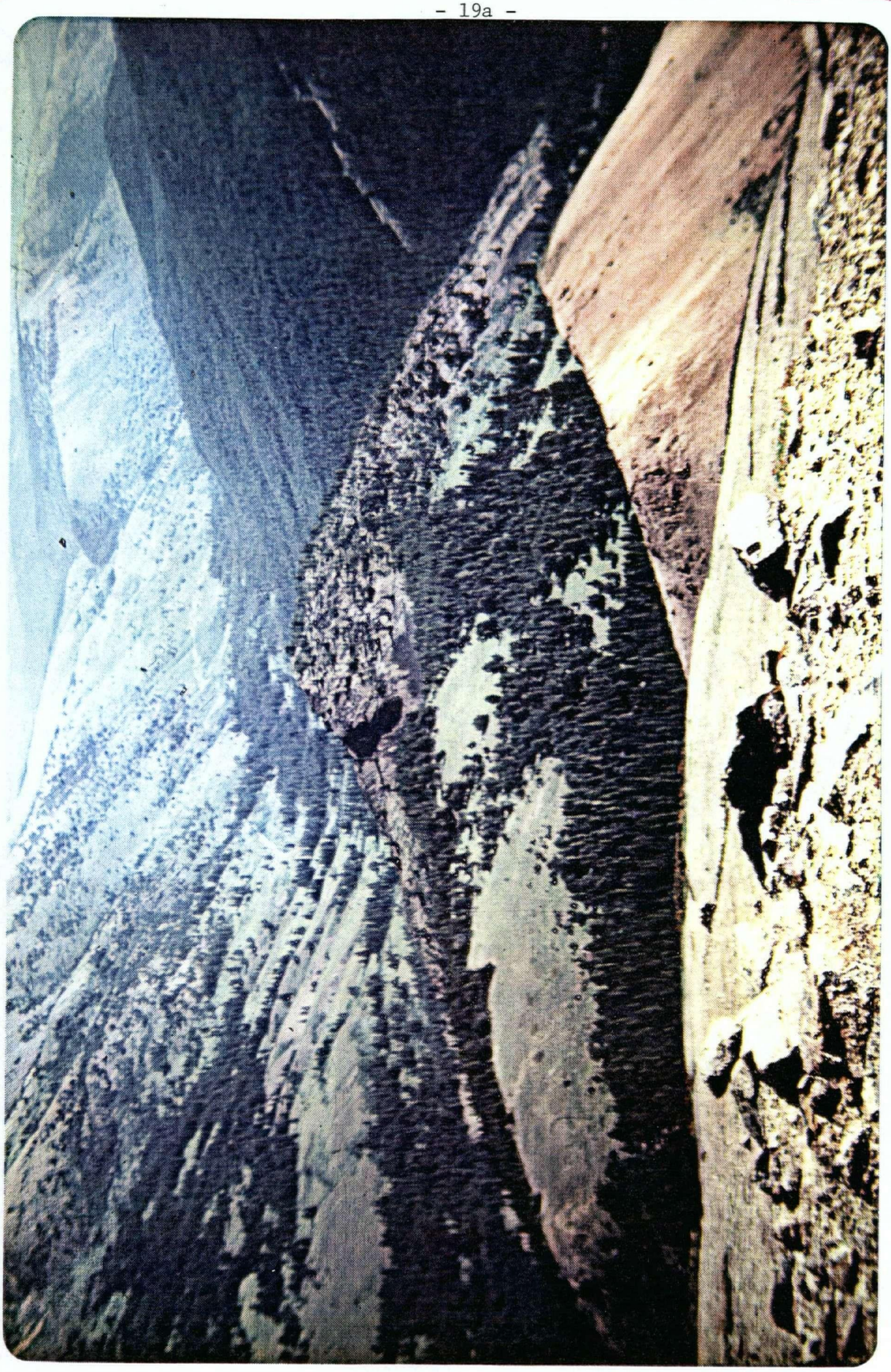


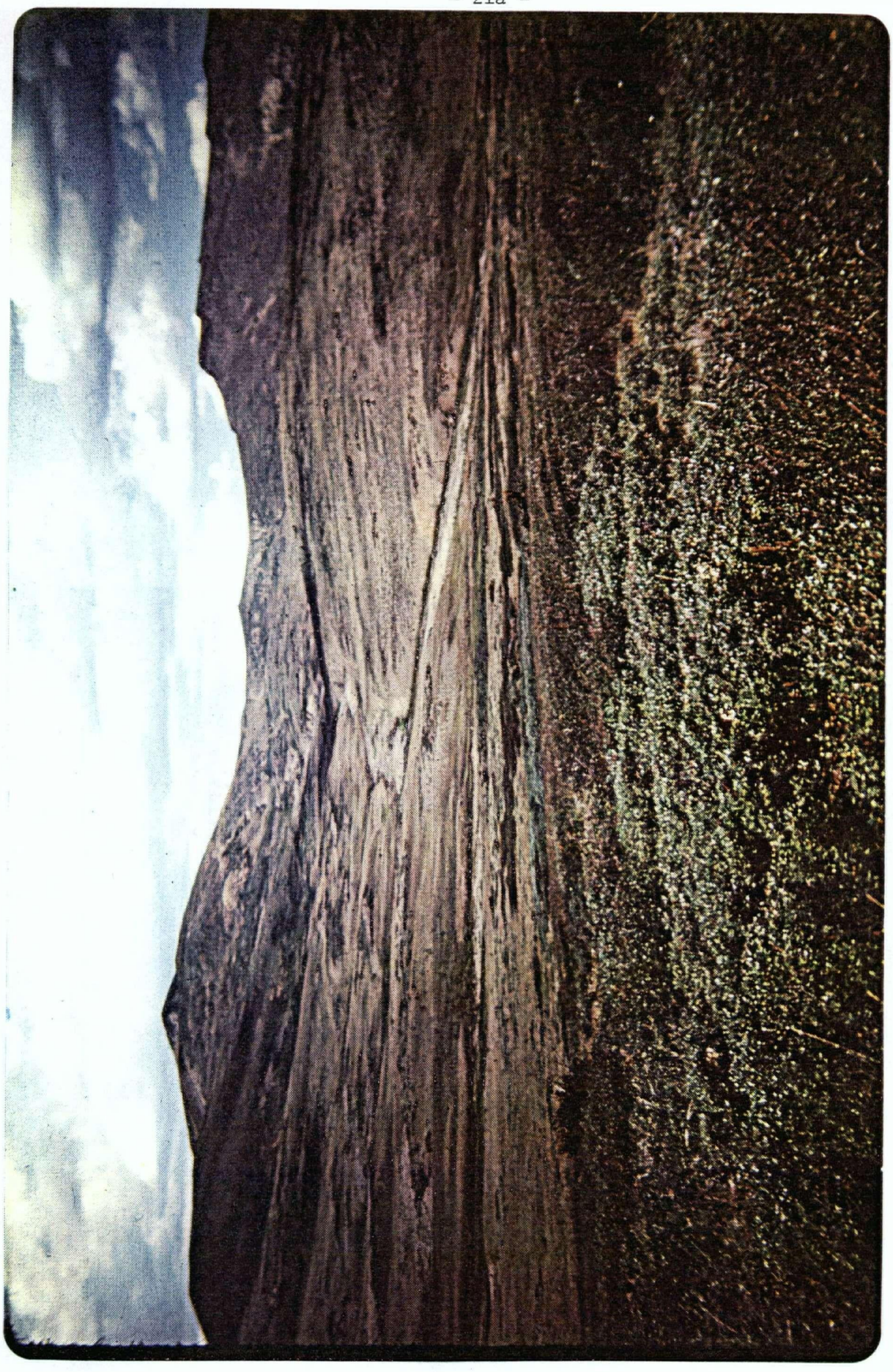
Plate II. Photograph of Relay Valley grazing unit. Note the open south-facing slopes and the forested north-facing slopes.



The vegetation in the alpine zone is dominated by herbs, bryophytes and lichens, along with some low shrubs (Plate III). Climax species are thought to be Cassiope mertensiana (C. tetragona in the north), Phyllodoce empetriformis, P. glanduliflora and Empetrum nigrum (Archer, 1963).

In the Charlie Cunningham area, the alpine vegetation falls into three main physiognomic categories - shrublands dominated by Salix brachycarpa and Betula glandulosa; herbaceous meadows dominated by Festuca spp., Poa spp. and Carex spp. plus numerous forbs; and lichen-dominated fellfields and boulder fields.

Plate III. Photograph showing west side of Dash Plateau



CHAPTER 2

Literature Review

Vegetation ecology in the alpine and subalpine zones has been studied throughout the world (Eady, 1971; Ives and Barry, 1974). For a discussion of ecological principles and classification systems the reader is referred to Mueller-Dombois and Ellenberg (1974) and Poore (1955; 1962). Amongst many others, Buttrick (1978) discussed environmental factors responsible for the diversity in composition and distribution of alpine plant communities. He considers precipitation (especially snowfall), geography, and substrate to be the primary controlling factors.

High elevation ecosystems have not been extensively studied in British Columbia. The coastal alpine zone in recently deglaciated areas of Garibaldi Park was described by Archer (1963). Fraser (1970) examined pioneer succession and the relationship between vegetation and environment in three glacial valleys in Garibaldi Park. These were at subalpine elevations (1464-1525 m). Brink (1959;1964) also discussed pioneer species and plant communities in Garibaldi Park. The subalpine zone of the coastal forest was characterized by Brooke et al. (1970). Kuramoto and Bliss (1970) described subalpine meadows in the Olympic Mountains of Washington.

Ecological work in the southern interior of British Columbia has been done on the Engelmann spruce-subalpine fir zone near Kamloops (Arlidge, 1955) and in the Nelson Forest District (Utzig et al., 1978). Subalpine parkland vegetation was not classified in either study. Eady (1971) included both alpine and timberline vegetation in her study on Big White Mountain as did Douglas and Bliss (1977) in their description of the vegetation in the North Cascades Range of Washington and British Columbia and Del Moral (1979) in his classification of high elevation vegetation in the Wenatchee Mountains of Wash-

ington. Scheffler (1972) briefly described high elevation communities in the Ashnola in relation to wildlife habitat. Timberline vegetation in Washington and Oregon is discussed by Franklin and Dyrness (1973), who also suggest that very few data are available from the alpine zone. Pojar (1977) examined alpine and subalpine communities in the Gladys Lake Ecological Reserve and surrounding Spatsizi Plateau Wilderness Park in north central British Columbia. The alpine vegetation of Nevis Mountain and vicinity in northeastern British Columbia was discussed by Lord and Luckhurst (1974) in relation to stone sheep habitat.

Aside from research in the Ashnola (Morrison, 1972) and on Nevis Mountain (Luckhurst, 1973), little work has been done in British Columbia on alpine-subalpine vegetation in relation to grazing use by domestic animals. A general discussion of the fescue grasslands of western Canada was presented by Looman (1969) and Hanson (1951) defines condition classes for mountain rangelands in southwest Alberta. On the other hand, alpine range research in the western United States has a long history. Grazing of high elevation rangelands by domestic livestock was common in the Central Rockies of the United States as early as the mid-1800's. The demand for forage at high elevations increased as a result of overstocking on lower more accessible rangelands. Early use was almost entirely unregulated but in the early 1900's people began to voice concerns about depleted ranges, erosion, excessive livestock numbers, and lack of management. National Forests were established in the United States at about this time and the management of mountain rangelands began (Turner and Paulsen, 1976). Much of the range research done in the mountains of the western United States is applicable to the high elevation ranges in B.C. as the principles of sound range management are not influenced by the 49th parallel. Application of these principles, however, requires a knowledge of local conditions as well as an understanding of these range principles.

The period of grazing in alpine and subalpine ecosystems is necessarily short, resulting from topographic and climatic limitations. The growing season is only 6-10 weeks (Thilenius, 1975) and it is often difficult to predict its length. Site variations can significantly affect plant development and of course various species differ in their rate of development. It is hard to reconcile this variability with the requirement for a specific time period in which to graze the summer rangelands. A knowledge of both plant growth and soil conditions is necessary in order to set acceptable limits on the grazing season.

The snow pack and rate of snow melt are the major factors determining range readiness (Turner and Paulsen, 1976; Thilenius, 1975). Dormancy in plants may be broken as early as April or as late as August. Although some species may begin growth under 50-100 cm of snow, the breaking of dormancy is more often associated with the melting of snow cover, soil and air temperatures rising above $0^{o}C$ and the presence of liquid water (Bliss, 1962). Costello (1939) correlated the developmental stages of important range plants with date of snow melt. He found that in subalpine meadows flowering stalks were in evidence an average of 33 days after the snow had disappeared. Seeds had ripened an average of 99 days after snow disappearance. For every 1000 foot increase in elevation there was a delay of roughly 10-14 days in the date at which a particular stage of growth was reached (north-facing slopes might be even later). Thus cattle cannot be allowed merely to drift to the higher ranges as plant development may not be sufficient to provide adequate forage and still allow for recovery of vigor and completion of the seasonal growth cycle (Ellison, 1944; Costello, 1939).

The soil is most susceptible to damage after snow disappearance. There is an abundance of water from the melting snow and soil moisture content reaches a high of about 30 percent of the dry weight of soil (Costello, 1939). An early grazing season might result in an increase in trampling damage on wet soils.

Summer growth of plants is influenced primarily by temperature and precipitation. Early in the season temperature largely determines the rate of growth (Billings and Mooney, 1968). Costello (1939) found that there was an inverse relationship between temperature and the number of days required to complete any stage of development. This correlation is not as apparent later in the growing season when drought, photoperiod and carbohydrate accumulation become the more critical factors limiting growth (Billings and Mooney, 1968), while summer precipitation can extend the length of the growing season (Costello, 1939). In some years there may be little or no viable seed production or germination because of soil drought or a cold growing season with temperatures that inhibit flowering and fruiting (Bliss, 1962; Billings and Mooney, 1968). If grazing extends late into September, preformed flower buds in both dicots and monocots may be removed resulting in an alteration of the flower-root reserve replenishment cycle. This could have adverse affects on plant growth in the following year (Thilenius, 1975). Thus it is imperative that grazing neither begin too early nor extend too late into the season if a good vegetative cover is to be maintained.

The quantity and quality of forage produced on the range is an important consideration in calculating the carrying capacity of any range unit. Most high elevation range units are a composite of many plant communities and an overall estimate of productivity is often both difficult and inadequate unless proper distribution can be assured. Although the quantity and quality of

forage in a community is not identical from site to site the values reported in the literature can be used to determine the approximate range that might be expected from a given habitat type.

Moisture and species composition are the most important factors affecting productivity. Xeric sites generally have a low herbage production while sites with available moisture are highly productive. Subalpine mixed grass-forb meadows have the highest average productivity with values ranging from 110-220 g/m^2 (air dry weight) (Johnson, 1962; Turner and Paulsen, 1976). Hurd (1961) describes Idaho fescue (Festuca idahoensis Elmer) stands with a herbage production of 364 g/m^2 (air dry weight) with grasses and sedges contributing an average of 54 percent of the total production. Idaho Fescue alone had an average contribution of 19 percent. This meadow type is found also in the alpine and represents the most productive sites there. Generally alpine meadow and turf sites have a productivity range of 7-122 g/m^2 (air dry weight) (Paulsen, 1960; Hurd, 1961; Johnson, 1962; Wasser and Retzer, 1966; Thilenius, 1975). Highest production was on the sedge meadow sites and lowest was on windswept turf sites and stands with less than 50 percent plant cover (Paulsen, 1960). According to Branson and Lommason (1958) heavy use can decrease the productivity of mountain rangelands by as much as 50 percent. Dwarf willow and wet meadow sites also had relatively low reported productivity - values were 22 and 82 g/m^2 respectively (Johnson, 1962).

There has been remarkably little information published from British Columbia on the quantity of forage at high elevations. Brink et al. (1972) reported values for three alpine locations in British Columbia In Garibaldi, an area of high snowfall, Lupinus arcticus S. Wats. meadows had a net productivity of 95 g/m^2 at 1707 m and 188 g/m^2 at 1990 m, while Phyllodoce empetriformis was four times as productive with a value of 805 g/m^2 at 1990 m. In the

drier environment of the Ashnola, Danthonia - Carex meadows on Flatiron Mountain had a reported value of 176.8 g/m^2 (2164 m) with Carex meadows at 138 g/m^2 (2256 m). Productivity estimates from Nevis Mountain in the north ranged from a low of 36 g/m^2 on high elevation (1820-1920 m) grasslands to a high of 234 g/m^2 on lower elevation (1554-1570 m) Elymus-Agropyron meadows.

Mountain forage species generally provide a high quality diet. Turner and Paulsen (1976) suggested that forage grown in the open tends to have a higher carbohydrate content than that grown in the shade. In vitro dry matter digestibility of alpine forage was relatively high throughout the grazing period (Strasia et al., 1970; Thilenius, 1975). Average percent digestibility of grasses was 64 percent; sedges and forbs 60 percent; and cushion plants 44 percent (Thilenius, 1975). Nitrogen was highest early in the grazing season (which began in July) and decreased with time, but generally remained above the required levels (Strasia et al., 1970). Crude protein averaged 50 percent greater and phosphorus 100 percent greater in alpine grasses of the southeastern Canadian Cordillera than in comparable species (at the same phenological stage) from a lower elevation Festuca scabrella association, while alpine sedges averaged twice the levels of the non-alpine species (Johnston et al., 1968). Both crude protein and phosphorus levels were highest at the leaf stage and declined with advancing maturity. By late summer, crude protein levels were frequently below recommended maintanance levels (8.3 percent) for cows and calves although calcium levels were generally adequate (Pond and Smith, 1971; Paulsen, 1969; Johnston et al., 1968).

Forbs are an important part of the diet of sheep while they form a small percentage of the cattle diet. Paulsen (1969) found several forbs to be nutritionally superior to grasses during the first half of the grazing season,

and they were above minimum required levels of crude protein, phosphorus and calcium even after they were dry and decumbent. Many of these forbs were highly preferred during the first half of the growing season and were utilized as heavily as the grasses although their contribution to the diet was not as high because their productivity was relatively low (Paulsen, 1969).

Forage preference and utilization are important factors to consider in the management of rangelands. "Key" forage species may not be always the most preferred, and highly preferred species may be subjected to severe grazing pressure if they are not considered in the determination of grazing levels. Table I lists some of the species preferred by cattle on mountain grassland ranges.

Relatively little research has been done on the diet of domestic sheep on alpine-subalpine meadows (Pickford and Reid, 1942; May, 1960; Paulsen, 1960; Johnson, 1962; Strasia et al., 1970; Pond and Smith, 1971). Sheep appear to prefer forbs; 60-70 percent of their diet consists of forbs (Thilenius, 1975); however Strasia et al. (1970) reported that by late summer forbs had decreased to 31 percent of the diet. This was probably a function of seasonal availability, although red and sheep fescues (Festuca rubra L. and F. ovina L.) were found to be a major part of the diet and were highly preferred on the alpine ranges in the central Rocky Mountains (Strasia et al., 1970). Generally forbs are at the top of both lists but forage utilization does vary among sites. May (1960) found that forbs were a more important part of the sheep diet in basins while sedges and grasses were important on ridges (Table II).

Establishing acceptable grazing levels is not an easy task where the topography is rugged. Utilization is not uniform and livestock distribution may be related more directly to the nature of the topography than to the vegetation (Ellison, 1944). Conservative levels of use are recommended because of

TABLE I. Selective list of forage preference by cattle on mountain grassland ranges in Colorado and Wyoming

	Species (in general order of preference)
Festuca thurberi Vasey range in Colorado (Paulsen, 1969)	Helianthella quinquinervis (Hooker) A. Gray Poa pratensis Erigeron macranthus Nutt. Agoseris spp. Lathyrus leucanthus Rydb. Festuca idahoensis Stipa lettermannii Festuca thurberi Koeleria cristata Carex spp.
Festuca idahoensis Elmer range on sedimentary soils in Wyoming (Pond and Smith, 1971) (includes only major grasses and sedges)	Poa ampla Festuca idahoensis Bromus pumpellianus Scribn. Agropyron spp. Poa secunda & P. canbyi Poa interior Danthonia intermedia Stipa columbiana Carex petasata Carex obtusata Koeleria cristata

Table II. Selective list of forage preference by sheep on Festuca idahoensis Elmer range in western Colorado (May, 1960)

	Species (in order of preference)
ridge community	Oxytropis sericea Nutt. Bromus spp. Agropyron spp. Lupinus sericeus Pursh Poa secunda Presl. Aster spp. & Erigeron spp. Danthonia intermedia Koeleria cristata
basin community	Allium brevistylum S. Wats Taraxacum officinale Agoseris glauca Oxytropis sericea Aster spp. & Erigeron spp. Agropyron spp. Bromus spp. Carex phaeocephala Phleum alpinum Lupinus sericeus Poa secunda Danthonia intermedia Trisetum spicatum Potentilla diversifolia Poa spp. Koeleria cristata Geum triflorum Achillea millefolium

the fragility of high elevation environments and the short growing season. Recovery from damage can take 30 years or more (Ellison, 1949) and, according to the work of Pickford and Reid (1942), the grazing capacity of range in deteriorated condition (the second weed stage) was 96 percent lower than in climax condition. This does not achieve the basic purpose of range management which was defined by Ellison (1944) as: "to maintain the resource in such a condition that it will supply man with a maximum of the products and services he needs, or if the resource is already depleted to restore it to that condition".

Suggested utilization of green fescue (Festuca viridula Vasey) range in Oregon & Washington was 50 percent (Pickford and Reid, 1942). In the Uinta Mountains, sheep stocking guides are based on 40 percent utilization of forage species on wet meadows and 30 percent on other communities (Lewis, 1970). Utilization of less than 40-45 percent was required to maintain or improve forage production of Idaho fescue on alpine cattle range in the Bighorn Mountains of Wyoming (Beetle et al., 1961). Thilenius (1975) states that "light to moderate removal (20-30 percent of herbage) appears to be a reasonable range of allowable use".

The basic objective of high elevation range management should be to maintain a balance between topography, climate, soils, plants and animals (Ellison, 1944). An effective plant cover and a stabilized soil are fundamental to sound management. The diversity of sites and plant communities in mountain rangelands precludes the widespread management goal of a particular species composition or successional stage. However, once the primary objective has been met, the range manager can attempt to "develop and maintain those types and species combinations which are most valuable as forage", but this requires a detailed knowledge of the species, their relative abundance, and their relative desir-

ability (Ellison, 1944). This information is not readily available for most mountain rangelands.

The condition of mountain rangelands is influenced to some extent by forage preference as selectivity affects the direction of change in vegetation under grazing. According to Ellison (1944), "mountain range in good condition is characterized by a mixture of many species, of which a large proportion are palatable". Those species which are continually selected for may have difficulty in completing their life cycle since the short growing season generally coincides with the grazing season. However, radical changes in species composition require many years (Ellison, 1944) and plant composition may show little change even when other signs of damage resulting from grazing are apparent (Lewis, 1970). Relative changes in abundance and a decline in vigor of the palatable species are the more visible vegetative evidences of change in range condition (Evanko and Peterson, 1955; Lewis, 1970). The result is a decline in forage value.

Changes in vegetation are often associated with changes in soil and microclimate. In areas of rugged topography, the soil-stabilizing influence of the vegetation is especially important (Ellison, 1944). Water surface run-off increases with a decrease in plant cover and the chances for erosion are greater when the soil is exposed to the full influence of sun, wind and water (Forsling, 1931; Ellison, 1944; Turner and Paulsen, 1976). Pickford and Reid (1942) found that the soil loss from a green fescue stand in the second weed stage, as defined by Sampson (1919), was 2076.9 metric tons per ha. Less organic matter is incorporated into the soil as a result of over-grazing (heavy grazing can decrease the amount of litter by 25 percent) which may cause poorer water retention and infiltration rates (Ellison, 1949; Pond and Smith, 1971). Direct trampling of soil increases these problems (Ellison, 1944).

These factors place great stresses on plant growth. Furthermore, the loss in vegetative cover allows the soil temperature to rise faster in the spring and continue higher throughout the summer (Turner and Paulsen, 1976). A side effect of this change in microclimate is earlier maturation of the vegetation (Turner and Paulsen, 1971). In addition, bare soil is hotter in the day (resulting in increased evaporation) and colder at night (frost heaving is greater in bare spaces) (Ellison, 1949) which hinders seedling establishment. Thus it can be difficult to restore a depleted range to satisfactory condition.

Indicators are often used in order to judge range condition. Discretion must be used however, as they can indicate different things under different conditions. Ellison (1944) provides an excellent discussion of indicators of condition and trend in high elevation range-watersheds.

The improvement of range condition has been attempted throughout a variety of programs. Of prime importance is the regulation of grazing by riding, salting and fencing to prevent unequal distribution and undue congregation of animals (Pickford and Reid, 1942). Fencing, water development and trail building (though expensive in rugged terrain and in some cases requiring annual maintenance) may help to maintain proper distribution and to minimize further damage to areas already suffering from heavy use. Seeding has been used rather unsuccessfully in attempts to halt erosion (Evanko and Peterson, 1955; Thilenius, 1975). When desirable plants are scarce, seeding may be necessary. Ellison (1949) suggests mulching of the soil surface to improve the microclimate for seedling establishment. These areas should be protected until plants are well established. Fertilization was generally felt to be uneconomic (Billings and Mooney, 1968; Thilenius, 1975; Turner and Paulsen, 1976) although fertilizer does increase palatability and might therefore be used to improve cattle distribution. Pond and Smith (1971) found that 56

kg/ha of nitrogen fertilizer in the Idaho fescue community resulted in a 5 percentage point increase in crude protein content and increased production by as much as 168 kg/ha. The cost was not evaluated.

All of these range improvement techniques should be used in conjunction with appropriate regulation of grazing use. Delaying the start of the grazing season would allow forage plants to reach a stage that would minimize damage from grazing (Costello, 1939). A knowledge of plant development at different elevations would allow an ecologically meaningful regulation of the time of grazing and division of the range into grazing units (Branson and Lommason, 1958). When based on local conditions, grazing systems, such as rotation or rest-rotation, were found to benefit mountain ranges grazed by cattle (Johnson, 1965; Turner and Paulsen, 1976). However, Pond and Smith (1971) suggest that stocking rates are more important than systems of grazing. Light to moderate grazing maintains plant vigor, allows for adequate seed production and helps to sustain or improve the microenvironment (Ellison, 1949). Certainly these factors are fundamental to improved range condition. Even when a grazing scheme is implemented levels of use should be monitored and the results of the system evaluated.

This requires a basic knowledge of plant species and communities in the area under management. The range manager is able to develop or maintain those plant communities which provide the most valuable forage only when he knows what species are present and their relative abundance. This information in conjunction with a knowledge of species palatability allows the range manager to judge the condition of specific parts of the range and to establish objectives against which range trend can be assessed (Ellison, 1949). The framework for improved range management is provided by vegetation classification.

CHAPTER 3

Methodology

Environment, physiognomy and species composition were the main characteristics used in the classification and mapping of vegetation. The distribution of taxa is controlled largely by environment and groups of species are characteristic of specific habitats. These habitats, which form a mosaic over the landscape, may have distinct boundaries or may grade into each other, depending on the steepness of environmental gradients (Buttrick, 1978). Physiognomy can be used for identification of broad vegetation units, which are then refined and classified on the basis of species composition and ecological site characteristics.

Ecological terminology often requires clarification. In this thesis "stand" refers to a specific example of vegetation which was sampled and similar stands are grouped into plant communities. A "community" is considered to be a specific, concrete assemblage of plants which has boundaries and can be described in terms of its structure, species composition and environment. The characteristics of the communities, as here defined, are based on the stand characteristics.

The a posteriori mode of classification discussed by Kuchler (1967) provided the basis for the methods used in the study. In this approach one "maps first, and classifies later". Maps of the study area were made from B.C. Forest Service black-and-white, 40-chain air photos. (These were used because they were readily available at a minimal cost.) Physiognomically homogeneous vegetation units were delineated on the air photos prior to the field work and were used to locate sampling sites in the field.

Field work was carried out in the summer of 1977. Familiarity with the study area was gained during a two week reconnaissance survey in June. Vege-

tation sampling was done in July and August. The Gang Ranch cabin in Relay Valley (elevation 1640 m) was used as the base camp. All supplies and research collections were transported in and out by helicopter. Aside from the initial trip into the cabin all transportation was by foot.

An extensive collection of the vascular plants, bryophytes and macrolichens was made during the summer. Vascular plant identification was based on Hitchcock & Cronquist (1973) and Hultén (1968). Assistance in the identification of mosses was given by Dr. W.B. Schofield and Mr. B. Tan. Hale (1969) was used for lichen identification. Part of the lichen collection was identified by Mr. M.T. Goward and a few difficult specimens were identified by Mr. G. Otto. A list of all species identified is found in Appendix A. Voucher specimens have been deposited in the UBC herbarium and ecological duplicates are on file in the Forest Service herbarium at Williams Lake.

Two hundred and thirty-nine sites were sampled during the field season. The sampling procedure was adapted from Douglas (1974) and Pojar (1977). This system is basically a reconnaissance-type technique which allows for a large area to be covered in a limited amount of time but still gives quantitative data. Sample plots were randomly located within the homogeneous units delineated on the air photos. Plot size was related to plant physiognomy according to the scale used by Pojar (1977):

	radius of circle
herbaceous	1 m
low shrub	3 m
tall shrub	7 m
forested	15 m

Crown cover was estimated for all species found within the plot using the 6 cover classes of Daubenmire (1959) (0-5, 5-25, 25-50, 50-75, 75-95, 95-100

percent). Cover estimates were also made for rock, bare ground and litter. For each plot environmental data were collected on slope, aspect, elevation, hygrotope, and soil temperature at a depth of 20 cm. Hygrotope assessments are a relative rating of available moisture during the growing season where mesic is considered average, xeric is drier than average, hygric is wetter than average, and hydric is saturated throughout much of the growing season. It is a subjective classification. Rare species, which occured within the stand but outside the plot, were also recorded.

Vegetation tables were constructed with the aid of computer programs written by Klinka and Phelps (1978) and by Ceska and Roemer (1972). Plots were grouped according to floristic and environmental similarities. Sorensen's coefficient was used by the Ceska and Roemer Program (1972) to calculate mean similarity of the plot groupings. The formula for this index of similarity is IS = $C/\frac{1}{2}(A+B)$ where C = the number of species common to two releves, A = the total number of species in releve A, and B = the total number of species in releve B. The larger the value the greater the similarity. Similarity indices of 25-50 percent are common (Mueller-Dombois and Ellenberg, 1974). Cover and constancy were used to evaluate species significance. Both dominants and characteristic species were used to describe the community types. Constancy was based on the percentage of plots (P) in which species were present. The constancy classes are according to the Braun-Blanquet scale (Klinka & Phelps, 1978).

Percent presence	constancy	
81-100	V	constantly present
61-80	IV	mostly present
41-60	III	often present
21-40	II	seldom present
1-20	I	rare

For communities with fewer than five plots, constancy was replaced by a simple relative frequency value calculated using the fraction of plots in which a species was present (e.g. 2/3 = 66 percent). A mean species significance (MS) value was obtained by converting the cover class to percentage using the midpoint value. The average cover percentage was then converted back to a cover class which represents the mean species significance. For example, a species present in 5 plots which form a plant association might have cover class values of 1, 2, 3, 4, and 5. The corresponding percent midpoint values are 2.5, 15, 37.5, 62.5, and 85. The average of these values is 40.5 percent or cover class 3. Tables for each community are presented in the results section. The species are arranged by layers, by decreasing constancy within each layer, and by decreasing mean species significance within each constancy class. Species occurring in only one plot are listed at the bottom of each table. The resulting tables for each community are presented in the results section.

An inventory map was drawn to illustrate the distribution of the plant community types (Appendix C). No management interpretations have been included. The map was produced at the scale of the air photographs used in the study (40 chain or 1:29,200) although some of the communities are small and barely distinguishable at this scale. To map at a larger scale would have required different photographs and more time than was justified for this phase of the study. Delineation of units would be more accurate at a larger scale, however. Where mapping units represent two community types, the first one is dominant. Meadows are outlined with solid lines as these units represent the primary grazing areas for cattle and are therefore of greatest importance to the range manager.

CHAPTER 4

Results

The alpine and subalpine rangelands in the Chilcotin Ranges are composed of a number of plant communities interwoven to form a complex pattern over the landscape. In the subalpine zone open meadows grade into shrub thickets and forest, while shrublands, fellfields and fescue meadows characterize the alpine zone. There is often no clear distinction between alpine and subalpine community types. For this reason, and the fact that each management unit incorporates both vegetation zones, all data were treated together. Nineteen plant communities have been classified based on the results of the Ceska-Roemer tabular analysis program (Ceska and Roemer, 1972). They fall into five main physiognomic types and will be presented accordingly. The abbreviations will be used in later figures and on the vegetation map.

I. Forest

1. Picea engelmanii - Abies lasiocarpa (pa)
2. Pinus albicaulis - Juniperus communis (pj)

II. Shrub

A. Tall Shrub

1. Salix barclayi - Carex aquatilis (SC)
2. Salix barrattiana (SA)
3. Salix brachycarpa - Salix barclayi (SB)
4. Salix brachycarpa - Festuca spp. (SF)
5. Salix brachycarpa - Phleum alpinum (SP)
6. Arctostaphylos uva-ursi - Amelanchier alnifolia (AA)

B. Alpine Dwarf Shrub

1. Salix cascadensis (SD)
2. Dryas octopetala (DO)
3. Dryas octopetala - Festuca altaica (DF)

IV. Meadow

1. Carex aquatilis/rostrata (CA)
2. Carex nigricans (CN)
3. Festuca altaica - Festuca brachyphylla (FF)
4. Festuca brachyphylla (FB)
5. Festuca brachyphylla - Phleum alpinum (FP)
6. Phleum alpinum - Carex phaeocephala (PC)
7. Koeleria cristata (KC)

V. Rock-talus-lichen Terrain Unit (rt)

A dichotomous key to the field identification of these community types is presented in Figure 8. This key is based on physiognomy and characteristic species combinations derived from the Ceska-Roemer tabular analysis program (1972). Species groups and releve or community types are simultaneously formed by this computer program. The species group is formed under various percent combinations which define the minimum number of species required for a releve to contain this species group (e.g. 5/10) and the maximum number of occurrences outside the group. Species are treated separately for each stratum. Those releves characterized by a particular species group are combined to form community types. A total of sixteen species groups are used to characterize the nineteen community types.

Group 1: 5/10

Abies lasiocarpa A1, B2, C
Picea engelmanii A1, B1
Vaccinium parvifolium
Linnaea borealis
Pyrola secunda
Lophozia hatcheri
Letharia columbiana

Group 2: 1/1

Carex rostrata

Group 3: 1/3

Carex aquatilis
Drepanocladus aduncus
Plagiomnium rostratum

Group 4: 3/7

Salix brachycarpa
Salix barclayi
Betula glandulosa
Equisetum arvense
Luzula parviflora
Aulacomnium palustre
Tomenthypnum nitens

Group 5: 1/3

Salix barrattiana
Eriophorum polystachion
Carex canescens

Group 6: 2/3

Salix cascadensis
Arenaria obtusiloba
Pedicularis ornithorhyncha

Group 7: 1/3

Dryas octopetala
Cetraria nivalis
Cetraria cucullata
[Cladonia squamulose]

Group 9: 2/4

Festuca brachyphylla
Penstemon procerus
Polemonium pulcherrimum
Geum triflorum

Group 10: 1/3

Phleum alpinum
Trisetum spicatum
Arenaria capillaris

Group 11: 1/1

Carex nigricans

Group 12: 3/8

Koeleria cristata
Agropyron caninum
Arctostaphylos uva-ursi
Poa interior
Erigonum umbellatum
Cirsium hookerianum
Rosa acicularis
Erigeron speciosus

Group 13: 2/6

Phacelia sericeus
Smilacina stellata
Amelanchier alnifolia
Shepherdia canadensis
Penstemon fruticosus
Rosa acicularis

Group 14: 1/1

Juniperus communis
Populus tremuloides

Group 15: 2/5

Pinus albicaulis A, B1, B2
Phyllodoce empetriformis
Poa nervosa

Group 8: 2/3

Festuca altaica
Cetraria islandica
[Cladonia squamulose]

Group 16: 2/4

[Black crustose lichens]
Rhizocarpon geographicum
Oxytropus campestris
[Crustose lichens]

These diagnostic groups, with their corresponding releve or community types, are presented in Table III. One additional group is included. Group 17 includes species which appear to have increase in abundance and distribution in areas that have been disturbed. It is represented in 2/3 of the communities described. Releve type 19 is characterized by this species group only which requires the presence of four of the followng nine species:

Cerastium arvense
Achillea millefolium
Carex phaeocephala
Taraxacum officinale
Potentilla diversifolia
Fragaria virginiana
Galium boreale
Poa pratensis
Tortula norvegica

This table utilizes only 68 species (out of 423 collected in the study area) to characterize the community types. Other species having a high constancy or dominance will be discussed in the individual community descriptions.

Forest Types:

The subalpine forest was not extensively sampled, as it provides only a limited amount of forage. It is however an important component of the landscape and is an essential part of the habitat requirements for wildlife. Two broad coniferous types are apparent from the limited data collected - the Picea engelmanii-Abies lasiocarpa (spruce-fir) type and the Pinus albicaulis-Juniperus communis (white bark pine-juniper) type. In addition, there are successional stands of Populus tremuloides (quaking aspen) that have been

Figure 8. Dichotomous key for the identification of plant community types

1a Tree or shrub layer (greater than 30 cm) present.
- 2a Tree species dominant
  - 3a Evergreen forest
    - 4a At least (5/10) of the Abies lasiocarpa species group (1) are present. . . . . Picea-Abies forest (pa)
    - 4b At least (2/5) of the Pinus albicaulis species group (15) are present. . . . . Pinus albicaulis forest (pj)
  - 3b Deciduous forest with Populus tremuloides and species group (13) present . . . . . Populus tremuloides forest (AA)
- 2b Shrubs dominant
  - 5a At least (3/7) species from Salix brachycarpa species group (4) are present.
    - 6a Salix barrattiana is present . . . . . Salix barrattiana alpine shrub wetland (SA)
    - 6b Salix barrattiana not present; Salix barclayi and/or S. brachycarpa dominant
      - 7a At least 1/3 species from the Carex aquatilis or Carex rostrata species groups are present in herb strata . . . . . Salix barclayi shrub wetland (SC)
      - 7b Understory composed of a variety of grasses and forbs of low cover values . . . . . Salix barclayi-Salix brachycarpa shrubland (SB)
  - 5b Less than 3 species from the Salix brachycarpa species group are present.
    - 8a At least 2/6 species from the Amelanchier alnifolia group (14) are present (may contain scrub Populus tremuloides or P. trichocarpa). . . . . Arctostaphylos uva-ursi-Amelanchier alnifolia dry shrubland (AA)
    - 8b Shrub layer is dominated by Salix brachycarpa and/or Betula glandulosa
      - 9a Herbaceous vegetation dominated by Festuca altaica and Salix brachycarpa-Festuca brachyphylla species groups (8 and 9). . . . . Salix brachycarpa-Festuca shrub meadow (SF)
      - 9b Herbaceous vegetation dominated by Phleum alpinum and Carex phaeocephala (species group 10) . . . . . Salix brachycarpa-Phleum shrub meadow (SP)

1a Vegetation characterized by sedges, grasses, forbs and/or low shrubs less than 50 cm; crustose lichens predominate in 18b.
- 10a Carex aquatilis or Carex rostrata dominant (species groups 2 or 3); generally on wet sites . . . Carex aquatilis/rostrata wetland (CA)
- 10b Vegetation composed of a variety of species; not dominated by Carex species groups (except Carex nigricans)
  - 11a Salix cascadensis (species group 6) dominant . . . . . Salix cascadensis dwarf willow (SD)
  - 11b Salix cascadensis absent
    - 12a Vegetation dominated by the Dryas octopetala species group (7) with or without the Festuca altaica species (8)
      - 13a Contains 2/3 species from the Festuca altaica species group . . . . . Dryas octopetala-Festuca altaica meadow (DF)
      - 13b Lacks 2/3 species from the F. altaica species group; vegetation dominated by grasses, forbs and sedges . . . . . Dryas octopetala fellfield (DO)
    - 12b Vegetation dominated by grasses, forbs and sedges
      - 14a At least 3/8 species from the Koeleria species group (13) are present . . . . . Koeleria cristata dry meadow (KC)
      - 14b Does not contain three species from the Koeleria group; vegetation dominated by Festuca spp., Phleum alpinum or Carex nigricans (except in 18b by lichens)
        - 15a At least 2/4 species from group (9) present or 2/3 from the Festuca altaica group (8)
          - 16a Festuca altaica and F. brachyphylla are codominant grasses . . . . . Festuca spp. meadow (FF)
          - 16b Festuca brachyphylla species group present but lacks 2/3 species from F. altaica group
            - 17a Contains 2/3 species from the Phleum alpinum species group (10) or one species with a cover greater than 1. . . . . Festuca-Phleum alpinum meadow (FP)
            - 17b Festuca brachyphylla species group dominant; Oxytropus campestris dominant on rocky soils. . . . . Festuca brachyphylla meadow (FB)
        - 15b Festuca spp. absent; vegetation dominanted by sedges, forbs, lichens or Phleum alpinum
          - 18a At least 1/3 species from Phleum alpinum species group (10) present
            - 19a Carex nigricans present . . . . . Carex nigricans snowbed meadow (CN)
            - 19b Carex nigricans absent; vegetation dominated by Phleum alpinum, Trisetum spicatum and Carex phaeocephala . . . . . Phleum alpinum-Carex phaeocephala meadow (PC)
          - 18b Lacks Phleum species group; contains 2/4 species from the black crustose lichen species group (16) . . . . . Rock-talus-lichen terrain unit (rt)

Table III. Summary floristic table showing characteristic species groups for the nineteen community types. Constancy values are recorded only when a species occurs in 20% or more of the plots included in the community type.

Community Type	Pe Al	Cr	Ca	Sb Ca	Sa	Sb Sb	Sb Fab	Sb Pa	Sc	Do	Do Fa	Fa Fb	Fb	Fb Pa	Pa Cp	Cn	Kc	Au Aa	Pa Jc	Rt	19
Number of Plots	5	1	5	8	9	14	17	7	6	12	12	18	24	20	15	4	24	12	5	9	5
Species/Plot x 10	256	10	62	203	240	265	297	271	198	172	244	215	181	200	168	152	195	224	430	94	124
Mean Similarity	47	100	27	30	33	31	39	41	51	28	46	45	35	41	32	30	39	42	46	25	36
Group 1																					
Abies lasiocarpa B2	V																		IV		
Abies lasiocarpa C	IV																				
Lophozia hatcheri	IV																				
Pyrola secunda	IV																				
Letharia columbiana	V																				
Linnaea borealis	III																				
Vaccinium parvifolium	III																				
Abies lasiocarpa A1	III																				
Picea engelmanii A1	IV																				
Picea engelmanii B1	III																				
Group 2																					
Carex rostrata		1	II																		
Group 3																					
Carex aquatilis			V	IV																	
Depranocladus aduncus			II	IV	II																
Plagiomnium rostratum			II	II																	
Group 4																					
Salix brachycarpa				IV	II	V	V	V													
Aulacomnium palustre				IV	IV	IV															
Betula glandulosa				IV	IV	III	III														
Equisetum arvense				III	IV	IV		II													
Luzula parviflora				II	III	IV										3					
Salix barclayi				V		IV															
Tomenthypnum nitens				IV	III																
Group 5																					
Salix barrattiana					V																
Eriophorum polystachion					II																
Carex canescens			II		II																
Group 6																					
Salix cascadensis									V												
Pedicularis ornithorhyncha									IV		II										
Arenaria obtusiloba									V		III										
Group 7																					
Dryas octopetala							II					V	IV								
Cetraria nivalis							IV					II	III								
Cetraria cucullata							III					II	III								
Group 8																					
Festuca altaica						II	V		II			V	V	II							
Cetraria islandica							III				II	V	IV								
[Cladonia squamulose]							II		II			III	IV						II		
Group 9																					
Festuca brachyphylla					II	II	V	II	IV	III	V	V	V	III				II		II	
Penstemon procerus					II	II	III	IV		II		IV	III	IV	II		II	II	II		
Polemonium pulcherrimum						II				II		IV	IV	IV			III	III	IV	II	
Geum triflorum		II					II					II	IV	IV			III	III			
Group 10																					
Phleum alpinum				III	III		V							IV	IV				II		
Trisetum spicatum					II		IV			II	II	II	II	III	III	3			IV		
Arenaria capillaris							II			II	II	IV		III	II		II		IV		
Group 11																					
Carex nigricans																4					
Group 12																					
Koeleria cristata													II				V	V			
Agropyron caninum							III							II			III	III			II
Arctostaphylos uva-ursi						II							II				II	V	II	II	
Poa interior																	III	III			II
Eriogonum umbellatum																	II	III	II		
Cirsium hookerianum																	II	IV	II		
Rosa acicularis C																	IV	III			
Erigeron speciosus																	III	III			
Group 13																					
Amelanchier alnifolia																		IV			
Phacelia sericeus																		III			
Smilacina stellata																		III			
Shepherdia canadensis																		III	II		
Penstemon fruticosus																		III			
Rosa acicularis B2																		III			
Group 14 (associated spp.)																					
Juniperus communis																		III	V		
Populus tremuloides																		II			
Group 15																					
Pinus albicaulis																			V		
Phyllodoce empetriformis																			II		
Pinus albicaulis A1																			III		
Poa nervosa																			II		
Pinus albicaulis																			III		
Group 16																					
[Black crustose lichens]	II						II		III	III	III						II	II	II	IV	
Rhizocarpon geographicum	II								IV	III	IV								II	V	
Oxytropus campestris										II			III				II			III	
[Crustose lichens]									II	II									II	III	
Group 17																					
Cerastium arvense		II			II	II	IV	III		II	II	V	V	V	II		V	IV	II	II	V
Achillea millefolium	II			II	III	III	IV	V				IV	IV	V	V		V	V	V		V
Carex phaeocephala									II			IV	III	IV	IV		III	II	II		III
Taraxacum officinale								III						II	III		II		III	II	III
Potentilla diversifolia	II			II	IV	III	V	V	V	III	V	V	IV	IV	IV						III
Fragaria virginiana	III			IV		II		IV						III	III		IV	IV	V		III
Galium boreale								IV					III	III	II		V	IV	II		II
Tortula norvegica						II	III	II	III			II	II	II	II		II				II
Poa pratensis																					III

classified by the predominant understory vegetation - either a Koeleria cristata (Junegrass) meadow or a dry shrub (Arctostaphylos-Amelanchier) type - and will be discussed with those communities.

1. Picea engelmanii - Abies lasiocarpa forest: (Table IV)

The spruce-fir forest type occurs commonly on north to north-west facing slopes but was found also along drainage channels on southeast facing slopes in Relay Valley. Flat valley bottoms to steep (27^{o}) slopes support this type of vegetation. Best development within the study area occurs from 1600 to 1865 meters on mesic or hygric sites. At higher elevations subalpine park-land with tree islands of stunted subalpine fir replace the continuous forest.

Picea engelmanii (Engelmann spruce) and Abies lasiocarpa (subalpine fir) dominate the canopy in mature stands. Tree height averages 10-11 meters. Occasional even-aged stands of lodgepole pine (Pinus contorta) have resulted from past fires, but spruce and fir are present in the subcanopy strata. The shrub layers are generally poorly developed, giving the community an open appearance and young trees are frequently the only species present. However, snowbush (Rhododendron albiflorum) was abundant on the steep, north facing slopes of Relay Valley and Barclay's willow (Salix barclayi) was common in the spruce swamp of the valley floor. Numerous species are found in the herb layer. Arnica cordifolia, Pedicularis bracteosa, Epilobium angustifolium, Pyrola secunda, Vaccinium parvifolium, Linnaea borealis, Lupinus nootkatensis, and Fragaria virginiana all have a high constancy (60 percent) but generally a low cover. Subalpine fir seedlings were present in all but the wettest stands. Common lichens and bryophytes are Cladonia spp., Peltigera aphthosa, Drepanocladus uncinatus, Lophozia hatcheri, Brachythecium spp., Pohlia nutans, and Polytrichum juniperinum. Letharia columbiana is a constant epiphyte.

Table IV. Picea engelmanii-Abies lasiocarpa forest

Plot Number		Mean	209	225	89	206	88
Biogeoclimatic Unit			ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1757.0	1830	1865	1670	1820	1600
Slope Gradient (°)		13.8	27	19	3	17	3
Aspect			310	110	10	269	F
Hygrotope			mesic	mesic	mesic	mesic	mesic
Soil Temperature (°C)		8.3	9	9	7	8	8.5
Litter		3	2	3	4	3	2
Bare Ground		2			2		2
Rocks		1	1	2			
Species	P	MS			COVER CLASS		
TREES							
A1							
Picea engelmanii	80.0	2		2	2	3	2
Abies Lasiocarpa	60.0	2	2	3		2	
Pinus contorta	40.0	2	3		4		
A2							
Picea engelmanii	40.0	2				2	2
A3							
Picea engelmanii	40.0	1				2	1
Pinus contorta	40.0	1	1		2		
SHRUBS							
B1							
Picea engelmanii	60.0	1	2			1	1
Abies lasiocarpa	40.0	2		2	2		
B2							
Abies lasiocarpa	100.0	3	2	3	2	3	2
HERBS							
C							
Arnica cordifolia	100.0	1	2	2	2	2	1
Abies lasiocarpa	80.0	1	+	+	1	2	
Pedicularis bracteosa	80.0	1	1	1		1	1
Epilobium angustifolium	80.0	1		1	1	1	1
Pyrola secunda	80.0	1	1		1	1	1
Vacinnium parvifolium	60.0	2	3		1		2
Linnaea borealis	60.0	2		2	2		1
Lupinus nootkatensis	60.0	1	2		1	1	
Fragaria virginiana	60.0	1		2		1	1
Thalictrum occidentale	40.0	2		2		2	
Aster foliaceous	40.0	1		1			2
Lillium columbianum	40.0	1		1		1	
Achillea millefolium	40.0	1		1		1	
Potentilla diversifolia	40.0	1		1		1	
BRYOPHYTES AND LICHENS							
DH							
Cladonia spp.	80.0	2	3	1	1	1	
Peltigera apthosa	80.0	2	2		1	3	1
Drepanocladus uncinatus	80.0	2	2	1	+		2
Lophozia hatcheri	80.0	1	2	1		1	1
Brachythecium spp.	60.0	2	1	2		2	
Pohlia nutans	60.0	2			2	2	1
Polytrichum juniperinum	60.0	1		1	1	2	
Pleurozium schreberi	40.0	2			2	2	
Bryum spp.	40.0	1	1	2			
Dicranum scoparium	40.0	1			+	1	
Leptobryum pyriforme	40.0	1	1				+
DW							
Letharia columbiana	100.0	2	1	1	1	2	2
DR							
Rhizocarpon geographicum	40.0	1	1	2			
[Black crustose lichens]	40.0	1	1	1			

Other species with a frequency of 20% or less and their cover:

Rhododendron albiflorum 5, Salix barclayi 3, Juniperus communis 1, Salix sitchensis 1, Carex disperma 4, Equisetum arvense 3, Petasites frigidus 3, Equisetum scirpoides 2, Habenaria obtusata 2, Poa nervosa 2, Pyrola asarifolia 2, Rubus acaulis 2, Artemesia norvegica 1, Cornus canadensis 1, Osmorrhiza chilensis 1, Vaccinium deliciosum 1, Valeriana dioica 1, Anemone occidentalis 1, Carex aquatilis 1, Carex phaeocephala 1, Carex rossii 1, Erigeron speciosus 1, Galium trifidum 1, Geum triflorum 1, Lonicera involucrata 1, Luzula parviflora 1, Moneses uniflora 1, Polygonum viviparum 1, Rosa acicularis 1, Saxifraga arguta ? x ? lyallii 1, Stellaria crispa 1, Valeriana sitchensis 1, Pinus albicaulis +, Aulacomnium palustre 3, Plagiomnium ellipticum 3, Tomenthypnum nitens 2, Amblystegium serpens 1, Atriplex patula 1, Blepharastoma trichophyllum 1, Calypogeia muelleriana 1, [Cladonia squamulose 1], Climacium dendroides 1, Lophozia spp. 1, Plagiochila asplenioides 1, Timmia austriaca 1, Helodium blandowii 1, Kiaeria starkei 1, Cladonia spp. 1, [Crustose lichens 1]

Species group 1 contains the diagnostic species for the community. These species have a high fidelity for this forest type as they are found almost exclusively in only this association. Mean similarity of the releves is 47 (based on Sorensen's coefficient). Plot 88 represents a wet variation of the community as species group 3 and 4 are also present. A more detailed study of the subalpine forest probably would lead to the characterization of several spruce-fir forest types. For the purpose of this study one general mesic to hygric forest type is sufficient.

2. Pinus albicaulis - Juniperus communis dry forest: (Table V)

This association occurs on ridges or rocky south to southeast facing slopes in the subalpine parkland zone. All of the stands sampled were on the north side of Relay Valley between 1790 and 2015 meters. Relief is generally straight to convex. Slopes of 11^{o} were most common but 40^{o} was recorded at one site. The soil is stony and well drained. This community type falls onto the dry end of the hygrotopic scale. Mean similarity of the five plots is 46.

Pinus albicaulis (whitebark pine) forms the most conspicuous element of this community. The forest is generally open with the dominant trees averaging 3-8 meters in height. Subalpine fir is usually present in the tall shrub strata along with whitebark pine. Juniperus communis (mountain juniper) is a constant low shrub component along with (to a lesser extent) subalpine fir and whitebark pine. Characteristic members of the herb layer include Arnica cordifolia, Achillea millefolium, Agoseris glauca, Antennaria microphylla, Epilobium angustifolium, Lupinus nootkatensis, Trisetum spicatum, Erigeron peregrinus, Artemesia norvegica, Arenaria capillaris, Solidago multiradiata, Castilleja miniata, Polemonium pulcherrimum, and Sedum lanceolatum all with a

Table V. Pinus albicaulis-Juniperus communis dry forest

Plot Number		Mean	70	227	47	213	136
Biogeoclimatic Unit			ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1926.0	2015	1985	1940	1900	1790
Slope Gradient (°)		16.6	11	11	11	10	40
Aspect			108	146	100	360	180
Hygrotope			xeric	xeric	submesic	submesic	xeric
Soil Temperature (°C)		11.2	11	10	8.25	12.5	14.25
Litter		2	1	2	1		2
Bare Ground		2	2	1	2	1	3
Dead Wood		3				3	
Rocks		2	2	3	1	1	1
Species	P	MS			COVER CLASS		
TREES							
A1							
Pinus albicaulis	80.0	3	3	2	3		3
A3							
Pinus albicaulis	60.0	2	2	2			2
SHRUBS							
B1							
Pinus albicaulis	100.0	2	1	1	3	2	2
Abies lasiocarpa	80.0	2	1	2	2	3	
B2							
Juniperus communis	100.0	2	2	2	3	1	2
Abies lasiocarpa	80.0	2	1	1	2	2	
Pinus albicaulis	60.0	1	2	1			1
Shepherdia canadensis	40.0	2		2			2
Pinus contorta	40.0	1	1	1			
HERBS							
C							
Arnica cordifolia	100.0	2	2	2	2	1	1
Achillea millefolium	100.0	2	1	2	2	1	1
Antennaria microphylla	100.0	1	1	1	1	2	1
Fragaria virginiana	100.0	1	1	2	1	1	1
Epilobium angustifolium	100.0	1	1	1	1	1	1
Lupinus nootkatensis	80.0	3	3	1	4	2	
Trisetum spicatum	80.0	2	2	2	2	2	
Erigeron peregrinus	80.0	2	2	1	2	2	
Artemesia norvegica	80.0	2	2	1	2	1	
Arenaria capillaris	80.0	2	2	1	2	1	
Castilleja miniata	80.0	1	1	1	1	2	
Solidago multiradiata	80.0	1	1	2	1	1	
Polemonium pulcherriumum	80.0	1	1	1		1	1
Sedum lanceolatum	80.1	1	1	1	1		1
Vaccinium caespitosum	60.0	2	2	1	3		
Agoseris glauca	60.0	1			2	1	1
Juncus drummondii	60.0	1		1	2	1	
Agoseris aurantiaca	60.0	1		1	1	1	
Gentiana amarella	60.0	1		1	1	1	
Hieracium gracile	60.0	1	1		1	1	
Potentilla diversifolia	60.0	1	1	1	1		
Silene parryi	60.0	1		1		1	1
Arctostaphylos uva-ursi	40.0	2		2			3
Phleum alpinum	40.0	2			2	2	
Poa nervosa	40.0	2	2				2
Sibbaldia procumbens	40.0	2			2	2	
Agrostis variabilis	40.0	1			1	2	
Astragalus alpinus	40.0	1		1			2
Carex phaeocephala	40.0	1			2	1	
Carex rossii	40.0	1	1		2		
Eriogonum umbellatum	40.0	1			1		2
Phyllodoce empetriformis	40.0	1			2	1	
Poa Palustris	40.0	1		2		1	
Anenome multifida	40.0	1		1			1
Antennaria neglecta	40.0	1		1		1	
Aster foliaceus	40.0	1		1		1	
Cerastium arvense	40.0	1				1	1
Cirsium hookerianum	40.0	1		1			1
Danthonia intermedia	40.0	1	1	1			
Galium boreale	40.0	1		1			1
Penstemon procerus	40.0	1	1		1		
Pinus albicaulis	40.0	1	1				+

Table V continued

Plot Number			70	227	47	213	136
BRYOPHYTES AND LICHENS							
DH							
Peltigera rufescens	60.0	1	1	1	1		
Polytrichum juniperinum	40.0	2			4	2	
Polytrichum piliferum	40.0	2	3	1			
Bryum caespiticium	40.0	2	2			2	
Cladonia squamulose	40.0	2			2	2	
Stereocaulon spp.	40.0	1	2			1	
Cladonia spp.	40.0	1		1		1	
DR							
[Crustose spp.]	40.0	1	2	1			
Rhizocarpon geographicum	40.0	1		2		1	
[Black crustose]	40.0	1		1		1	

Other species with a frequency less than 20% and their cover:

Abies lasiocarpa 2, Pinus contorta 2, Picea engelmanii 1, Salix spp. 1, Symphoricarpos albus 1, Vaccinum deliciosum 1, Poa cusickii 3, Arnica parryi 2, Arnica sororia 2, Bromus inermis 2, Erigeron speciosus 2, Linnaea borealis 2, Poa fendleriana 2, Poa interior 2, Vacinnium parvifolium 2, Abies lasiocarpa 1, Allium cernuum 1, Equisetum arvense 1, Erigeron acris 1, Agrophyron spicatum 1, Amelanchier alnifolia 1, Arabis drummondii 1, Arabis lyallii 1, Arnica latifolia 1, Artemesia frigida 1, Aster sibiricus 1, Carex albonigra 1, Draba spp. 1, Elymus glaucus 1, Epilobium alpinum 1, Festuca brachyphylla 1, Festuca saximontana 1, Geum triflorum 1, Heracleum lanatum 1, Hordeum jubatum 1, Koeleria cristata 1, Oxytropus campestris 1, Pachistima myrsinites 1, Phacelia sericea 1, Poa glauca 1, Pyrola secunda 1, Ranunculus eschscholtzii 1, Rhinanthes crista-galli 1, Rosa acicularis 1, Senecio lugens 1, Senecio streptanthifolius 1, Stipa columbiana 1, Thalictrum occidentale 1, Valeriana sitchensis 1, Veronica wormskjoldii 1, Picea engelmanii +, Cladonia ecmocyna 2, Peltigera malacea 1, Brachythecium albicans 1, Brachythecium spp. 1, Ceratadon purpureus 1, Cetraria islandica 1, Cetraria nivalis 1, Pohlia nutans 1, Tortula norvegica 1, Letharia columbiana 2

constancy of IV or V and an average cover class of 1 or 2. Phyllodoce empetriformis and Poa nervosa are associated species of low significance. They have a higher fidelity to this type than to any other community which explains their presence in the diagnostic species group (15) for this association.

Tall Shrub Types:

There are six shrub dominated community types in the study area.

1) Salix barclayi-Carex aquatilis shrub wetland: (Table VI)

This association was found in the subalpine zone along streams in all the valleys studied ranging in elevation from 1615-1920 meters. The slope was minimal (0-7°) in all but one stand which had numerous small rivulets flowing down a moderate slope of 17°. The aspect ranges from flat valley bottoms to north or northeast facing slopes. It is identified by the presence of both species groups 3 and 4. The presence of Carex aquatilis indicates areas subject to extensive flooding and indeed the hygrotope in this community ranged from hygric to hydric throughout the growing season. The eight plots in this type have a mean similarity of 30.

Salix barclayi (Barclay's willow) is the dominant shrub, attaining a height of 90-120 cm. It has a mean species significance of 4 (62.5 percent). Betula glandulosa (dwarf birch) also has a high constancy (V) but has an average cover of only 2 (15 percent). A small amount of Salix brachycarpa is found occasionally in the shrub strata as well. Carex aquatilis (water sedge) is the most characteristic species of the herb-layer. It has a constancy of IV and a mean cover of 4.

Fragaria virginiana var. glauca (blueleaf strawberry) also has a high constancy (IV) but has a low mean species significance. Three primary mosses with a constancy of IV characterize the D layer - Aulacomnium palustre,

Table VI. Salix barclayi - Carex aquatilis shrub wetland

Plot number		Mean	155	38	87	159	166	112	83	53
Biogeoclimatic unit			ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1806.9	1860	1620	1615	1845	1830	1920	1790	1975
Slope Gradient (°)		4.6	2	0	0	5	0	17	6	7
Aspect			82	F	F	60	F	80	2	350
Hygrotope			hygric	hygric	hygric	subhygric	mesic	hygric	subhygric	hygric
Soil Temperature (°C)		9	10	7	7.5	10	9	11.5	10	7
Litter		2	2	2	2	3	2	1	1	1
Bare Ground		2	1		1		1	1	2	2
Rocks		1								1
Species	P	MS					COVER CLASS			
SHRUBS										
B2										
Salix barclayi	100.0	4	5	3	5	4	5	3	4	5
Betula glandulosa	75.0	2	2	2	2	1	1	3		
Salix brachycarpa	62.5	2		2		3	2		1	2
HERBS										
C										
Carex aquatilis	62.5	3	4	3	2	5	4			
Fragaria virginiana	62.5	1	1		2	1		1	2	
Aster foliaceus	50.0	2	2			2		2	1	
Valeriana dioica	50.0	1	2	1	2	1				
Equisetum arvense	50.0	1		1	1				1	1
Thalictrum occidentale	37.5	2			1	1		3		
Potentilla diversifolia	37.5	1	1						2	1
Senecio pauciflorus	37.5	1	1		2	1				
Epilobium angustifolium	37.5	1			1	1		1		
Luzula parviflora	37.5	1	1					1		1
Pedicularis bracteosa	37.5	1				1		1		1
Pyrola asarifolia	37.5	1		1	1			1		
Ranunculus eschscholtzii	37.5	1	1			1				1
Carex disperma	25.0	2		3	3					
Poa cusickii	25.0	1							2	2
Rubus acaulis	25.0	1		2	2					
Castilleja miniata	25.0	1				1		2		
Petasites frigidus	25.0	1			2	1				
Senecio triangularis	25.0	1						2		1
Carex rostrata	25.0	1			1					1
Achilles millefolium	25.0	1						1	1	
Carex albonigra	25.0	1				1		1		
Geum triflorum	25.0	1			1				1	
Stellaria longipes	25.0	1	1				1			
Veronica wormskjoldii	25.0	1	1							1
Picea engelmanii	25.0	1			1		+			
BRYOPHYTES AND LICHENS										
DH										
Aulacomnium palustre	75.0	3	3		3	2	2	4		5
Tomenthypnum nitens	62.5	2	2	2	3	1		2		
Drepanocladus aduncus	62.5	2	2	1	3			1	1	
Pohlia nutans	50.0	1				1	+			+
Plagiomnium rostratum	37.5	2	2	3	2					
Bryum caespiticium	25.0	2	+						3	
Peltigera spuria	25.0	1					1	2		
Plagiomnium ellipticum	25.0	1	2			1				
Brachythecium spp.	25.0	1					+		1	

Other species with a frequency less than 20% and their cover:

Pinus contorta 2, Astragalus alpinus 3, Carex nigricans 3, Poa alpina 3, Anemone occidentalis 2, Antennaria microphylla 2, Antennaria pulcherrima 2, Astragalus robbinsii 2, Carex limnophila 2, Carex norvegica 2, Carex rossii 2, Eriophorum polystachion 2, Festuca brachyphylla 2, Phleum alpinum 2, Saxifraga arguta ? x ? lyallii 2, Smilacina stellata 2, Taraxacum officinale 2, Valeriana sitchensis 2, Agoseris aurantiaca 1, Anemone multifida 1, Arnica sororia 1, Artemesia norvegica 1, Botrychium lunaria 1, Caltha biflora 1, Carex dioica 1, Epilobium alpinum 1, Equisetum scirpoides 1, Galium boreale 1, Geum macrophyllum 1, Juncus drummondii 1, Penstemon procerus 1, Poa interior 1, Poa leptocoma 1, Polygonum viviparum 1, Pyrola minor 1, Senecio streptanthifolius 1, Trisetum spicatum 1, Cratadon purpureus 2, Polytrichum strictum 2, Peltigera apthosa 2, Cladonia spp. 1, [Cladonia squamulose 1], Climacium dendroides 1, Leptobryum pyriforme 1, Peltigera rufescens 1, Philonotis fontana 1, Amblystegium serpens +, Bryum spp. +, Bryum weigelii +, Desmatadon latifolius +, Polytrichum juniperinum +.

Tomenthypnum nitens and Drepanocladus aduncus. There are no lichens characteristic for this community.

There was no evidence of past cattle grazing in this community type.

2) Salix barrattiana alpine shrub wetland: (Table VII)

This is the alpine and timberline counterpart of the Salix barclayi wet shrub community just described. It occurs between 1920 and 2150 meters, with a north aspect and a mean slope of 6^{o}. Two of the nine plots have a south aspect. These are in an open basin (Two Lakes Basin) on the north side of the lakes. They maintain a mesic to hygric moisture status throughout the summer as do the other stands. This community type is found only in areas of slow moving water or with a seepage influence, possibly resulting from late snow melt. The terrain was generally slightly concave. The mean similarity of these plots was 33.

Salix barrattiana is the dominant shrub present in all stands. It attains an average height of 60 cm and a mean cover of 3 (37.5 percent). An associated shrub, Betula glandulosa (dwarf birch) has a constancy of IV and a mean species significance of 2 (15 percent). Salix brachycarpa and Salix barclayi are occasionally present. The herb layer is characterized by Polygonum viviparum, Equisetum arvense, Potentilla diversifolia, and Veronica wormskjoldii all with a constancy of IV and a mean species significance of 1 or 2. Fourteen sedges were identified for this association all of which have a low frequency of occurrence. Aulacomnium palustre is the only bryophyte of significant constancy (IV) and mean cover class (3). No lichens were found in this community.

The community type is identified by the presence of Salix barrattiana in species group 5. Eriophorum polystachion and Carex canescens have a high fidelity for this shrub type although they also occur in sedge wetlands. Most stands also meet the criteria for species group 4.

Table VII. Salix barrattiana alpine shrub wetland

Plot number		Mean	231	219	20	19	230	61	18	193	201
Biogeoclimatic unit			ESSF	AT	ESSF	ESSF	ESSF	AT	ESSF	AT	AT
Elevation (M)		2030.0	1950	2190	1955	1960	1955	2065	1965	2110	2120
Slope Gradient (°)		6.1	8	4	3	3	8	9	6	14	0
Aspect			162	22	360	320	170	352	330	326	352
Hygrotope			subhygric	hygric	hygric	hygric	hygric	hygric	hygric	hygric	hygric
Soil Temperature (°C)		7.6	8	8	9	7	7	7	4.5	7.5	10.5
Litter		2	2	2	1	1	1	1	1	1	1
Bare Ground		2	2	1	1		1		2	1	3
Rocks		1			2						2
Species	P	MS					COVER CLASS				
SHRUBS											
B2											
Salix barrattiana	100.0	3	2	1	2	4	3	5	3	3	1
Betula glandulosa	66.7	2	3	3	2	2	3		2		
Salix brachycarpa	22.2	2		4	2						
HERBS											
C											
Polygonum viviparum	77.8	2		1	2	1	1		2	1	2
Equisetum arvense	77.8	1	1	2		1	2		1	1	1
Potentilla diversifolia	66.7	2	2	1	2				1	2	1
Veronica wormskjoldii	66.7	1		1	1	1			1	1	1
Poa alpina	55.6	2	2		2	2			1		2
Luzula parviflora	55.6	2		1			2	2		1	2
Anenome occidentalis	55.6	1			1			2	2	1	1
Phleum alpinum	55.6	1	2	1	1					1	2
Artemesia norvegica	55.6	1	2	1	1	1			1		
Achillea millefolium	44.4	1	1		2				2	1	
Caltha biflora	44.4	1				1	1		2		2
Senecio triangularis	44.4	1		1				1	2	2	
Salix nivalis	33.3	2		2						3	2
Carex capitata	33.3	2		1	4						1
Aster foliaceus	33.3	1	2	1			2				
Carex canescens	33.3	1	2			2			1		
Carex albonigra	33.3	1					2	1			1
Eriophorum polystachion	33.3	1			1	2			1		
Festuca brachyphylla	33.3	1			2				1		1
Ranunculus eschscholtzii	33.3	1			1				1	1	
Castilleja miniata	33.3	1	1		1				1		
Carex norvegica	22.2	2				2			3		
Solidago multiradiata	22.2	1	2		2						
Valeriana dioica	22.2	1	2		2						
Antennaria alpina	22.2	1			2					1	
Arnica diversifolia	22.2	1						2		1	
Agoseris glauca	22.2	1		2							1
Delphinium glaucum	22.2	1	1	2							
Epilobium alpinum	22.2	1								1	2
Juncus drummondii	22.2	1								2	1
Petasites frigidus	22.2	1		2				1			
Poa arctica	22.2	1								1	2
Valeriana sitchensis	22.2	1				2		1			
Erigeron humilis	22.2	1		1							1
Erigeron peregrinus	22.2	1		1							1
Senecio pauciflorus	22.2	1		1		1					
Cerastium arvense	22.2	1		1	1						
Pedicularis bracteosa	22.2	1						1	1		
Penstemon procerus	22.2	1	1		1						
Rubus acaulis	22.2	1				1	1				
Stellaria longipes	22.2	1		1							1

Table VII continued

Plot Number			231	219	20	19	230	61	18	193	201
BRYOPHYTES AND LICHENS											
DH											
Aulacomnium palustre	77.8	3		2		2	2	5	2	4	2
Tomenthypnum nitens	55.6	2		2		2	1		2	1	
Philonotis fontana	55.6	1			1		2	+		1	2
Peltigera apthosa	33.3	1		1		1			2		
Drepanocladus aduncus	22.2	1		3		1					
Lophozia spp.	22.2	1				2			2		
Brachythecium spp.	22.2	1		2							1
Climacium dendroides	22.2	1			2	1					
Peltigera rufescens	22.2	1	2							1	
Peltigera spuria	22.2	1					1				1
Desmatadon latifolius	22.2	1	1		+						

Other species with a frequency less than 20% and their cover:

Salix barclayi 3, Carex disperma 3, Carex aquatilis 2, Carex nigricans 2, Carex pachystachya 2, Carex rostrata 2, Equisetum palustre 2, Equisetum variegatum 2, Eriophorum brachyantherum 2, Festuca altaica 2, Juncus mertensianus 2, Luzula piperi 2, Arnica mollis 1, Carex phaeocephala 1, Abies lasiocarpa 1, Anenome multifida 1, Antennaria microphylla 1, Arenaria obtusiloba 1, Arnica cordifolia 1, Carex aurea 1, Carex dioica 1, Carex limnophila 1, Carex paysonis 1, Danthonia intermedia 1, Draba spp. 1, Epilobium angustifolium 1, Epilobium latifolium 1, Gentiana amarella 1, Gentiana prostrata 1, Geum triflorum 1, Halpopappus lyallii 1, Linnaea borealis 1, Petasites sagittatus, Pyrola minor 1, Salix scouleriana 1, Sibbaldia procumbens 1, Taraxacum officinale 1, Veronica serpyllifolia 1, Bryoerithrophyllum recurvirostrum 2, Distichium capillaceum 2, Hylocomium splendens 2, Pohlia nutans 2, Peltigera ? canina 2, Polytrichum juniperinum 1, Bryum spp. 1, Cladonia spp. 1, [Cladonia squamulose 1], Mnium thompsonii 1, Plagiomnium rostratum 1, Polytrichum strictum 1, Tortula norvegica 1, Campylium stellatum +, Drepanocladus revolvens +, Drepanocladus uncinatus +, Lophozia ? incisa +, Plagiomnium ellipticum +, Timmia austriaca +

Several plots had evidence of trampling disturbance. This may have been the result of past use by cattle as these sites were often on the edge of ponds used by cattle. The high moisture levels in this community make it extremely sensitive to trampling damage which results in soil mucking.

3) Salix brachycarpa-Salix barclayi shrubland: (Table VIII)

This low shrub community type is found in both alpine and subalpine environments on all but south-facing slopes. It ranges in elevation from 1835 to 2120 meters. The majority (85 percent) of sites occur on gentle lower slopes and valley bottoms with a slope gradient between 0 and 15° and are found throughout the study area. Two stands are on steep (35°) west-facing slopes. This association has a good moisture regime ranging from mesic to hygric. The terrain is predominantly concave. The mean similarity for the fourteen plots included in this type was 31.

Salix brachycarpa is the most characteristic shrub for this association. It has a constancy of V and a mean species significance of 3 (37 percent). A height of 60 cm is common for this willow although it occasionally reaches 90-120 cm. Salix barclayi also has a mean species significance of 3 (37 percent) but is present in only 64 percent of the releves giving it a constancy of IV. Luzula parviflora, Aster foliaceous and Equisetum arvense are constants (IV) in the herb strata with average cover values of 1 and 2. The D layer contains only one species of importance - Aulacomnium palustre with a constance of IV and mean species significance of 2 (15 percent). Tomenthypnum nitens is conspicuously absent in all but one plot.

Only species group 4, the Salix brachycarpa group, characterizes this community type. The presence of this group and the lack of groups 3 and 5 can be used to classify plots into this association.

Table VIII. Salix brachycarpa - Salix barclayi shrubland

Plot number		Mean	106	108	119	168	194	162	169	189	120	186	128	125	145	60
Biogeoclimatic unit			ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	AT	AT	ESSF	ESSF	AT	AT	ESSF
Elevation (M)		1982.1	1930	1900	1965	1870	2035	1835	1850	2035	2035	1965	2070	2070	2120	2070
Slope Gradient (°)		9.9	8	0	4	8	11	0	0	15	35	9	10	4	0	34
Aspect			104	F	214	108	8	F	F	300	238	276	118	94	84	304
Hygrotope			hygric	mesic	hygric	hygric	hygric	hygric	mesic	hygric	sub-hygric	hygric	mesic	mesic	sub-hygric	sub-mesic
Soil Temperature (°C)		9.0	10	9.5	8	12	8	10	19	8.5	7	7	9	10	4	4.5
Litter		2	1	1	2	2	1		1	2	3	2	3	2	5	2
Bare Ground		2	1	2	1		1	1	2	1	2	1		1		2
Rocks		1							2			2				1
Species	P	MS								COVER CLASS						
SHRUBS																
B2																
Salix brachycarpa	85.7	3			1	3	2	2	2	2	4	4	5	5	5	2
Salix barclayi	64.3	3	5	5	5	4	3	4	4	2	2					
Betula glandulosa	50.0	2			2	2		2			2		1		2	2
HERBS																
C																
Luzula parviflora	78.6	1	1	1	1		1		1	1	1	1		1	1	1
Aster foliaceus	64.3	2	1	1	2	2		2			2	3	2	3		
Equisetum arvense	64.3	2	3	1	1	3	1		2			1	1	1		
Potentilla diversifolia	57.1	2		2	3					1	2	1		2	1	2
Polygonum viviparum	57.1	1		1	1		1			2	1			1	1	2
Thalictrum occidentale	57.0	2	1	1		3		2			3	2	2			
Anenome occidentalis	50.0	2	2	1						2	2	1		2		1
Poa alpina	50.0	1		1					2	1	1	1		2		2
Stellaria longipes	50.0	1			1			1	1	1		1	1		2	
Achillea millefolium	42.9	2		1						1	2	2		2	2	
Artemesia norvegica	42.9	2								2	2		1	2	1	2
Epilobium angustifolium	42.9	2	1			2		2			2	2	1			
Phleum alpinum	42.9	1	1	1				2			1	2		1		
Poa palustris	42.9	1	1			1		2	1			2		1		
Senecio pauciflorus	42.9	1		1				2		1	1	2	1			
Pedicularis bracteosa	42.9	1	1			1				1	1			1	2	
Fragaria virginiana	35.7	1			2				1		1	1	1			
Cerastium arvense	35.7	1		1								1		1	1	1
Festuca brachyphylla	35.7	1		1					1	1	1				1	
Gentiana amarella	35.7	1		1					1	1	1	1				
Veronica wormskjoldii	35.7	1			1					1	1	1		1		
Solidago multiradiata	28.6	2							1	5	1				1	
Festuca altaica	28.6	2								2			1		2	3
Carex albonigra	28.6	1		2	1					1	2					
Erigeron peregrinus	28.6	1	2							1	1			1		
Valeriana dioica	28.6	1		1	2			1					1			
Astragalus alpinus	28.6	1							1	1	1				1	
Agoseris aurantiaca	28.6	1		1					1		1	1				
Penstemon procerus	28.6	1								1	1	1		1		
Ranunculus eschscholtzii	28.6	1								1	1	1				1
Sibbaldia procumbens	28.6	1		1							1			1		1
Carex pachystacha	28.6	1			+						1	1		1		
Carex disperma	21.4	2			3	2		4								
Equisetum variegatum	21.4	1					2		1			2				
Arnica cordifolia	21.4	1									2		2		1	
Geum macrophyllum	21.4	1			1			2				2				
Pyrola asarifolia	21.4	1	1									2	2			
Myosotis alpestris	21.4	1									1				1	2
Senecio triangularis	21.4	1	2			1		1								
Trisetum spicatum	21.4	1		1								1		1		
Erigeron humilis	21.4	1		1						1						1
Polemonium pulcherrimum	21.4	1							1	1	1					
BRYOPHYTES AND LICHENS																
DH																
Aulacomnium palustre	71.4	2	1	2	1	2	2	2	1	3	2	3				
Tortula norvegica	35.7	1			+				1		1			+	1	
Polytrichum juniperinum	28.6	1		1							2	1		2		
Pohlia nutans	28.6	1		1					1	+						2
Brachythecium spp.	28.6	1			1			1	+			1				
Bryum caespiticium	21.4	2			3							1		3		
Peltigera rufescens	21.4	1	1						2	1						
Bryum spp.	21.4	1					1	2		+						
Peltigera ? canina	21.4	1						1			1	1				
Marchantia polymorpha	21.4	1	1						1			1				
Philonotis fontana	21.4	1			+	1						1				

Other species with a frequency less than 20% and their cover values:

Abies lasiocarpa 2, Salix nivalis 3,2, Cares atrata 2, Carex nigricans 2, Castilleja miniata 2, Vaccinium caespitosum 2,1, Agrostis variabilis 2,1, Poa fendleriana 2,1, Poa fendleriana 2,1, Poa leptocoma 1, Delphinium glaucum 1, Epilobium alpinum 1, Gentiana propinqua 1, Geum triflorum 1, Poa arctica 1, Poa sandbergii 1, Veronica serpyllifolia 1, Antennaria microphylla 2, Caltha biflora 2, Dryas octopetala 2, Juncus drummondii 2, Mitella pentandra 2, Oxytropus campestris 2, Pedicularis ornithorhyncha 2, Trifolium repens 2, Valeriana sitchensis 2, Antennaria alpina 1, Antennaria umbrinella 1, Arabis drummondii 1, Botrychium lunaria 1, Cardamine bellidifolia 1, Carex capitata 1, Carex rossii 1, Carex spectabilis 1, Draba incerta 1, Draba praealta 1, Draba spp. 1, Erigeron speciosus 1, Galium boreales 1, Gentiana prostrata 1, Habenaria obtusata 1, Haplopappus lyallii 1, Heracleum lanatum 1, Juncus mertensianus 1, Luzula spicata 1, Phyllodoce empetriformis 1, Platanthera dilatata 1, Poa nervosa 1, Poa rupicola 1, Pyrola secunda 1, Rubus acaulis 1, Rumex acetosa 1, Saxifraga adscendens 1, Saxifraga arguta ? x ? lyallii 1, Sedum lanceolatum 1, Silene acaulis 1, Silene douglasii 1, Stellaria crispa 1, Taraxacum officinale 1, Picea engelmanii +, Cetraria islandica 1, Cladonia spp. 1, Desmatadon latifolius 1, Drepanocladus uncinatus 1, Ceratadon purpureus +, Pohlia cruda +, Cratoneuron commutatum 5, Hylocomium splendens 3, Tomenthypnum nitens 3, Amblystegium serpens 2, Climacium dendroides 2, Cratoneron filicinum 2, Distichium capillaceum 2, Ditrichum flexicaule 2, Bryoerithrophyllum recurvirostrum 2, Campylium stellatum 1, Cetraria nivalis 1,[Cladonia squamulose 1], Dactylina arctica 1, Dicranum scoparium 1, Hypnum revolutum 1, Lophozia ? obtusa 1, Lophozia hatcheri 1, Mnium thompsonii 1, Pannaria spp. 1, Peltigera malacea 1, Peltigera spuria 1, Solorina crocea 1, Stereocaulon spp. 1, Brachythecium collinum +, Lophozia ? wenzelii +, Cetraria pinastri 1, Black crustose 1,[Crustose lichens 1], Rhizocarpon geographicum 1

Although small amounts of several grasses (Poa alpina, Phleum alpinum, Festuca brachyphylla, Festuca altaica, etc.) were found in most plots, there was no evidence of past grazing use by cattle. The high shrub cover and sparsity of desirable forage provide little incentive for the use of this vegetation type by cattle.

4) Salix brachycarpa - Festuca spp. shrubfield: (Table IX)

This shrubfield is found in mesic to xeric alpine and timberline environments. It ranges in elevation from 1930 to 2240 meters on non-south facing slopes with an average gradient of 13^{o}. The topography varies from convex to slightly concave. Seventeen stands with a mean similarity of 39 were used to characterize this community type.

Salix brachycarpa is the constant (V) dominant of this association. It has a mean species significance of 3 (37 percent) and an average height of 30-60 cm. Betula glandulosa is an associated shrub with a constancy of III. However, in some stands dwarf birch is the only shrub present with an average cover of 3 for the 9 plots in which it is found. Festuca altaica, Festuca brachyphylla and Potentilla diversifolia are the most characteristic species in the herb strata all having a constancy of V and a mean species significance of 2. Additional species with a high constance (IV) and mean species significance of 1 are Solidago multiradiata, Myosotis alpestris, Artemesia norvegica, Polygonum viviparum, and Cerastium arvense. In the D layer, Cetraria nivalis is the only characteristic species. This lichen has a constancy of IV and a mean significance of 1.

This community type is identified first by its physiognomy. There is an obvious shrub stratum but it does not fit into species group 4. The second key to the identification of this community is the presence of species groups 7, 8

Table IX. Salix brachycarpa - Festuca spp. shrubfield

Plot number		Mean	207	93	198	99	148	217	202	97	92	140	181	176	191	15	183	101	195
Biogeoclimatic unit			AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		2098.8	2090	2150	2170	2100	2230	2195	2135	2170	2125	2070	2040	2240	2080	1955	1980	1930	2020
Slope Gradient (°)		13.1	14	11	7	31	0	4	9	15	15	13	0	15	16	7	8	35	22
Aspect			338	360	290	344	F	60	240	58	84	214	F	234	342	150	20	240	208
Hygrotope			sub-xeric	sub-mesic	mesic	xeric	hygric	mesic	sub-mesic	xeric	sub-mesic	sub-mesic	sub-mesic	mesic	sub-mesic	sub-hygric	sub-mesic	xeric	sub-mesic
Soil Temperature (°C)		9.6	5	6.5	9.5	6.5	11	8	11	11	10	7.5	10.5	13	9.5	10	12	12	10
Litter		2	2	2	2	3	2	2	2	3	2	2	2	2	2	2	2	1	2
Bare Ground		2		1	2	2	1	1	1	1	2	2	1	3	1	2	1	2	2
Rocks		2		2	1	1	2	1			2					2		2	
Species	P	MS	COVER CLASS																
SHRUBS																			
B2																			
Salix brachycarpa	82.4	3	2			4		2	2	2	2	4	2	4	5	2	3	3	3
Betula glandulosa	52.9	3	5	2	3		4	4	5			2	3			3			
HERBS																			
C																			
Festuca altaica	94.1	2	2	2	2	3	1	3	2	2	2	1	3	2	3		2	2	3
Potentilla diversifolia	94.1	2	1		1	1	2	2	2	1	2	1	1	1	1	1	1	2	1
Festuca brachyphylla	82.4	2	1		2	1		1	2		3	1	2	2	1	2	2	2	2
Solidago multiradiata	76.5	1			2		1	1	2	1	1	1	1	2		2	2	1	1
Cerastium arvense	76.5	1			1	1			1	1	1	1	1	1	1	1	1	2	1
Artemesia norvegica	70.6	2	2		2	2	1	2	1			2	1		2	1	1	2	
Myosotis alpestris	64.7	1	1		1	1		1	1	1	1	1		1	1			2	
Polygonum viviparum	64.7	1		1	1		1		1	1	1	1	1		1	1	1		
Achillea millefolium	64.7	1	1						1		1	1	1	1	1	1	1	1	1
Luzula spicata	58.8	1	1	1	1			1		1		1	1		1		1	1	
Penstemon procerus	52.9	1		1	1				1		1	1	2	1				2	1
Poa alpina	52.9	1			1	1		1	1			1	1	1		2		1	
Stellaria longipes	52.9	1	1			1	1	1	1			1			1		1	1	
Delphinium glaucum	41.2	1	1						1			1		1	2		1	1	
Rumex acetosa	41.2	1			1			2	1		1	1	1			1			
Sedum lanceolatum	41.2	1			1				1	1	1	1	1				1		
Salix nivalis	35.3	2			3	2	2	2	2						1				
Kobresia myosuroides	35.3	2			1					3	2	2					1		2
Carex capitata	35.3	2		2	1			2			2					2	2		
Senecio streptanthifolius	35.3	1									1	1		1	2		1		1
Agrostis variabilis	35.3	1			1		1	1	1				1			1			
Arctostaphylos uva-ursi	29.4	2								3	2	1					2		2
Agoseris glauca	29.4	1						2					1	1	1	1			
Astragalus alpinus	29.4	1		1						1	2	1						1	
Gentiana amarella	29.4	1							1		1			1			1		1
Dryas octopetala	23.5	2	2	4	2										1				
Geum triflorum	23.5	1									2			2			1		2
Arenaria rubella	23.5	1		1	1							1							
Haplopappus lyallii	23.5	1			1	1	1							1			1		
Poa arctica	23.5	1					1	1	1						1				
Sibbaldia procumbens	23.5	1		1				1	1						1				
BRYOPHYTES AND LICHENS																			
DR																			
Cetraria nivalis	64.7	1	2	2	1	1	1			1		1	1		1		1	1	
Tortula norvegica	58.8	1				+		1	1	2	1	2	1		2			2	1
Cladonia spp.	58.8	1			1	1	1	1	2			1	1		1	1	1		
Cetraria islandica	41.2	1		1						1	1	1	1		1	3			
Bryum spp.	41.2	1		+			1	2				+	+			2		1	
Polytrichum juniperinum	41.2	1			2	1		1	1				1			1	1		
Cetraria cucullata	41.2	1	1	2			1			1		1		1	1				
[Cladonia squamulose]	35.3	1					1	1		3	1	2	2						
Ceratadon purpureus	29.4	1			1							+	2			+	1		
Desmatadon latifolius	29.4	1										1	+		+	1			1
Peltigera apthosa	23.5	1	1					2									1	1	
Stereocaulon spp.	23.5	1			2			1					1				1		
DR																			
[Black crustose lichens]	23.5	1		1	1		1				1								

Other species with a frequency less than 20% and their cover values:

Juniperus communis 1, Carex scirpoidea 2, Epilobium angustifolium 1,2, Carex pachystachya 1,2, Antennaria alpina 1,2, Silene acaulis 1,2, Draba incerta 1, Selaginella densa 1, Androsace septentrionalis 1, Carex albonigra 1, Draba praealta 1, Trisetum spicatum 1, Carex phaeocephala 2, Agropyron caninum 1,2, Anenome multifida 1,2, Antennaria umbrinella 1,2, Poa sandbergii 1,2, Erigeron acris 1, Fragaria virginiana 1, Aster sibiricus 1, Draba spp. 1, Galium boreale 1, Oxytropus campestris 1, Pedicularis ornithorhyncha 1, Phleum alpinum 1, Poa palustris 1, Polemonium pulcherrimum 1, Thalictrum occidentale 1, Valeriana dioica 1, Veronica wormskjoldii 1, Carex nardina 2, Epilobium latifolium 2, Erigeron peregrinus 2, Poa fendleriana 2, Poa glauca 2, Poa prstensis 2, Arnica cordifolia 1, Cardamine bellidifolia 1, Luzula parviflora 1, Abies lasiocarpa 1, Anenome drummondii 1, Antennaria microphylla 1, Arabis lyallii 1, Arenaria capillaris 1, Arenaria obtusiloba 1, Carex spectabilis 1, Danthonia intermedia 1, Draba aurea 1, Erigeron humilis 1, Gentiana propinqua 1, Gentiana prostrata 1, Pedicularis bracteosa 1, Phacelia sericea 1, Picea engelmanii 1, Potentilla nivea 1, Salix spp. 1, Saxifraga bronchialis 1, Saxifraga occidentalis 1, Silene parryi 1, Thlaspi arvense 1, Agrostis borealis +, Dicranum fuscescens 2, Hypnum revolutum 2, Brachythecium spp. 1,2, Peltigera rufescens 1,2, Lophozia floerkei 1,2, Dicranum muehlenbeckii 1, Drepanocladus uncinatus 1, Eurynchium pulchellum +, Hylocomium splendens 1,3, Polytrichum strictum 1,3, Bryum caespiticium 3, Cetraria ericitorum 2, Peltigera malacea 1,2, Peltigera spuria 1, Polytrichum piliferum 1, Bartramia ithyphylla 1, Isopterygium pulchellum 1, Thamnolia subuliformis 1, Mnium thompsonii +, Rinodina spp. 3, Aulocomnium palustre 2, Brachythecium albicans 2, Bryoerithrophyllum recurvirostrum 2, Lecanora spp. 2, Solorina bispora 1, Blepharastoma trichophyllum 1, Blindia acuta 1, Cornicularia aculeata 1, Drepanocladus revolvens 1, Pertusaria spp. 1, Philonotis fontana 1, Psoroma spp. 1, Tortella fragilis 1, Amblystegium serpens +, Cephalozia ? Bicuspidata +, Distichium capillaceum +, Ditrichum flexicaule +, Encalypta vulgaris +, Lescuraea radicosa +, Pohlia cruda +, Pohlia nutans +, Thuidium abietinum +, Cetraria pinastri 1, [Crustose lichens 1],Rhizocarpon geographicum 1

or 9. Festuca altaica must be present or Festuca brachyphylla must have a cover greater than 5 percent.

Evidence of past grazing by cattle is present in this habitat type. Bunch grasses have been close-cropped and the average amount of litter is 15 percent (cover class 2). This community is generally more open than the wetter shrub types and has more desirable grazing species.

5) Salix brachycarpa - Phleum alpinum shrubfield: (Table X)

This shrub-grass meadow community is common in subalpine valley bottomlands between 1632 and 2030 meters. The mean slope gradient is 7^{o} on convex to slightly concave topography. The hygrotope varies from sub-mesic to subhygric where there is seepage from above. The seven stands which characterize this association have a mean similarity of 41.

The shrub stratum is dominated by Salix brachycarpa which has a constancy of V and a mean species significance of 3. Salix sitchensis replaced Salix brachycarpa on the one rocky site that was sampled (in Graveyard Valley). The height of this stratum varies from 30 to 150 cm. The herb stratum is characterized by the grasses Phleum alpinum (alpine timothy) and Trisetum spicatum (spike trisetum). There is little or no fescue present. Important forbs with a constancy of IV or V are Achillea millefolium, Potentilla diversifolia, Thalictrum occidentale, Epilobium angustifolium, Fragaria virginiana, Penstemon procerus, Aster foliaceus and Galium boreale. No bryophytes or lichens are consistently present.

This community type is readily identified by the presence of diagnostic species group 10 (Phleum and Trisetum) in association with a shrub stratum that does not meet the species requirement for the Salix brachycarpa species group (number 4).

Table X. Salix brachycarpa - Phleum alpinum shrubfield

Plot number		Mean	82	52	102	29	40	77	158
Biogeoclimatic unit			ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1878.9	1800	1970	1900	2030	1632	1970	1850
Slope Gradient (°)		7.0	16	5	5	10	3	5	5
Aspect			14	346	290	140	180	70	174
Hygrotope			mesic	submesic	submesic	subhygric	mesic	submesic	mesic
Soil Temperature (°C)		9	9.5	6	9	8	6.5	13	11
Litter		2	2	3	1		1	2	1
Bare Ground		2	1	2	1	1	1	2	
Rocks		1	1						
Species	P	MS	COVER CLASS						
SHRUBS									
B2									
Salix brachycarpa	85.7	4	4	4		4	4	3	4
Salix sitchensis	28.6	2			4			2	
HERBS									
C									
Phleum alpinum	100.0	3	2	2	3	2	2	3	3
Thalictrum occidentale	100.0	2	2	1	2	1	2	2	3
Achillea millefolium	100.0	2	2	1	1	1	2	2	2
Potentilla diversifolia	85.7	2	1	2	3	1	1	2	
Epilobium angustifolium	85.7	2	2	2	1		2	1	2
Aster foliaceus	85.7	2	1	2	1		2	1	2
Fragaria virginiana	71.4	2	2			1	3	1	2
Trisetum spicatum	71.4	2	1	2	2			2	2
Penstemon procerus	71.4	1	1	1	2		1		1
Galium boreale	71.4	1	1			1	1	1	1
Artemesia norvegica	57.1	2	2	3	2	1			
Astragalus alpinus	57.1	2	2		2		1		2
Taraxacum officinale	57.1	2					2	2	1
Carex pachystachya	57.1	1		2	1		1		1
Agropyron caninum	42.9	2					2	2	2
Poa alpina	42.9	2	2	2	2				
Erigeron peregrinus	42.9	1			2	1			
Stellaria longipes	42.9	1					1	2	1
Agoseris aurantiaca	42.9	1	1		1	1			
Agoseris glauca	42.9	1	1			1			1
Cerastium arvense	42.9	1	1	1	1				
Gentiana amarella	42.9	1	1	1					1
Solidago multiradiata	42.9	1	1	1					1
Veronica wormskjoldii	42.9	1	1		1	1			
Equisetum arvense	28.6	2			1			3	
Arenaria capillaris	28.6	2	2	2					
Carex rossii	28.6	1	2	1					
Castilleja miniata	28.6	1			2		1		
Delphinium glaucum	28.6	1	1					2	
Pedicularis bracteosa	28.6	1			2	1			
Valeriana sitchensis	28.6	1			2		1		
Danthania intermedia	28.6	1	1				1		
Epilobium alpinum	28.6	1			1	1			
Festuca brachyphylla	28.6	1	1	1					
Polygonum viviparum	28.6	1				1	1		
Ranunculus eschscholtzii	28.6	1	1		1				
BRYOPHYTES AND LICHENS									
DH									
Cladonia spp.	42.9	1	1	1	1				
Brachythecium spp.	28.6	2	2			4			
Polytrichum juniperinum	28.6	1		2	1				
Tortula norvegica	28.6	1	2		1				
Peltigera malacea	28.6	1		1	1				

Other species with a frequency less than 20% and their cover values:

Betula glandulosa 3, Abies lasiocarpa 1, Gentiana prostrata 2, Geranium richardsonii 2, Geum triflorum 2, Heracleum lanatum 2, Poa cusickii 2, Poa interior 2, Poa leptocoma 2, Senecio triangularis 2, Trollius laxus 2, Arnica sororia 1, Anenome occidentalis 1, Antennaria microphylla 1, Antennaria pulcherrima 1, Arabis drummondii 1, Astragalus miser 1, Astragalus robbinsii 1, Carex phaeocephala 1, Carex scirpoidea 1, Carex spectabilis 1, Draba crassifolia 1, Erigeron speciosus 1, Geum macrophyllum 1, Juncus drummondii 1, Luzula spicata 1, Mitella pentandra 1, Oxytropus deflexa 1, Poa fendleriana 1, Poa palustris 1, Polemonium pulcherrimum 1, Rhinanthes crista-galli 1, Rumex acetosa 1, Salix nivalis 1, Sedum lanceolatum 1, Sibbaldia procumbens 1, Vaccinum caespitosum 1, Valeriana dioica 1, Poa pratensis 3, Agrostis scabra 2, Agrostis variabilis 2, Arnica chamissonis 2, Arnica cordifolia 2, Bromus anomalus 2, Carex nigricans 2, Alectoria ochroleuca 2, Dicranum muehlenbeckii 2, Pohlia nutans 2, Aulacomnium palustre 1, Bryum spp. 1, Peltigera apthosa 1, Lophozia spp. +, [Black crustose lichens 1], Rhizocarpon geographicum 1

Evidence of grazing in this habitat type is not as abundant as in the Salix-Festuca meadow community. There were trails through most stands, cow pies were present, and some grasses obviously had been grazed but either there was not extensive use of this type or regrowth of the dominant grasses was better than in the fescue stands.

6) Arctostaphylos uva-ursi - Amelanchier alnifolia dry shrubland: (Table XI)

This dry shrub association commonly occurs on xeric or subxeric sites with a southerly aspect. Slopes are generally moderate to steep, ranging from 16° to 39° with a mean of 28°. All stands were in the subalpine zone between 1720 and 1940 meters. Bare, rocky soil covered an average of 30 percent of each plot while rocks and coarse fragments averaged 10%. All sites were on convex slopes. Twelve stands with a mean similarity of 42 were used to characterize this community type.

All but one stand included at least one species in the B2 (30cm-2m) layer but no single species is characteristic of the community as a whole. Shrub height rarely exceeded 60 cm. Half of the plots contained Shepherdia canadensis (soopolallie) with a cover of 2 or 3 and half supported scrub aspen or poplar (Populus tremuloides or Populus trichocarpa); however some stands contained both while others contained neither. Although these two variations are of interest there does not seem to be a sufficient difference in the C or D strata of these samples to justify subdividing this community type.

Three prostrate or low shrubs are characteristic of this association. Arctostaphylos uva-ursi (bearberry) has a constance of V and a mean significance of 3. Amelanchier alnifolia (Saskatoon berry) has a constancy of IV and an average cover class of 2, but also has a high fidelity for this community. Rosa acicularis is found in either the B or C strata with a constancy of V (it

Table XI. Arctostaphylos uva-ursi - Amelanchier alnifolia dry shrubland

Plot number		Mean	36	48	138	237	43	211	210	46	35	177	178	80
Biogeoclimatic unit			ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1807.1	1730	1900	1775	1775	1795	1750	1720	1815	1740	1910	1940	1835
Slope Gradient (°)		28.1	18	16	38	32	16	38	39	21	19	32	31	37
Aspect			130	170	180	170	162	206	214	168	134	144	168	138
Hygrotope			submesic	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric
Soil Temperature (°C)		14.7	11	11	19	12	13.5	21	17.5	10	11	14.5	16.5	19
Litter		2	1	1	2	3	2	2	2	1	2	2	2	1
Bare Ground		3	3	2	3	3	4	1	2	2	2	3	4	3
Rocks		2	1	2	1		1	3	2	2	3	2	1	2
Species	P	MS							COVER CLASS					
SHRUBS														
B2														
Shepherdia canadensis	50.0	2	3	2	2	3		2	3					
Rosa acicularis	50.0	2		2	2	2		2				1	1	
Juniperus communis	41.7	2		2	2	1				2		2		
Populus tremuloides	33.3	2						3	2	2	2			
Artemesia frigida	25.0	1					2	3					1	
Symphoricarpos albus	25.0	1	2		1				1					
HERBS														
C														
Achillea millefolium	100.0	2	1	1	1	1	2	1	2	1	1	1	1	2
Arctostaphylos uva-ursi	91.7	3	2	4	3	2		3	2	4	3	2	3	3
Koeleria cristata	83.3	2	2	2		2	2		3	3	2	1	1	2
Cirsium hookerianum	75.0	2	2	1		1	2		1	1		2		1
Galium boreale	75.0	1	1		1	1	2		1	1	1	1	1	
Cerastium arvense	66.7	2	2	2			2		2	1		1	1	2
Amelanchier alnifolia	66.7	2	1		2		2	2		1	1	1		2
Poa interior	58.3	2	2	2	1		2			2	1			2
Antennaria microphylla	58.3	2	2	2		1			2	2	1			2
Smilacina stellata	58.3	1	1	1			1			1		1	1	1
Phacelia sericea	58.3	1	1	1	1			1		1		1	1	
Erigeron speciosus	50.0	2	2		1		2			2	2			2
Eriogonum umbellatum	50.0	2	2	2	2				1	2				2
Agropyron caninum	50.0	2			1		1		2	1			1	3
Anemone multifida	50.0	1	1	2		1				2	1		1	
Penstemon fruticosus	50.0	1	2	1			2	1	1		1			
Fragaria virginiana	41.7	1		2		1		1		2				2
Geum triflorum	41.7	1	1	2			1			2				2
Rosa acicularis	41.7	1	1						1	1	2			1
Polemonium pulcherrimum	41.7	1				1			1	1		1	1	
Thalictrum occidentale	41.7	1				1		1	1	1				1
Festuca brachyphylla	33.3	1	1	2	1									2
Agoseris glauca	33.3	1	1			1				2				1
Bromus anomalus	33.3	1	2						1		1		1	
Sedum lanceolatum	33.3	1	1			1		1			2			
Sitanion hystrix	33.3	1	1			1					2		1	
Senecio streptanthifolius	33.3	1		1								1	1	1
Poa fendleriana	25.0	1				2	2			2				
Astragalus alpinus	25.0	1		1			1				2			
Calamagrostis purpurascens	25.0	1		2								1	1	
Carex phaeocephala	25.0	1		1				1	2					
Penstemon procerus	25.0	1							1	2				1
Castilleja miniata	25.0	1						1	1		1			
Allium cernuum	25.0	1	1					1			1			
Festuca saximontana	25.0	1								1	1	1		
Gentiana amarella	25.0	1				1				1				1
BRYOPHYTES AND LICHENS														
DR														
[Black crustose lichens]	25.0	1		1						2		1		

Other species with a frequency less than 20% and their cover values:

Populus trichocarpa 2, Amelanchier alnifolia 2, Pinus albicaulis 2, Prunus emarginata 1, Arenaria capillaris 1,2, Oxytropus campestris 1,2, Solidago multiradiata 1,2, Elymus glaucus 1,2, Erigeron peregrinus 1, Geum macrophyllum 1, Silene parryi 1, Stipa columbiana 1, Agrostis variabilis 2, Balsamorhiza sagittata 2, Bromus inermis 2, Pachistima myrsinites 2, Poa glauca 2, Poa rupicola 2, Vaccinum caespitosum 2, Carex rossii 1, Crepis occidentalis 1, Poa pratensis 1, Potentilla gracilis 1, Androsace septentrionalis 1, Arabis hirsuta 1, Aster sibiricus 1, Botrychium lunaria 1, Carex albonigra 1, Delphinium glaucum 1, Draba aurea 1, Epilobium angustifolium 1, Habenaria obtusata 1, Hieracium scouleri 1, Lillium columbianum 1, Lupinus nootkatensis 1, Polygonum spergulariaeforme 1, Populus trichocarpa 1, Symphoricarpos albus 1, Taraxacum officinale 1, Trisetum spicatum 1, Desmatadon latifolius 1, Peltigera rufescens 1, Tortula norvegica 1, [Crustose lichens 1]

has a constancy of III for each strata separately). Penstemon fruticosus and Phacelia sericea are associated low shrubs with a constancy of III and an average cover class of 1 but a high fidelity for this type. Koeleria cristata is the most common grass with a mean species significance of 2 (17.5 percent) and a constancy of V. Achillea millefolium, Cirsium hookerianum, Galium boreale and Cerastium arvense are all in constancy classes IV or V with an average cover of less than 5 percent (1). Smilacina stellata with a mean species significance of 1 and a constancy of III is a diagnostic species because of its high fidelity for this association. No bryophytes or lichens are characteristic.

Species group 13 is diagnostic for this community type although the Koeleria species group (12) is generally present as well. It is probable that this is a later successional stage of the Koeleria grassland community which will be described later.

This habitat type appeared to have received little grazing use by cattle; the slopes are too steep and rocky, and there is not an abundance of forage available. However, Saskatoon berry is an important game browse species and soopolallie berries are eaten by bears. In addition aspen has a high grazing preference for sheep, cattle and game (McLean et al., 1964).

Dwarf Shrub Types:

The three dwarf shrub community types are all found in the alpine zone. The prostrate, woody growth form is an adaptation to harsh environmental conditions above treeline.

1) Salix cascadensis dwarf willow shrubland: (Table XII)

This alpine community type occurs only on the Dash Plateau between 2065 and 2310 meters. The mean slope gradient is 8^{o} and all sites had a

Table XII. **Salix cascadensis dwarf willow shrubland**

Plot number		Mean	151	216	220	150	154	153
Biogeoclimatic unit			AT	AT	AT	AT	AT	AT
Elevation (M)		2245.0	2240	2185	2230	2230	2310	2275
Slope Gradient (°)		6.7	4	10	7	8	5	6
Aspect			46	46	336	12	322	360
Hygrotope			submesic	subxeric	subxeric	xeric	xeric	xeric
Soil Temperature (°C)		11.6	9	9	9	13	13	17
Litter		2	2	2	2	2	2	1
Bare Ground		2	2	1	1	1	2	1
Rocks		3	1		1	5	3	5
Species	P	MS			COVER CLASS			
HERBS								
C								
Salix cascadensis	100.0	2	2	3	2	2	2	2
Arenaria obtusiloba	100.0	2	2	1	1	1	2	1
Luzula spicata	100.0	2	2	2	1	1	1	1
Potentilla diversifolia	83.3	2	2	1	2	1	1	
Sibbaldia procumbens	83.3	2	2	2	1	1		1
Poa alpina	83.3	1	2		1	1	1	1
Pedicularis ornithorhyncha	66.7	2	2	1	2	2		
Silene acaulis	66.7	2			1	1	2	2
Festuca brachyphylla	66.7	1	1			1	2	1
Antennaria alpina	66.7	1	1	2		1		1
Polygonum viviparum	50.0	2	2		1		2	
Stellaria longipes	50.0	1	1			1	1	
Agrostis variabilis	33.3	2		2	2			
Carex phaeocephala	33.3	1		1				2
Festuca altaica	33.3	1	2			1		
Haplopappus lyallii	33.3	1					2	1
Artemesia norvegica	33.3	1				1		1
Draba crassifolia	33.3	1	1					1
BRYOPHYTES AND LICHENS								
DH								
Stereocaulon spp.	100.0	2	2	2	3	2	2	1
Polytrichum piliferum	66.7	1	2	2		1		1
Tortula norvegica	50.0	2	2	2			2	
Cladonia spp.	50.0	1	1		1		2	
Polytrichum juniperinum	33.3	1	2		2			
[Cladonia squamulose]	33.3	1					2	1
Drepanocladus uncinatus	33.3	1			2	1		
Hypnum revolutum	33.3	1					2	1
Solorina crocea	33.3	1		1	2			
Peltigera malacea	33.3	1	1			1		
DR								
Rhizocarpon geographicum	66.7	1	1		1	2	1	
[Black crustose lichens]	50.0	1				1	1	1
[Crustose lichens]	33.3	2				2		2

Other species with a frequency less than 30% and their cover values:

Carex pyrenaica 2, Luzula parviflora 2, Pedicularis langsdorfii 2, Androsace septentrionalis 1, Carex albonigra 1, Carex dioica 1, Carex nardina 1, Draba spp. 1, Gentiana propinqua 1, Myosotis alpestris 1, Poa arctica 1, Polemonium pulcherrimum 1, Ranunculus eschscholtzii 1, Trisetum spicatum 1, Bryum spp. 2, Desmatadon latifolius 2, Peltigera apthosa 2, Dicranum muehlenbeckii 1, Lophozia ? obtusa 1, Rinodina spp. 1, Cetraria islandica +, Encalypta vulgaris +

northerly aspect. The soils are generally rocky and well drained with a hygrotope of xeric to sub-mesic. Topography varies from slightly concave to convex. Six plots with a mean similarity of 51 were included in this association.

The herb layer is characterized by Salix cascadensis (cascade willow) with a mean significance of 2 (15 percent), Arenaria obtusiloba (mean significance = 2), Luzula spicata (mean significance = 2), and Poa alpina (mean significance = 1), all of which are in constancy class V. Potentilla diversifolia and Sibbaldia procumbens are present in 71 percent of the stands (IV). Both have an average cover class of 2. Pedicularis ornithorhyncha or P. langodosfii are associated species. The height of the C layer varies from 2-12 cm. Stereocaulon is a constant (V) lichen present in the D layer.

This association is identified by the presence of species group 6, of which Salix cascadensis is the most diagnostic species. Little or no evidence of grazing was found in this community. Those stands located near a source of water did have some cropping of grasses and cow dung present, but by and large, there was not an adequate amount of forage to attract grazing cattle to this habitat type.

2) Dryas octopetala fellfield: (Table XIII)

This fellfield community type is a frequent component of the alpine environment. It was found on moderate to steep non-south facing slopes ranging in elevation from 2075 to 2220 meters. Most stands were along rocky ridges and appeared to be well drained. The hygrotope was xeric to sub-mesic. The diversity of the 12 plots included in this community is suggested by the mean similarity value of 28.

Dryas octopetala is the only constant member of this community type. It occurs in all stands with a mean significance of 3. No other single species

Table XIII. Dryas octopetala fellfield

Plot number		Mean	208	58	59	57	55	142	73	199	141	94	96	144
Biogeoclimatic unit			AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT
Elevation (M)		2159.2	2075	2200	2130	2220	2205	2180	2220	2170	2160	2075	2120	2155
Slope Gradient (°)		17.1	15	32	18	25	18	10	13	4	13	11	20	26
Aspect			348	322	336	310	300	252	70	274	218	356	70	68
Hygrotope			xeric	xeric	submesic	xeric	xeric	xeric	xeric	xeric	xeric	submesic	xeric	mesic
Soil Temperature (°C)		9.9	13	3.5	5.5	4	7	-	15	16.5	12	9	11	13
Litter		2	2	2	2	2	2	2	2	1	3	2	2	2
Bare Ground		2	2	2			3	1	3	3	2	2	2	2
Rocks		3	3	2	1	1	4	4	3	3	2	1	1	
Species	P	MS	COVER CLASS											
HERBS														
C														
Dryas octopetala	100.0	3	3	3	3	2	2	2	2	2	3	1	2	4
Festuca brachyphylla	58.3	1					2	1	1	1	2	1	1	
Potentilla diversifolia	58.3	1			1				1	2	1	1	1	1
Salix nivalis	50.0	2		1	3	1		1				2		2
Artemesia norvegica	50.0	2			2					1	2	2	1	2
Haplopappus lyallii	41.7	1			1				2		2		1	1
Polygonum viviparum	41.7	1		1	2	2						1		1
Antennaria alpina	33.3	1									1	2	1	1
Arenaria capillaris	33.3	1									1	1	2	1
Astragalus alpinus	33.3	1					2		1	1				1
Sibbaldia procumbens	33.3	1			1							1	2	1
Penstemon procerus	33.3	1								1	1	1		1
Cerastium arvense	33.3	1			1	1	1					1		
Kobresia myosuroides	25.0	2		1	2	3								
Luzula spicata	25.0	1			2							1	2	
Silene acaulis	25.0	1			2	2						1		
Carex capitata	25.0	1						1			1	2		
Potentilla villosa	25.0	1				1	2	1						
Myosotis alpestris	25.0	1			1	1				1				
Oxytropus campestris	25.0	1	1			1			1					
Polemonium pulcherrimum	25.0	1							1	1		1		
Sedum lanceolatum	25.0	1								1	1			1
Trisetum spicatum	25.0	1	1							1	1			
Veronica wormskjoldii	25.0	1										1	1	1
BRYOPHYTES AND LICHENS														
DH														
Stereocaulon spp.	33.3	2									4	3	3	1
Polytrichum piliferum	33.3	2									2	3	3	1
Cladonia spp.	33.3	1				1		1			1	1		
Hypnum revolutum	33.3	1	1				1			1		1		
Cetraria cucullata	25.0	1				2	2	2						
Cetraria nivalis	25.0	1				2	2	2						
Cetraria islandica	25.0	1	1			2	1							
Peltigera rufescens	25.0	1	2								1			1
DR														
[Black crustose lichens]	58.3	2	2			1	2	4	1	1	1			
Rhizocarpon geographicum	50.0	1	1			1	1	2	1		1			
[Crustose lichens]	25.0	1	1	2						1				

Other species with a frequency less than 20% and their cover values:

Festuca altaica 2, Arnica rydbergii 1,2, Carex nardina 1,2, Erigeron compositus 1,2, Erigeron peregrinus 1,2, Poa alpina 1,2, Saxifraga bronchialis 1,2, Arenaria obtusiloba 1, Draba spp. 1, Poa rupicola 1, Selaginella densa 1, Cassiope tetragona 4, Carex atrata 2, Carex phaeocephala 2, Carex scirpoidea 2, Juncus parryi 2, Pedicularis ornithorhyncha 2, Poa arctica 2, Poa sandbergii 2, Salix brachycarpa 2, Abies lasiocarpa 1, Solidago multiradiata 1, Agoseris aurantiaca 1, Anenome multifida 1, Carex albonigra 1, Draba nivalis 1, Erigeron humilis 1, Oxyria digyna 1, Ranunculus eschscholtzii 1, Saxifraga adscendens 1, Silene douglasii 1, Stellaria longipes 1, Taraxacum officinale 1, Polytrichum juniperinum 2,3, Alectoria ochroleuca 1,2,[Cladonia squamulose 1,2],Pohlia cruda 1,2, Dicranum muehlenbeckii 1, Tortula norvegica 1, Thamnolia subuliformis +, Bryum spp. 3, Hylocomium splendens 2, Ochrolechia upsaliensis 2, Brachythecium spp. 2, Pohlia nutans 2, Bryum caespiticium 1, Bryoerithrophyllum recurvirostrum 1, Caloplaca spp. 1, Ceratadon purpureus 1, Desmatadon latifolius 1, Blepharastoma trichophyllum +, Climacium dendroides +, Cornicularia aculeata +, Distichium capillaceum +, Tortella fragilis +

is characteristic of this group of plots. Two subtypes can be distinguished. The first contains Festuca brachyphylla and other meadow species such as Artemesia norvegica, Arenaria capillaris, and Antennaria alpina. Kobresia myosuroides is a dominant in the second subtype which is represented by only three sample plots. Polygonum viviparum and Silene acaulis are associated species. Snow willow (Salix nivalis) is found more consistently in the Kobresia subtype. This community attains an average height of 10 cm.

This community type is easily recognized by the presence of Dryas octopetala without the Festuca altaica species group (8) in association. A variety of other species may be present including many crustose lichens. Evidence of grazing in this harsh environment was not prevalent.

3) Dryas-Festuca altaica alpine grassland: (Table XIV)

This community type is restricted to the alpine zone where it covers a large part of the more gentle topography. The mean slope gradient is 9^{o} although one stand was on a moderate 22^{o} slope. The terrain is straight to convex. Best development occurs at an elevation of about 2200 meters on all aspects. Most sites are rocky and well drained with a hygrotope of xeric to sub-mesic. There is a relatively high mean percentage of rock and coarse fragments (15 percent) in addition to an average 15 percent cover of litter. The mean similarity of the twelve plots which comprise this community is 46.

Festuca altaica, Potentilla diversifolia, Salix nivalis, Festuca brachyphylla and Polygonum viviparum are all constant members of this association with a mean significance of 2. Dryas octopetala (the only low shrub element) and Polygonum viviparum are also characteristic with a constancy of IV and mean cover classes of 2 and 1 respectively. The general height of the C stratum is 100-200 cm. The D layer is dominated by the lichens Cetraria

Table XIV. Dryas - Festuca altaica alpine grassland

Plot number		Mean	223	197	221	152	218	147	123	205	222	54	146	149
Biogeoclimatic unit			AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT	AT
Elevation (M)		2213.8	2370	2170	2250	2265	2190	2260	2170	2135	2300	2130	2115	2210
Slope Gradient (°)		9.0	2	8	6	4	2	13	10	14	2	16	22	9
Aspect			166	300	318	36	130	40	12	26	266	66	44	58
Hygrotope			xeric	submesic	xeric	submesic	xeric	submesic	xeric	xeric	xeric	submesic	xeric	mesic
Soil Temperature (°C)		10.9	12	9	11	9	11	11	11	12.5	10	6.5	16.5	11
Litter		2	2	2	2	3	1	2	3	2	2	3	2	2
Bare Ground		2		1	1	1	1	1	1	2	1	2	2	1
Rocks		2	3		2	1	4	3	1		2		3	2
Species	P	MS						COVER CLASS						
HERBS														
C														
Festuca altaica	91.7	2	2	2	1	1	2	2	2		2	2	2	2
Potentilla diversifolia	91.7	2	2	2	2	1	1	1		1	1	1	2	1
Salix nivalis	83.3	2	3	2	1	1			3	2	2	3	2	4
Festuca brachyphylla	83.3	2	2	2		1	1	1	2	2	2	2	1	
Polygonum viviparum	83.3	2	1	1	1	2	1	1		1	1	2		2
Dryas octopetala	66.7	2			2	4	3	3	3	2		2	3	
Luzula spicata	66.7	1		1	1	1	1		1	1	1			1
Sedum lanceolatum	58.3	1	1	1		1			1	1		1	1	
Stellaria longipes	58.3	1	1	1	1	1	1	1						1
Carex capitata	50.0	2	1	2	2		1			1	2			
Antennaria alpina	50.0	1		1			1	1			1	2		1
Selaginella densa	50.0	1			1	1	1		2	1	1			
Arenaria obtusiloba	50.0	1			1	1			1		1	1		1
Carex nardina	41.7	1	2		1	2	1	2						
Silene acaulis	41.7	1		1	2	1	1				2			
Artemesia norvegica	41.7	1		1					1	1	2		1	
Arenaria rubella	41.7	1		1		1	1	1		1				
Trisetum spicatum	33.3	1		1					1		1	1		
Solidago multiradiata	33.3	1		1			1	1				1		
Cerastium arvense	33.3	1	1		1						1	1		
Draba spp.	33.3	1					1	1			1		1	
Agrostis variabilis	25.0	1		2						2				1
Carex albonigra	25.0	1	2					1			1			
Pedicularis ornithorhyncha	25.0	1			1				1	2				
Arenaria capillaris	25.0	1							1	1				
Haplopappus lyallii	25.0	1			1						1		1	
Draba incerta	25.0	1	1		1				1					
Veronica wormskjoldii	25.0	1								1		1		1
BRYOPHYTES AND LICHENS														
DH														
Cetraria islandica	100.0	2	2	2	2	2	2	1	2	1	1		1	1
Stereocaulon spp.	91.7	2	2	3	3	1	2	2	4	1	2		2	1
Cetraria cucullata	58.3	2	2	1	2	3	2	1			2			
Cetraria nivalis	58.3	2	2	1	2	3	2		1		2			
[Cladonia squamulose]	41.7	1				2	1			2		1		1
Thamnolia subuliformis	41.7	1	+	2	1			+			1			
Cladonia spp.	41.7	1	1	1	1	1			+					
Cornicularia aculeata	33.3	1	1	2					1	1				
Peltigera rufescens	33.3	1	1						1			2	1	
Polytrichum juniperinum	25.0	1							2			2		1
Alectoria ochroleuca	25.0	1					1	1				2		
DR														
Rhizocarpon geographicum	66.7	1	1		1	1	1	1			1		1	2
[Black crustose lichens]	50.0	1	1			1	2				1		1	2
[Crustose lichens]	16.7	1	1				1							
Psoroma spp.	16.7	1	1								1			

Other species with a frequency less than 20% and their cover values:

Kobresia myosuroides 1,2, Penstemon procerus 1,2, Poa alpina 1,2, Sibbaldia procumbens 1,2, Vaccinium caespitosum 1, Erigeron peregrinus 1, Myosotis alpestris 1, Polemonium pulcherrimum 1, Astragalus alpinus 2, Carex pyrenaica 2, Cassiope tetragona 2, Oxytropus campestris 2, Pedicularis langsdorfii 2, Poa arctica 2, Hieracium gracile 1, Anenome multifida 1, Antennaria umbrinella 1, Carex concinnoides 1, Carex phaeocephala 1, Gentiana amarella 1, Poa fendleriana 1, Salix brachycarpa 1, Saxifraga lyallii 1, Silene douglasii 1, Drepanocladus uncinatus 1,2, Caloplaca spp. 1, Dicranum scoparium 1, Polytrichum piliferum 1, Tortula norvegica 1, Ceratadon purpureus +, Dicranum fuscescens 2, Dicranum muehlenbeckii 2, Bartramia ithyphylla 1, Dactylina arctica 1, Ochrolechia upsaliensis 1, Peltigera malacea 1, Peltigera spuria 1, Sphagnum recurvum 1, Desmatadon latifolius +, Hypnum revolutum +, Lophozia hatcheri +, Lophozia spp. +, Pohlia nutans +, Ochrolechia upsaliensis 1, Pseudephebe spp. 1, Umbilicaria spp. 1

islandica and Stereocaulon spp. (each with a mean significance of 2) on soil and by the presence of Rhizocarpon geographicum (a crustose lichen) on rocks.

Classification of this type requires the presence of species groups 7 (Dryas) and 8 (F. altaica).

As would be expected of a grassland there was evidence of grazing throughout this community type. Many fescue bunchgrass plants had been close cropped although cow dung was noted in only three sites. Deer were sited at these elevations and may have been responsible for some of the close grazing. No evidence of recent grazing was seen.

Meadow Types:

The seven community types that have a herb dominated physiognomy can be divided into two main groups. The first is characterized by the predominance of sedges while the second has an abundance of grasses. The sedge communities tend to be restricted and patchy in their occurrence while the grass meadows occur more extensively throughout both the alpine and subalpine zones.

1) Carex aquatilis/rostrata wetland: (Table XV)

Sedge-dominated wetlands are found occasionally on poorly drained depressions on valley bottomlands. The soil remains saturated throughout the growing season. Stands sampled ranged in elevation from 1620 to 1960 meters. None were above treeline. The species diversity is lower than for any other community type, averaging only 6 species per plot. The mean similarity of the five Carex aquatilis stands is 27. One Carex rostrata stand is also included in this type.

Carex aquatilis or Carex rostrata form the dominant cover in this association. The average cover class is 5. Carex canescens is an associated species of high significance (3 & 4) in two stands. The herb stratum

Table XV. Carex aquatilis/rostrata wetland

Plot number		Mean	182	37	165	11	16	17
Biogeoclimatic unit			ESSF	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1875.0	1940	1620	1820	1950	1960	1960
Slope Gradient (°)		0.0	0	0	0	0	0	0
Aspect			F	F	F	F	F	F
Hygrotope			hydric	hydric	hygric	hydric	hydric	hydric
Soil Temperature (°C)		8.1	9.5	7	12	6	7	6
Litter		2	2	2	2	1	2	1
Species	P	MS			COVER CLASS			
HERBS								
C								
Carex aquatilis	83.3	4		5	5	5	5	3
Carex canescens	33.3	2					3	4
Epilobium alpinum	33.3	1		1				2
Galium trifidum	33.3	1		2				1
Geum macrophyllum	33.3	1			2			1
Cerastium arvense	33.3	1					1	1
Carex rostrata	16.7	2	5					
BRYOPHYTES								
DH								
Drepanocladus aduncus	33.3	2		5			2	
Plagiomnium rostratum	33.3	2		2			1	

Other species with a frequency of 20% or less and their cover values:

Carex pachystachya 2, Eriophorum polystachion 2, Festuca brachyphylla 2, Poa palustris 2, Salix brachycarpa 2, Stellaria longipes 2, Viola ? nephrophylla 2, Aster foliaceus 1, Chrysosplenium tetrandum 1, Poa arctica 1, Philonotis fontana 4, Bryum caespiticium 3, Calliergon giganteum 3, Cinclidium stygium 3, Amblystegium saxatile 2, Bryoerithrophyllum recurvirostrum 2, Peltigera refescens 2, Calliergon stramineum +

generally attains a height of about 45 cm. A number of mosses are associated and have a high significance but none has a high constancy.

This community type is easily identified by the dense sward of sedge. Species groups 2 (Carex rostrata) or 3 (Carex aquatilis) must be present. There was no visible evidence of past grazing by cattle.

2) Carex nigricans late snowbed meadow: (Table XVI)

This sedge community occurs at timberline in areas of late snow melt. Best development was in depressions or on moderate slopes (up to 23°) where solifluction was an active process. The hygrotope was mesic to sub-hygric. Of the four stands included in this association, three were on east facing slopes and one was on a west facing slope. The mean elevation was 2065 meters. This community type has a mean similarity of 30.

Carex nigricans (black alpine sedge) is the most frequent member of this community and has the highest mean significance (3). Species found in 3/4 stands include Salix nivalis (also a dominant with a mean significance of 2), Luzula parviflora, Artemesia norvegica, Ranunculus eschscholtzii, Juncus drummondii and Trisetum spicatum. Cassiope mertensiana was present in 2/4 plots with an average cover class of 4. The general height of the C strata was 8-12 cm.

The Phleum species group (10) and the Carex nigricans species group (11) are diagnostic for this community type. It is not extensive and did not appear to have been grazed.

3) Festuca altaica - Festuca brachyphylla meadow: (Table XVII)

The dominant grassland community at high elevations in the study area is this mixed fescue type. It is common between 1820 and 2225 meters on predominantly east, south and west aspects. The slope gradient is gentle to

Table XVI. Carex nigricans late snowbed meadow

Plot number		Mean	187	56	192	190
Biogeoclimatic unit			ESSF	ESSF	ESSF	AT
Elevation (M)		2065.0	2020	2070	2100	2070
Slope Gradient (°)		13.8	8	23	21	3
Aspect			282	48	56	98
Hygrotope			mesic	mesic	subhygric	mesic
Soil Temperature (°C)		8.5	9	6	9.5	9.5
Litter		2	1	2	2	1
Bare Ground		2			2	
Species	P	MS		COVER CLASS		
HERBS						
C						
Carex nigricans	100.0	3	2	3	1	5
Salix nivalis	75.0	2	4	2	1	
Luzula parviflora	75.0	2	2	2	1	
Artemesia norvegica	75.0	2	1	2	1	
Ranunculus eschscholtzii	75.0	1	1	2		+
Juncus drummondii	75.0	1	1	1		+
Trisetum spicatum	75.0	1	1	1	+	
Cassiope mertensiana	50.0	3		5	3	
Sibbaldia procumbens	50.0	2	2	2		
Anenome multifida	50.0	1	1		1	
Senecio pauciflorus	50.0	1	1	1		
Veronica wormskjoldii	50.0	1	1	1		
BRYOPHYTES AND LICHENS						
DH						
Stereocaulon spp.	50.0	1		1	2	
Polytrichum juniperinum	50.0	1	1		1	

Other species occurring in 1/4 stands with their cover values:

Agoseris glauca 2, Anenome occidentalis 2, Antennaria alpina 2, Caltha biflora 2, Carex spectabilis 2, Erigeron speciosus 2, Phyllodoce empetriformis 2, Erigeron purpuratus 1, Polygonum viviparum 1, Salix spp. 1, Arenaria capillaris 1, Arenaria obtusiloba 1, Castilleja miniata 1, Hieracium gracile 1, Phleum alpinum 1, Poa arctica 1, Sedum lanceolatum 1, Abies lasiocarpa +, Aulacomnium palustre 3, Polytrichum strictum 3, Dicranum muehlenbeckii 2, Peltigera apthosa 2, Bartramia ithyphylla 1, Bryum spp. 1, Lophozia spp. 1, Philonotis fontana 1, Polytrichum piliferum 1, Distichium capillaceum +, Pohlia nutans +

Table XVII. Festuca altaica - Festuca brachyphylla meadow

Plot number		Mean	75	204	185	200	143	188	122	171	124	172	129	163	66	116	9	130	131	132
Biogeoclimatic unit			ESSF	AT	ESSF	AT	AT	AT	AT	AT	AT	AT	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		2037.8	1990	2110	1960	2030	2170	2080	2145	2170	2225	2145	2015	1820	1945	1865	1960	2015	2010	2025
Slope Gradient (°)		9.4	9	15	8	4	16	13	0	13	5	21	6	3	18	10	16	5	2	5
Aspect			206	20	220	284	228	328	F	180	40	176	260	220	274	100	180	268	272	272
Hygrotope			xeric	sub-mesic	mesic	sub-xeric	mesic	sub-mesic	mesic	sub-mesic	mesic	sub-mesic	mesic	xeric	xeric	sub-mesic	xeric	mesic	mesic	mesic
Soil Temperature (°C)		11.8	11	11.5	12.5	11	10.5	9	12	11	9	15	11	14.5	12	18.5	7	12	12	13
Litter		2	3	2	3	3	3	2	1	3	2	2	3	3	3	2	2	3	2	2
Bare Ground		2	3	1	1	1			2		1	2	1	2	2	2	3	1	2	1
Rocks		1	1						1	1						1	1			
Species	P	MS																		
HERBS																				
C																				
Festuca brachyphylla	94.4	2	2		2	2	1	1	2	2	1	2	1	2	2	3	3	1	1	3
Potentilla diversifolia	94.4	2	1	1	2	2	1	1	2	2	2	1	2	2		2	1	2	1	2
Cerastium arvense	94.4	1	1		1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1
Festuca altaica	83.3	2	2	1	2	2	2	2	2		2	2	3	3	2			2	2	1
Carex phaeocephala	77.8	2	2	2	1	1			3			2	2	3	1	2	1	2	2	2
Penstemon procerus	77.8	2			2	1	1	2	2	2	2	2	2			1	2	2	1	2
Achillea millefolium	66.7	1	2		1				1	1	1	1			1	1	1	1	1	1
Artemesia norvegica	61.1	2	2	2		1	2	2	3	1	3		1					2	3	
Arenaria capillaris	61.1	2				1	2	1					1	2	1	2	2	2	1	2
Polemonium pulcherrimum	61.1	1			1	1			1	1	1	1			1	1	1	1		1
Agoseris glauca	50.0	1	2		1	2						1		1	2			1	1	1
Poa alpina	44.4	1				1	2			1	1		1				1	1		2
Geum triflorum	38.9	2			2							2		2	2	2	1	2		
Solidago multiradiata	33.3	1					1			2			2	2	2		1			
Selaginella densa	27.8	1				1							1	2			2			1
Senecio streptanthifolius	27.8	1	1									1		1			2			2
Sibbaldia procumbens	27.8	1		2		2	1	1		1										
Luzula spicata	27.8	1		2		1	1			1							1			
Trisetum spicatum	27.8	1				1	1		1	1								1		
Stellaria longipes	27.8	1		1	1				1		1							1		
Danthonia intermedia	22.2	1			1									2		2				
Carex capitata	22.2	1		2		1	1			2							2			
Myosotis alpestris	22.2	1	2						1											
Haplopappus lyallii	22.2	1						1	2		2				1					
Poa sandbergii	22.2	1							1	1		1						+	2	
Poa fendleriana	22.2	1							1		1							+	+	
Agrostis variabilis	22.2	1		1		1						2							1	
Androsace septentrionalis	22.2	1							1	1										
												1		1	1					
BRYOPHYTES AND LICHENS																				
DH																				
Cetraria islandica	77.8	1	2		1	1	1	1												
[Cladonia squamulose]	72.2	2		3				1	1	1	2	1	2	1		1	1	1	2	
Polytrichum juniperinum	50.0	2		2		2		2		1	2		3	2	1	2	1	1	2	1
Tortula norvegica	38.9	1		1			2			4				3		+	2	2	2	
Cladonia spp.	38.9	1		1		2	1			1		1			2		1	+		
Peltigera malacea	33.3	1	2		1		1					1	1	1				1		
Polytrichum piliferum	22.2	2		2		3	3						1			1		1		
Ceratadon purpureus	22.2	1	2						1	1								2		
Stereocaulon spp.	22.2	1			1	1	2		1									1		
Peltigera rufescens	22.2	1							1	1		1			1					

Other species with a frequency less than 20% and their cover values:

Salix nivalis 1,3,5, Antennaria microphylla 1,2, Epilobium angustifolium 1,2, Phleum alpinum 1,2, Antennaria alpina 1,2, Carex pachystachya 1,2, Astragalus alpinus 1,2, Erigeron peregrinus 1,2, Polygonum viviparum 1, Poa cusickii 1, Rumex acetosa 1, Veronica wormskjoldii 1, Aster foliaceus 1,2, Sedum lanceolatum 1,2, Gentiana amarella 1, Koeleria cristata 1, Poa interior 1, Arenaria obtusiloba 1, Arenaria rubella 1, Antennaria umbrinella 2, Arctostaphylos uva-ursi 2, Delphinium glaucum 2, Eriogonum umbellatum 2, Luzula parviflora 2, Oxytropus campestris 2, Poa glauca 2, Poa pratensis 2, Senecio canus 2, Vaccinium caespitosum 2, Agropyron caninum 1, Silene acaulis 1, Anenome multifida 1, Arabis drummondii 1, Botrychium lunaria 1, Draba lanceolata 1, Draba spp. 1, Draba stenoloba 1, Galium boreale 1, Galium trifidum 1, Hieracium gracile 1, Pedicularis ornithorhyncha 1, Ranunculus eschscholtzii 1, Rosa acicularis 1, Bryum spp. 1, Eurynchium pulchellum 2, Cetraria nivalis 1, Desmatadon latifolius 2, Caloplaca spp. 1, Cladonia nemoxyna 1, Cornicularia aculeata 1, Cornicularia muricata 1, Rubus acaulis 1, Solorina crocea 1, Brachythecium collinum +, Encalypta vulgaris +, Lophozia spp. +, Rhizocarpon geographicum 1

moderate (a mean of 9° and an extreme of 21°) and the terrain is often hummocky. The hygrotope is on the dry end of the scale, varying from mesic to xeric. Soils are rocky and well drained. A large alluvial fan in Relay Basin supports the most extensive stand of this community. An average of 15 percent of the plot is exposed mineral soil while litter comprises an average of 15 percent of the ground cover. The eighteen stands sampled have a mean similarity of 45.

Festuca brachyphylla and Festuca altaica are the most characteristic components of this community. Both have a constancy of V and a mean significance of 2. These grasses reach an average height of 20-30 cm. Carex phaeocephala is a frequent (class IV) constituent with an average cover of 2 as well. Forbs with a constancy of IV or V include Potentilla diversifolia, Cerastium arvense, Penstemon procerus, Achillea millefolium, Artemesia norvegica, Arenaria capillaris, and Polemonium pulcherrimum. None of these is especially diagnostic. Cetraria islandica and Cladonia squamules are the only constant species in the D layer. They have mean cover classes of 1 and 2 respectively.

The key to the identification of this community type is the presence of the Festuca altaica species group (8) without the Dryas group (7). Group 9 (F. brachyphylla) is also present and diagnostic when in association with group 8. The high constancy of Arenaria capillaris results in the presence of the Phleum species group (10) as well but this is not considered of major importance in characterizing the association, although it does add to the species diversity of this type.

This community type has been heavily grazed by cattle in the past. Close cropping of fescue bunch grasses (Festuca spp.) resulting in their near demise is a common sight, as is an abundance of cow dung. Regrowth is slow because of the short growing season and dry conditions; however there were new shoots

around the edges of many of the dead bunches. These alpine and high subalpine meadows have probably been an important forage source for both cattle and wildlife.

4) Festuca brachyphylla meadow: (Table XVIII)

This community type is common throughout the study area in both the alpine and subalpine zones, ranging in elevation from 1670 to 2220 meters. It is restricted to southerly or easterly aspects on a wide range of slope gradients. The hygrotope varies from mesix to xeric. The terrain is generally convex. There is often a large amount of bare soil (15 percent on average) and of litter (a mean of 15 percent). The twenty-four plots included in this association have a mean similarity of 35.

The dominant grass in this meadow community is Festuca brachyphylla (alpine fescue) with a mean significance of 2. Important forbs with a constancy of IV or V are Cerastium arvense, Geum triflorum, Polemomium pulcherrimum, Potentilla diversifolia and Achillea millefolium. Oxytropus campestris (with a cover class of 2 or 3) is an important indicator of the rocky variant of this community which might be considered a subassociation. There are no characteristic bryophytes or lichens. The average height of this vegetation type is 12-30 cm.

Identification of this community is based on the presence of the Festuca brachyphylla species group (9) without the Festuca altaica group. The Phleum alpinum species group (10) may be represented by one species with a cover of less than 5 percent - any greater representation would place the stand in the next community type. The rocky subtype meets the requirement for the crustose lichen species group (16).

Table XVIII. Festuca brachyphylla meadow

Plot number		Mean	139	180	232	234	173	164	103	13	76	115	105	107	160	238	127	62	121	98	233	49	63	64	65	14
Biogeoclimatic unit			AT	AT	AT	AT	AT	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	AT	AT	AT	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1976.7	2040	2050	2150	2215	2065	1825	1900	1955	1990	1860	1905	1900	1835	1670	2100	1885	2155	2165	2220	1920	1890	1890	1900	1955
Slope Gradient (°)		18.7	24	26	25	20	32	18	0	0	28	0	33	0	0	40	18	24	26	0	22	10	25	25	23	30
Aspect			214	236	70	56	68	122	F	F	150	F	68	F	68	110	164	240	188	F	68	176	242	208	195	200
Hygrotope			mesic	xeric	sub-xeric	xeric	xeric	sub-xeric	sub-mesic	mesic	mesic	mesic	xeric	sub-mesic	sub-mesic	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric
Soil Temperature (°C)		11.9	11	13	8	8	17	15.5	13	7	12.5	12	15	13.5	12	10	13	14	14	13	8	10.5	11.5	11	13	10
Litter		2	3	3	1	2	1	3	3	2	2	2	2	2	1		2	2	2	1	2	2	3	2	2	2
Bare Ground		2	1	2	2	2	2	2	3	2	3	2	2		1	4	4	2	3		2	2	2	2	2	2
Rocks		2	1										1			1	1	2	2	4	2	2	1	3	2	2
Species	P	MS	COVER CLASS																							
HERBS																										
C																										
Festuca brachyphylla	87.5	2	1	1	2	2	2	2	2	3	2	2	1	3			2	2	1	1	1		1	1	1	2
Cerastium arvense	83.3	2	1			1	1	1		1	2	2	1	2	1		2	2	2	1	1	1	2	2	2	2
Geum triflorum	79.2	2	1	2		3	3	2		2	2	2		2	2	1	2	3	1		1	2	3	2	2	
Polemonium pulcherrimum	75.0	2		1	2	2	1			1		1		1	1	1	2	2	2	2	2	1	2		1	2
Potentilla diversifolia	66.7	2	1	1	2	2	1		1	2		2	1	2	2		2		2	2	3				1	
Achillea millefolium	66.7	1	1	1	1	2	1	1		2	2	1	1	1	2		1		1			1				1
Carex phaeocephala	58.3	2			1		1		1	1	2	3	2	2			2	2			1	1				1
Androsace septentrionalis	58.3	1	1		1		1			1	1	1		1			1	1						1		1
Erigeron compositus	45.8	1				1											1	1	2	2	1	1	1	1	1	1
Oxytropus campestris	41.7	2		1														3	2	2	2	3	2	2	2	3
Myosotis alpestris	41.7	1			1										1		2	1	2	1	1		1	1	1	
Penstemon procerus	41.7	1			1		1		1	1	1	2	1	2	1										1	
Galium boreale	41.7	1	1								2	1		1	1	1		1					1			2
Agoseris glauca	37.5	1				1	1	1			1	1		1	1	2			1							
Astragalus alpinus	33.3	1				1	1	1			2			1	2					1	1					
Gentiana amarella	33.3	1	1	1			1	1			1	1	1													
Poa fendleriana	29.2	1			1			2																		
Anemone multifida	29.2	1			2	1	2	1					1		2			2								
Epilobium angustifolium	29.2	1	2	1	2		1	1					1		1											
Poa sandbergii	25.0	1	1				2			2			1				2		1							
Delphinium glaucum	25.0	1								1	2						1		2	1						1
Arctostaphylos uva-ursi	20.8	1	2	4				2			2					1										
Festuca altaica	20.8	1	3	2	2			2			1															
Koeleria cristata	20.8	1																1				2	1	2	2	
Antennaria microphylla	20.8	1	1					2				1	2	1												
Haplopappus lyallii	20.8	1			2		1		1				1	1	1			1		1	2					
Trisetum spicatum	20.8	1																		1	1					
BRYOPHYTES AND LICHENS																										
DH																										
Tortula norvegica	33.3	1	2							1		1						+		1				1	2	2
DR																				1	1	1			1	
[Crustose lichens]	20.8	1																								

Other species with a frequency less than 20% and their cover values:

Antennaria umbrinella 1,2,3, Selaginella densa 2, Artemesia norvegica 1,2, Poa interior 1,2, Danthonia intermedia 1,2, Taraxacum officinale 1,2, Thalictrum occidentale 1,2, Poa alpina 1, Eriogonum umbellatum 2,3, Carex capitata 2,3, Cirsium hookerianum 1,2,3, Poa glauca 1,3, Fragaria virginiana 1,2, Luzula spicata 1,2, Poa palustris 1,2, Solidago multiradiata 1,2, Stellaria longipes 1,2, Aster foliaceous 2, Carex albonigra 2, Arenaria capillaris 1, Astragalus robbinsii 1, Phacelia sericea 1,2, Senecio streptanthifolius 1, Sedum lanceolatum 1, Agrostis variabilis 2, Anenome drummondii 2, Antennaria alpina 2, Calamagrostis purpurascens 2, Carex pachystachya 2, Carex rossii 2, Carex spectabilis 2, Juncus drummondii 2, Kobresia myosuroides 2, Poa cusickii 2, Potentilla gracilis 2, Potentilla quinquefolia 2, Salix brachycarpa 2, Sibbaldia procumbens 2, Stipa richardsonii 2, Agropyron caninum 1, Arnica sororia 1, Aster sibiricus 1, Populus trichocarpa 1, Agoseris aurantiaca 1, Agrostis scabra 1, Allium cernuum 1, Arabis lyallii 1, Arenaria obtusiloba 1, Arenaria rubella 1, Botrychium lunaria 1, Bromus anomalus 1, Calliergon stramineum 1, Draba incerta 1, Epilobium alpinum 1, Erigeron speciosus 1, Festuca saximontana 1, Poa arctica 1, Poa rupicola 1, Rosa acicularis 1, Rumex acetosa 1, Silene parryi 1, Smilacina stellata 1, Veronica wormskjoldii 1, Bryum spp. 1,2, Polytrichum juniperinum 1,3, Physconia muscigena 1,2, Peltigera rufescens 1, Cetraria islandica 1, Cladonia spp. 1, Cornicularia aculeata 1, Desmatadon latifolius 2,3, Polytrichum piliferum 1,2, Caloplaca spp. 1, Cetraria nivalis 1, Cladonia squamulose 2 Hypnum revolutum 2, Peltigera apthosa 2, Candelariella spp. 1, Orthotrichum speciosum 1, Peltigera malacea 1, Peltigera spuria 1, Stereocaulon spp. 1, Brachythecium collinum 1, Lophozia floerkei 1, [Black crustose lichens 1,2], Lecanora spp. 1, Rhizocarpon geographicum 1

Past grazing use by cattle was evident in most stands sampled. Some fescue bunchgrasses were close cropped and old cow pies were generally present. Many of the valley bottom meadows in Graveyard Valley fit into this community. This valley has been heavily grazed for many years.

5) Festuca brachyphylla- Phleum alpinum meadow: (Table XIX)

This plant community represents a transition between the Festuca brachyphylla and the Phleum alpinum associations. It is found generally where more mesic conditions prevail, although three of the twenty stands sampled were on rocky well drained sites. This community type occurs throughout the subalpine zone right up to timberline. The elevation ranges from 1640 to 2090 meters with a mean of 1874 meters. Flat valley bottoms to steep slopes (43^{o}) on all aspects support this type of vegetation. The terrain varied from straight to concave. The mean similarity for the stands in this community type was 41.

Numerous forbs dominate this association. Those with the highest constancy are Achillea millefolium and Cerastium arvense. Both have a mean significance of 2. Potentilla diversifolia, Thalictrum occidentale, Penstemon procerus, Polemonium pulcherrimum, and Geum triflorum are also present more than 60 percent of the time. Phleum alpinum and Carex phaeocephala are the dominant grass and sedge species with a constancy of IV and mean significance values of 2. Festuca brachyphylla and Trisetum spicatum are each present in 55 percent of the sample plots. This community attains an average height of 15 cm although in a few sites grasses reached a height of 45 cm.

Both the Festuca brachyphylla (9) and Phleum alpinum (10) species groups must be met for a stand to fit into this community type. Either two species from group 10 or one species with a cover greater than 1 is required. In

Table XIX. Festuca brachyphylla - Phleum alpinum meadow

Plot number		Mean	184	174	4	7	10	12	23	39	51	81	104	110	114	117	137	167	179	226	239	170
Biogeoclimatic unit			ESSF	AT	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	AT
Elevation (M)		1874.3	1925	2060	1640	1950	1960	1945	1700	1630	1935	1815	1900	1870	1860	1920	1785	1870	1955	1965	1710	2090
Slope Gradient (°)		12.0	7	43	0	0	16	19	21	0	4	14	0	0	0	21	21	21	17	0	20	16
Aspect			312	40	F	F	140	226	50	F	286	178	F	F	F	240	104	132	120	162	100	340
Hygrotope			mesic	xeric	mesic	mesic	xeric	xeric	mesic	mesic	mesic	mesic	sub-mesic	sub-mesic	sub-mesic	mesic	sub-mesic	sub-xeric	sub-mesic	mesic	xeric	mesic
Soil Temperature (°C)		11.1	10	16	12	7	8	10	11	8.5	8	12	10.5	13	13	11.5	14	15.5	12	12	10.5	8
Litter		2	1	1	1	1	3	2	1	1	2	2	1	2	2	2	1	2	2	1	2	2
Bare Ground		2		2			2	2	2	1	1	2	1	1	1	2	1		2	1	3	1
Rocks		1					2						1			2	1				1	
Species	P	MS					COVER CLASS										1					
HERBS																						
C																						
Achillea millefolium	100.0	2	2	3	2	1	1	2	2	1	2	1	1	1	1	2	2	2	2	2	1	1
Cerastium arvense	85.0	2		1	2	2	1	1	2	1	2	1	2	2	1	1		1	1	1	1	
Phleum alpinum	75.0	2	2	2	2	2			2	3	1	2	2	2	2	2		2	1	3		
Potentilla diversifolia	75.0	2	2	1		1	1	1	1	1	1		2	3	3	1	1			1		2
Thalictrum occidentale	75.0	1	2	1			1	1	1	1	1	1	1	1		2	1	1	2	3		
Carex phaeocephala	70.0	2			2	2	1	2	1	2	1	1	4	2	2	2		3	2			
Penstemon procerus	70.0	1	2	1	1	1	2		1	1	1		1	2	2	1					1	1
Polemonium pulcherrimum	70.0	1	1	1	1			1	1			2			1	1	1	1	1	1	2	1
Geum triflorum	65.0	2	3	3			2			2		2		2	2	2	1	2	2	2	1	
Fragaria virginiana	55.0	2		2	1		2		2	2		2				2	2	2	2	2		
Festuca brachyphylla	55.0	2	2			4	1	1			2		2	2	2			2	2			
Trisetum spicatum	55.0	1	2	2	2			1	1		1		1	1	1		1					1
Arenaria capillaris	45.0	2	1	1			2	3								2	1					
Galium boreale	45.0	1					2		1	2		1					1		3		2	2
Astragalus alpinus	40.0	2	2	1	3					1			2			1		2	1	1	1	
Danthonia intermedia	40.0	1			1		1				1	2				2	2	2				
Agoseris glauca	35.0	1	1	1					2	1			1							2		
Poa alpina	30.0	1	2		2						2	2				1						
Epilobium angustifolium	30.0	1									2		2		1					2		
Stellaria longipes	30.0	1	1						2	1	2	1				2		1	2		1	
Taraxacum officinale	25.0	2			4				2	2			1							1		
Carex pachystachya	25.0	1	1					1			2				2					3		1
Antennaria microphylla	25.0	1					1							2	1	1				2		
Androsace septentrionalis	25.0	1					1	1				1		1		1		1			1	
Gentiana amarella	25.0	1								1		1			1		1					
Artemesia norvegica	20.0	12									4					2	1					2
Aster foliaceous	20.0	1								2	1	2						1	2			
Anenome multifida	20.0	1		1																		
Agropyron caninum	20.0	1		1						1								2	1	2		
Selaginella densa	20.0	1						1														
Veronica wormskjoldii	20.0	1				1					1		1	2			1					
BRYOPHYTES AND LICHENS																						
DH																						
Polytrichum juniperinum	40.0	2	1			1	3	1		3				3							1	
Tortula norvegica	35.0	1			1	1		1			1					2					1	
Cladonia spp.	20.0	1								1		1		1			1				1	+

Other species with a frequency less than 20% and their cover values:

Vaccinium caespitosum 1,2,3, Eriogonum umbellatum 2, Koeleria cristata 1,2, Stipa columbiana 1,2, Agoseris aurantiaca 1,2, Poa pratensis 1, Poa sandbergii 1, Myosotis alpestris 1, Sedum lanceolatum 1, Rhinanthes crista-galli 2,3, Cirsium hookerianum 1,3, Festuca altaica 2, Festuca saximontana 2, Poa cusickii 2, Solidago multiradiata 2, Hackelia floribunda 1,2, Poa interior 1,2, Castilleja miniata 1,2, Geum macrophyllum 1,2, Agrostis variabilis 1,2, Arnica sororia 1, Erigeron peregrinus 1, Rumex acetosa 1, Salix nivalis 5, Antennaria umbrinella 2, Lupinus nootkatensis 2, Luzula parviflora 2, Oxytropus campestris 2, Poa arctica 2, Poa fendleriana 2, Senecio integerrimus 2, Senecio streptanthifolius 2, Carex capitata 2, Calamagrostis purpurascens 1, Carex nigricans 1, Geranium richardsonii 1, Agrostis scabra 1, Antennaria alpina 1, Antennaria pulcherrima 1, Arabis drummondii 1, Arenaria lateriflora 1, Arenaria obtusiloba 1, Botrychium lunaria 1, Bromus anomalus 1, Caltha biflora 1, Delphinium glaucum 1, Draba spp. 1, Galium trifidum 1, Haplopappus lyallii 1, Luzula spicata 1, Poa palustris 1, Ranunculus eschscholtzii 1, Senecio pauciflorus 1, Sibbaldia procumbens 1, Viola ? nephrophylla 1, Peltigera malacea 1,2, Bryum spp. 1,2, Peltigera rufescens 1,2, Cetraria islandica 1,[Cladonia squamulose 1], Desmatadon latifolius 1, Peltigera spuria 1, Stereocaulon spp. 1, [Crustose lichens]

addition, species group 17 (the Cerastium arvense group) is generally present but it is not used to classify the stands.

Grazing of this community type was common and often very heavy.

6) Phleum alpinum-Carex phaeocephala meadow: (Table XX)

This community type is widespread in the subalpine parkland but is found only occasionally in the alpine zone. The fifteen stands sampled ranged in elevation from 1640 meters at Relay Cabin to 2080 meters in Relay Basin. The slope gradient varied from flat to a steep 36^{o} on predominantly south to east aspects. The terrain was diverse and the hygrotope was in the range of sub-mesic to sub-hygric. This moisture regime resulted in an average grass height of 30-45 cm. Only 2 stands had rocky soil. The plots used to characterize this association had a mean similarity of 32.

The dominant species in this community are Phleum alpinum (alpine timothy) and Carex phaeocephala with mean significance values of 2, and Trisetum spicatum with a mean cover of 1. Achillea millefolium and Potentilla diversifolia are constant forbs with an average cover class value of 2. There are no characteristic bryophytes or lichens for this association.

Identification of this group is based on the presence of species group 10 - the Phleum group. At least one of the two grasses must be present. The Achillea species group (17) is also met for 80 percent of the stands but is not required for the classification of this type.

Grazing of this community type is common and cattle dung was noted in almost all stands. However, the grasses and sedges of this community do not show evidence of close cropping. Their more dispersed growth form might allow them to withstand grazing pressure more easily or perhaps the increased moisture availability permits better regrowth.

Table XX. Phleum alpinum - Carex phaeocephala meadow

Plot number		Mean	113	72	175	111	1	3	8	118	157	229	235	41	50	176	228
Biogeoclimatic unit			ESSF	AT	AT	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1874.0	1860	2080	2060	1970	1640	1640	1955	1960	1860	1775	1740	1700	1910	2075	1885
Slope Gradient (°)		10.7	0	7	18	36	0	0	2	11	0	21	22	6	13	12	12
Aspect			F	60	56	62	F	F	180	226	F	159	133	152	44	182	134
Hygrotope			mesic	mesic	xeric	xeric	mesic	mesic	mesic	mesic	mesic	mesic	mesic	mesic	mesic	sub-mesic	mesic
Soil Temperature (°C)		11.1	12	13.5	15	15	11	9	7	11	12	10.5	10	8	10	12	11
Litter		2	1		1	2		1	1	2		1	2		3	2	2
Bare Ground		2	1	2	1	1	1	1	2	2		2	1	1	1	3	
Rocks		1				2									1	1	
Species	P	MS									COVER CLASSES						
HERBS																	
C																	
Achillea millefolium	93.3	2		2	2	1	3	2	1	2	2	2	1	2	1	1	1
Phleum alpinum	80.0	2	3	2	2		2	2	2	1	3	2	3	3	1		
Potentilla diversifolia	73.3	2	3		1	1		1	2	2	3		2		1	2	1
Carex phaeocephala	66.7	2	3		1	2	2		2	4	2	3			2	2	
Trisetum spicatum	60.0	2		2	1	1	1	2		2					2	1	1
Taraxacum officinale	53.3	2	2	2			3	2			2	3	1	4			
Fragaria virginiana	53.3	2		2	2	1	2	2				1	2				2
Aster foliaceus	46.7	1	2				1	1		2	2	1					2
Agoseris glauca	46.7	1	1			1		2				1	1		1	1	
Astragalus alpinus	40.0	2		2	3		2	2					1				1
Thalictrum occidentale	40.0	1		1		1	1	2				1					2
Cerastium arvense	40.0	1	1				2	1	2	1	1						
Galium boreale	40.0	1					1	2			1	1		1			1
Artemesia norvegica	33.3	1		2		2									2	1	1
Penstemon procerus	33.3	1	1			1			2	1							1
Poa alpina	26.7	1			2			1	3	2							
Poa palustris	26.7	1						3			2	1		2			
Arenaria capillaris	26.7	1				2			2	1						2	
Anenome multifida	26.7	1			2	2							1		1		
Agropyron caninum	26.7	1		2	1						1			2			
Danthonia intermedia	26.7	1	1				1			2			2				
Sibbaldia procumbens	26.7	1							1	1					2	1	
Epilobium angustifolium	26.7	1		1	1							1	1				
Lupinus nootkatensis	20.0	2										1	1				5
Delphinium glaucum	20.0	1		2				2									1
Haplopappus lyallii	20.0	1				2				1					1		
Luzula spicata	20.0	1				1									1	1	
BRYOPHYTES AND LICHENS																	
DH																	
Polytrichum juniperinum	33.3	2	1			4		2							1	3	
Tortula norvegica	26.7	1		2	1			1									3

Other species with a frequency less than 20% and their cover values:

Stellaria longipes 1,3, Antennaria alpina 2, Poa pratensis 2, Vaccinium caespitosum 2, Carex rossii 1,2, Agrostis variabilis 1,2, Eriogonum umbellatum 1,2, Juncus drummondii 1,2, Selaginella densa 1,2, Agoseris aurantiaca 1, Erigeron speciosus 1, Gentiana amarella 1, Veronica wormskjoldii 1, Carex pachystachya 3, Cirsium hookerianum 3, Phyllodoce empetriformis 3, Rhinanthes crista-galli 3, Antennaria microphylla 2, Arnica parryi 2, Bromus carinatus 2, Carex albonigra 2, Equisetum arvense 2, Geum triflorum 2, Hieracium gracile 2, Luzula glabrata 2, Poa rupicola 2, Potentilla gracilis 2, Stipa columbiana 2, Poa cusickii 2, Hackelia floribunda 1, Ranunculus uncinatus 1, Agrostis scabra 1, Arenaria obtusiloba 1, Arnica cordifolia 1, Arnica sororia 1, Bromus anomalus 1, Carex capitata 1, Carex microptera 1, Castilleja minista 1, Erigeron peregrinus 1, Festuca brachyphylla 1, Geum macrophyllum 1, Polemonium pulcherrimum 1, Ranunculus eschscholtzii 1, Rumex acetosa 1, Salix brachycarpa 1, Saxifraga occidentalis 1, Sedum lanceolatum 1, Senecio pauciflorus 1, Abies lasiocarpa +, Polytrichum piliferum +,4, Aulacomnium palustre 1,3, Bryum caespiticium +,2, Pohlia nutans 1,2, Bryum spp. 1, [Cladonia squamulose 2] Peltigera apthosa 2, Peltigera spuria 2, Stereocaulon spp. 2, Philonotis fontana 1, Cladonia spp. 1, Desmatadon latifolius 1, Brachythecium spp. +, Tomenthypnum nitens +, [Black crustose lichens 1], [Crustose lichens 1], Rhizocarpon geographicum 1

7) Koeleria cristata meadow: (Table XXI)

This dry meadow community is abundant on moderate to steep (39°) south to south-east facing slopes. The soils are generally rocky and well drained ranging from xeric to sub-mesic on the hygrotopic scale. Exposed or bare soil comprises an average of 22 percent of the ground cover. The topography was straight to convex. This association is restricted to the subalpine zone between 1680 and 2020 meters. The twenty-four plots included in this type had a mean similarity of 39.

A shrub stratum was present in five of the sample plots. Juniperus communis, Populus tremuloides (also present as small trees in one stand), Populus trichocarpa and Shepherdia canadensis were each present in one to three stands. These may be transitional between the dry shrub and dry meadow communities. The two aspen stands are on more mesic sites and have a history of fire. These late successional sites will probably climax in a Pinus albicaulis (whitebark pine) open forest community.

The herb stratum is dominant for this plant community. Koeleria cristata is the most important grass with a constancy of V and mean cover of 2. Achillea millefolium, Cerastium arvense, Galium boreale, Fragaria virginiana and Agoseris glauca are all prominent forbs with a mean significance of 2. Rosa acicularis has a constancy of IV but an average cover of only 1. This stratum attains a height of 30-45 cm. There are no characteristic lichens or mosses.

There are a number of important diagnostic species of low constancy (II or III). Poa interior, Agropyron caninum, Erigeron speciosus, Arctostaphylos uva-ursi, Cirsium hookerianum and Eriogonum umbellatum are all members of species group 12 which is used to identify the Koeleria community type. This

Table XXI. Koeleria cristata dry meadow

Plot number		Mean	22	30	42	44	85	135	161	31	79	212	236	24	25	45	86	78	21	90	156	214	91	84	196	34
Biogeoclimatic unit			ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF	ESSF
Elevation (M)		1821.0	1710	1920	1785	1845	1830	1780	1890	1760	1895	1840	1820	1700	2005	1800	1765	1980	1680	1755	1865	1750	1760	1830	2020	1720
Slope Gradient (°)		22.6	12	12	20	17	32	30	32	12	22	36	32	13	14	15	30	23	15	4	39	19	26	33	34	20
Aspect			140	164	160	120	170	124	204	140	138	192	177	126	134	144	160	152	130	158	184	110	156	122	208	170
Hygrotope			xeric	mesic	xeric	xeric	xeric	xeric	sub-xeric	mesic	mesic	xeric	sub-mesic	xeric	xeric	xeric	xeric	xeric	sub-xeric	mesic	sub-xeric	xeric	mesic	mesic	xeric	sub-xeric
Soil Temperature (°C)		13.6	12	11	12.5	11	15	21	15	10	17	19.5	12	13	7	16	13	16	12	11	17	21	9	12	15.5	9
Litter		2	2	2	2	1	1	2	3	1	1	3	2	2	2	2	2	2	2	2	2	3	2	2	2	2
Bare Ground		2	5	2	4	2	3	3	2		2	2	2	2	2	3	3	3	3	1	2	2	1	2	2	2
Rocks		2		1			2	2			1	2	1			2		2						1	2	5
Species	P	MS	COVER CLASSES																							
HERBS																										
C																										
Achillea millefolium	95.8	2	2	2	2	1	1	1	2	1	2	1	1	1	2	1	2	2		2	2	1	2	2	1	2
Cerastium arvense	87.5	2	1		2	3	2		2	2	2	2	2	2	1	1	1	2	2	2	1	1	2	1		1
Koeleria cristata	83.3	2			2	3	1	1	3	1	2	3	2	2		3	3	2	2	2	2	1	2	2		2
Galium boreale	83.3	2	1	1		2	2	1	1	1	2	2		1	1	2	2		1	1	1	1	2	2	1	
Fragaria virginiana	62.5	2		2					1	4	2		1		1		2		2	2	2	1	2			
Agoseris glauca	62.5	2	2	1			2		1	2	1	1	1		2	1	1			2	1	2	2	2	1	2
Rosa acicularis	62.5	1	2	1			2	1		1			1	1	2	2	1	1		2	2	1	3			
Geum triflorum	58.3	2	1		2	2							1	2	3	1	2	3	2	1	3	2	1	1	2	1
Poa interior	54.2	2	1	2		1		2	2			2	1	1	2		1		1			2	2	2		1
Carex phaeocephala	54.2	1		1		2			1	1	2		1	1		2	1	1		2	1	2		2	2	
Polemonium pulcherrimum	50.0	1					1	2			2				2				2	1	2			2	1	
Agropyron caninum	50.0	1	1		2	1			1		2	2	1			2	1	1	1		2		1	2	1	
Danthonia intermedia	41.7	1				2				2	2		1	1		1	1		1			1	2	1		
Erigeron speciosus	41.7	1	1		2	2					2		1	1					2		2	2	1	1		
Arctostaphylos uva-ursi	37.5	2		2							2			2					2	2	1		1	1		
Cirsium hookerianum	37.5	1	1		2		2	1					1		2	3	3	3	2		1		1			1
Erigonum umbellatum	37.5	1				1			1	1			2	1	1		2				1		1		4	
Taraxacum officinale	33.3	1			1	2		2		1				1		1			2		1	1			1	
Anenome multifida	33.3	1		1					1	1			1							2		1		2		
Penstemon procerus	33.3	1							2	1				2		2			2		1		1			
Gentiana amarella	33.3	1									1		1						1	1	1		1	1		
Thalictrum occidentale	29.2	1							1		1		1		1					1		1	1	2	1	
Antennaria microphylla	29.2	1							1		2			1						2		2	3	2		
Bromus anomalus	29.2	1		2					1	1			2								2	1	1	2		2
Arenaria capillaris	25.0	1									2	1	2			1		1	1		2	2	1			
Astragalus alpinus	25.0	1		1	1						2						2			2	1					
Epilobium angustifolium	25.0	1					1		1											1	1			2		1
Oxytropus campestris	25.0	1	1					1			1	2		1				1								
Lupinus nootkatensis	20.8	1		1							2	1	1										3			
Poa arctica	20.8	1					1				1									2			3	1		
BRYOPHYTES AND LICHENS																										
DH																										
Tortula norvegica	25.0	1		1			1				+															
Bryum spp.	20.8	1		1					1		+	1														
DR												1								2				1		
[Black crustose lichens]	20.8	1					1						1								1					
																		1								2

Other species with a frequency less than 20% and their cover values:

Populus tremuloides 4, Juniperus communis 2, Populus tremuloides 3, Shepherdia canadensis 3, Populus trichocarpa 2, Solidago multiradiata 1,2, Aster sibiricus 1,2, Androsace septentrionalis 1, Botrychium lunaria 1, Phacelia sericea 1, Agrostis variabilis 2,3, Poa fendleriana 2,3, Rhinanthes crista-galli 2,3, Astragalus robbinsii 2, Festuca saximontana 2, Artemesia frigida 1,2, Bromus inermis 1,2, Hackelia floribunda 1,2, Poa glauca 1,2, Populus tremuloides 1,2, Potentilla diversifolia 1,2, Senecio lugens 1, Festuca brachyphylla 1, Poa cusickii 1, Allium cernuum 1, Antennaria alpina 1, Arabis drummondii 1, Calamagrostis purpurascens 1, Delphinium glaucum 1, Erigeron peregrinus 1, Senecio streptanthifolius 1, Stellaria longipes 1, Trisetum spicatum 1, Agropyron spicatum 2, Aster foliaceus 2, Astragalus miser 2, Carex hoodii 2, Carex pachystachya 2, Castilleja miniata 2, Festuca altaica 2, Hypnum revolutum 2, Symphoricarpos albus 2, Valeriana dioica 2, Populus trichocarpa 1, Agoseris aurantiaca 1, Agrostis scabra 1, Amelanchier alnifolia 1, Antennaria pulcherrima 1, Arabis holboellii 1, Arabis lyallii 1, Artemesia camestris 1, Equisetum arvense 1, Erigeron compositus 1, Geum macrophyllum 1, Haplopappus lyallii 1, Juniperus communis 1, Lillium columbianum 1, Luzula spicata 1, Penstemon fruticosus 1, Poa sandbergii 1, Potentilla arguta 1, Sibbaldia procumbens 1, Vacinnium caespitosum 1, Woodsia scopulina 1, Peltigera malacea 1, Encalypta vulgaris 1, Peltigera rufescens 2, Bryum caespiticium 1, Peltigera ? canina 1, Pohlia nutans 1, Polytrichum juniperinum 1,[Crustose lichens 1], Rhizocarpon geographicum 1

species group is also found in association with group 13 (the Phacelia sericeus group) which characterizes the dry shrub type. These two communities are on similar habitats and probably represent successional stages toward a climax whitebark pine forest.

This community appeared to be sensitive to grazing. Terracing was observed on several slopes although the grasses showed little evidence of past use. Half of the stands sampled met the requirements for the Festuca brachyphylla species group (9) largely because of the presence of Geum triflorum (old man's beard) with an average cover of 2. However fescue was very scarce. The prevalence of forbs may be a result of past grazing pressure. The species composition may reflect past levels of use, although this is difficult to quantify without proper control sites.

Rock-Talus-Lichen Terrain Unit: (Table XXII)

This type is identified by the terrain rather than a characteristic vegetation type. Talus slopes and boulderfields are a fairly prominent feature of the alpine landscape and are found occasionally in the subalpine. They occur primarily below cliffs. Sampled sites were between 1845 and 2345 meters. The slope ranged from 1 to 42^{o} on north, east and south aspects. Rock and coarse fragments or exposed shallow mineral soil comprised 60 to 100 percent of the ground cover. All stands were xeric although shaded, moist crevices did provide microhabitats for plant establishment. The mean similarity for the nine plots classified as this type is 25.

The herb stratum is sparse. There was an average of nine species per plot, but none has a high constancy or cover. Species with a constancy of II are Oxytropus campestris, Astragalus alpinus, Potentilla nivea, and Cerastium arvense. The cryptogram stratum is well developed. Rhizocarpon geographicum

Table XXII. Rock-talus-lichen terrain unit

Plot number		Mean	100	203	27	28	67	69	74	26	224
Biogeoclimatic unit			AT	AT	AT	AT	ESSF	ESSF	AT	AT	AT
Elevation (M)		2095.0	2080	2115	2085	2190	1845	2000	2120	2075	2345
Slope Gradient (°)		15.1	13	6	5	9	42	31	25	4	1
Aspect			210	140	100	210	62	62	10	130	114
Hygrotope			xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric	xeric
Soil Temperature (°C)		12.2	16	17.5	-	6	-	-	12.5	7	14
Litter		2	2	2		1	1			2	2
Bare Ground		2	1	2		2	1		5	3	
Rocks		4	2	4	6	5	6	6	2	4	4
Species	P	MS				COVER CLASSES					
HERBS											
C											
Oxytropus campestris	44.4	1	2	1		1					2
Astragalus alpinus	44.4	1		1		1			1		1
Potentilla nivea	33.3	1				1				1	1
Cerastium arvense	33.3	1		1					1		1
Arctostaphylos uva-ursi	22.2	2	3	2							
Carex albonigra	22.2	1	2								2
Festuca brachyphylla	22.2	1	2								2
Calamagrostis purpurascens	22.2	1	1	2							
Saxifraga bronchialis	22.2	1					1			2	
Selaginella densa	22.2	1					1			2	
Aster sibiricus	22.2	1		1						1	
Erigeron compositus	22.2	1								1	1
Potentilla diversifolia	22.2	1		1							1
Polemonium pulcherrimum	22.2	1							1	1	
Stellaria longipes	22.2	1				1				1	
BRYOPHYTES AND LICHENS											
DH											
Stereocaulon spp.	22.2	1					2				2
DR											
Rhizocarpon geographicum	88.9	2	1		4	1	3	3	1	2	2
[Black crustose lichens]	66.7	2		1	4	2	3	2	1		
[Crustose lichens]	44.4	2		1	2		2	4			
Umbilicaria spp.	22.2	1								2	2
Pseudephebe spp.	22.2	1								1	2

Other species:

Carex nardina 2, Draba oligosperma 2, Kobresia myosuroides 2, Lupinus lepidus 2, Poa rupicola 2, Populus trichocarpa 2, Salix nivalis 2, Woodsia scopulina 2, Erigeron peregrinus 1, Agoseris glauca 1, Anenome drummondii, Anenome multifida 1, Arenaria capillaris 1, Artemesia norvegica 1, Danthonia intermedia 1, Delphinium glaucum 1, Draba spp. 1, Juniperus communis 1, Koeleria cristata 1, Luzula spicata 1, Myosotis alpestris 1, Phacelia sericea 1, Poa interior 1, Polygonum viviparum 1, Rosa acicularis 1, Senecio canus 1, Senecio elmeri 1, Solidago multiradiata 1, Cetraria nivalis 2, Lecanora spp. 1, Polytrichum piliferum 1, Sphagnum recurvum 1, Tortula norvegica 1, Lophozia floerkei +, Thamnolia subuliformis +, Hypogymnia spp. 1, Ochrolechia upsaliensis 1, Pannaria spp. 1, Parmelia tasmanica 1, Xanthoria elegans 1

and black crustose lichens are common and prominent (cover classes range from 1-4). No mosses were characteristic.

This terrain unit can be classified by the rock or talus substrate and by the lack of characteristic species combinations for any of the other community types. The crustose lichen species group (16) is present and diagnostic when not in association with another species group.

CHAPTER 5

Relationship of Soil Temperature to Plant Community Distribution

Low soil temperatures are characteristic of alpine environments and have been considered important in "influencing the distribution of alpine and subalpine plants about timberline" (Higgens and Spomer, 1976). Soil temperature generally decreases with increasing elevation but it is also strongly correlated with slope exposure and soil moisture. Bliss (1956) found that alpine soil temperatures were highest on the ridges and lowest in wet meadow sites. He also noted that, in Alaska, soils on steep south-facing slopes were generally warmer in summer than those on north-facing slopes. High soil temperatures and low soil moisture regimes typified ridgetop fellfields in the North Cascades (Douglas and Bliss, 1977). Billings and Bliss (1959) attributed low surface temperatures to water saturated soils. Nimlos et al. (1965) associated cooler temperatures in the wet sedge-hummock stand type with the saturated condition of the soil and concluded that in the alpine, available soil moisture was the dominant factor determining the distribution of stand types. None of these studies measured soil temperatures in subalpine communities.

Soil temperature generally decreases from the surface to a depth of 76 cm as does the range in temperature (Bliss, 1956; Nimlos et al., 1965). In Montana the daily temperature range for air and soil at the 2.5 cm depth was 11°C, soil at 15 cm depth was 3.3°C, and at 76 cm depth was only 1°C (Nimlos et al., 1965). Douglas and Bliss (1977) found that "average temperatures at -10 cm. in a fellfield were 7-8° lower than at -2 cm and there appeared to be less fluctuation throughout the summer at the greater depths (-10, -20, and -30 cm)". The roots of many alpine plants extend to a

depth of about 30 cm (Bliss, 1956). Mean daily temperature fluctuations over the summer were largest at the dry meadow type and least at the sedge-hummock type (Nimlos et al., 1965). Mean summer soil temperatures reported for well drained soils in the alpine were; 5.5°C at -2.5 cm, 4.4° at -15 cm and 1.1° at -101 cm (Nimlos et al., 1965). Poorly drained soils had slightly lower values. Soil temperatures at -10 and -20 cm on Grouse Ridge, Mt. Baker ranged from 20-30°C at the top of the slope to 5-10°C towards the base of the slope (Douglas and Bliss, 1977).

Methods

In the present study, soil temperature at -20 cm was recorded for each plot sampled throughout the summer (July 11-August 30). Mean soil temperature with 95 percent confidence limits are presented for each plant community type in Figure 9. The characteristic hygrotope and elevation range for each community are summarized in Figures 10 and 11.

Results & Discussion

The mean summer soil temperature was between 7 and 9°C on wetter sites while it ranged from 11 to 15°C on well drained sites. Only the extreme ends of the scale are significantly different. These values are in the vicinity of those reported by Douglas and Bliss (1977) for Mt. Baker although soil temperatures above 20°C were not recorded at any time during the summer. Alpine and subalpine summer soil temperatures did not differ. Those plant communities found primarily in the alpine zone had mean soil temperatures ranging from 9 to 12°C. The Salix barrattiana community type is an exception with a mean temperature of 7.6°C. It is also the wettest type found in the alpine. Subalpine communities had mean soil temperatures between 7.9 and 14.7°C.

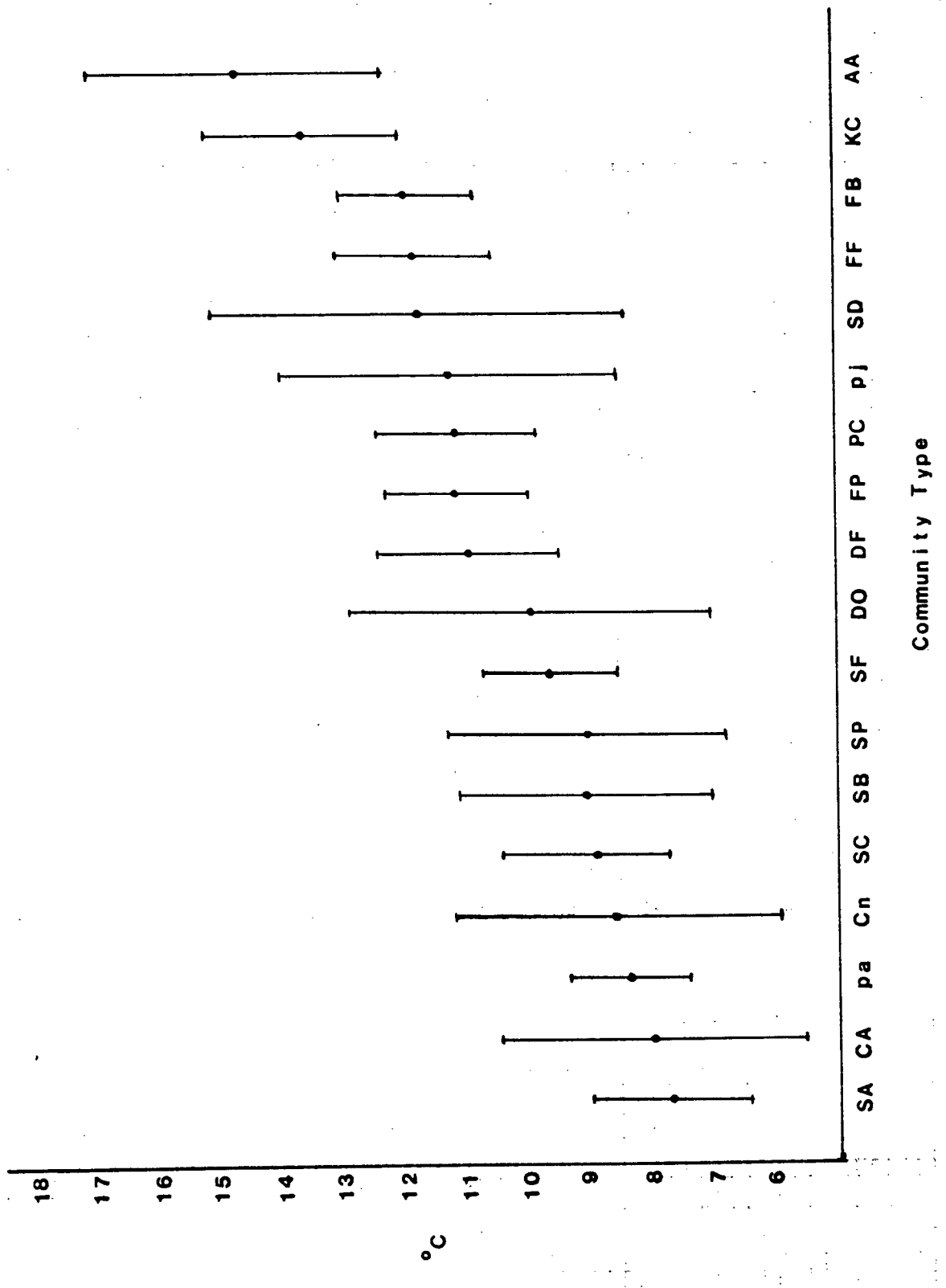


Figure 9. Mean soil temperatures with 95% confidence intervals for plant community types in the Southern Chilcotin Mountains. Soil temperature was recorded at -20 cm.

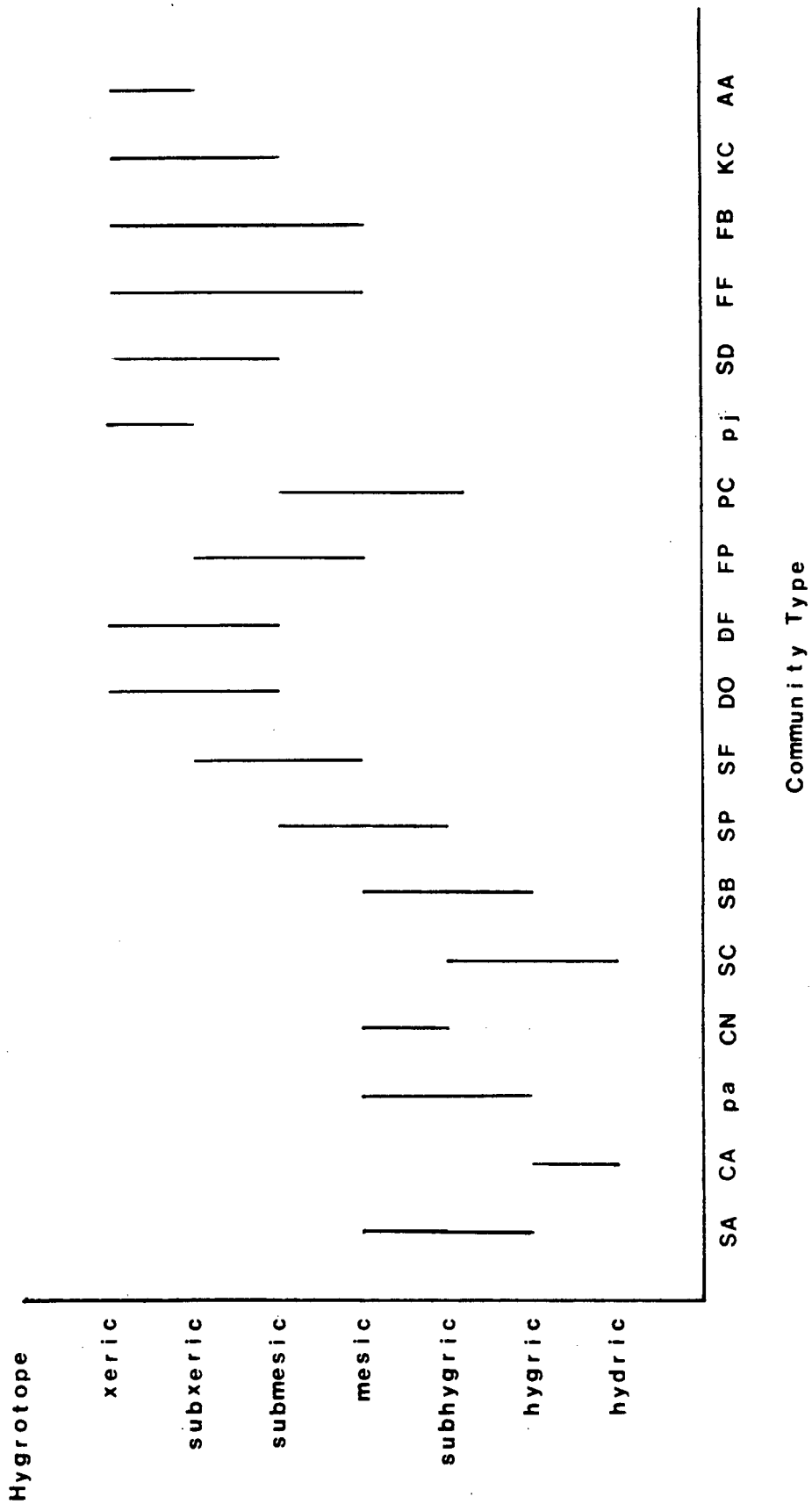


Figure 10. Hygrotope range for community types.

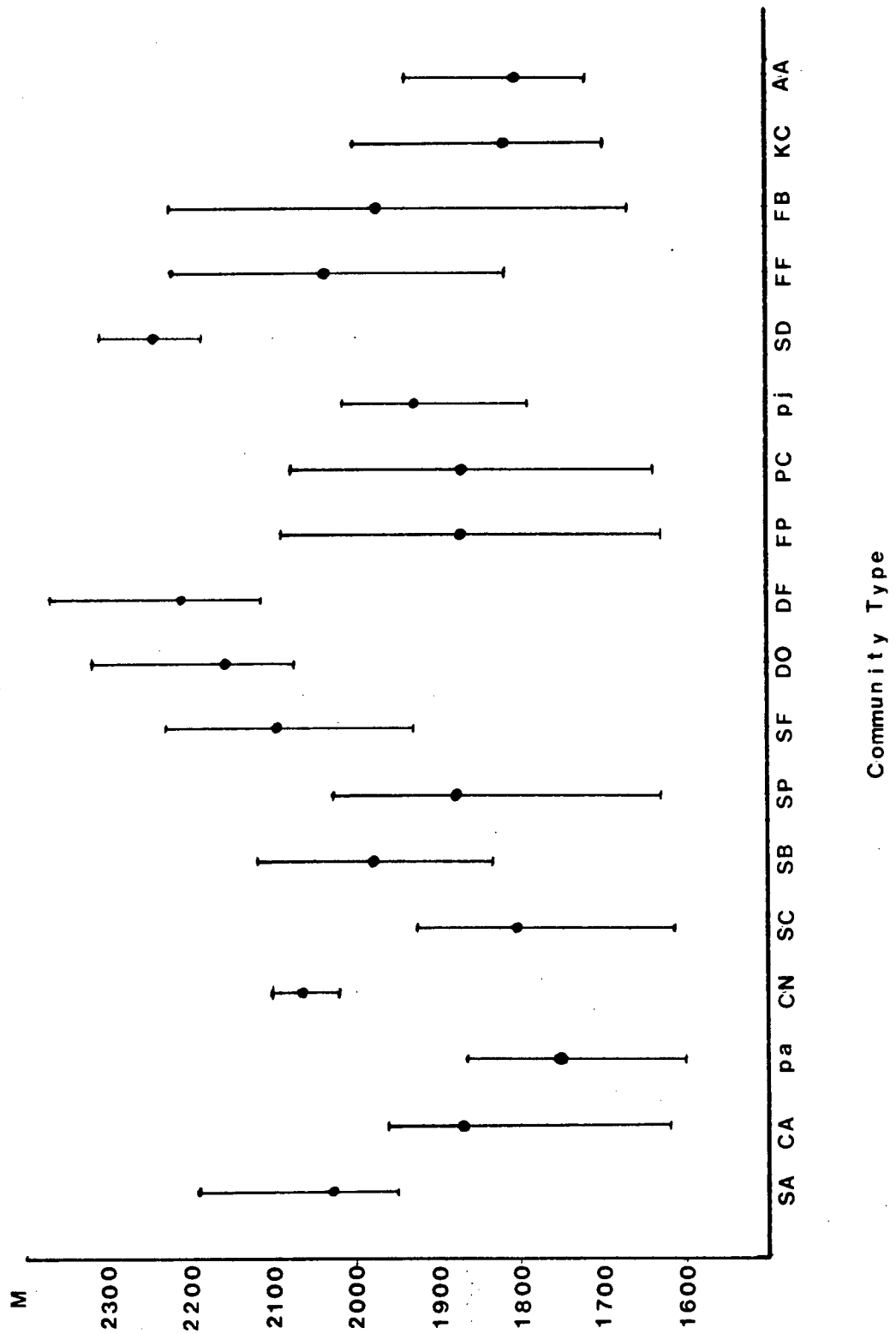


Figure 11. Mean elevation and elevation range for plant community types.

The highest soil temperatures tended to be on south or south-east facing slopes. The Koeleria cristata dry grassland and the Arctostaphylos-Amelanchier dry shrubland have mean temperatures of 13.6 and 14.7°C. These communities were also on relatively steep slopes. The Pinus albicaulis-Juniperus communis forest is also found on steep south to south-east facing slopes but the Salix cascadensis community is not. This dwarf willow type is found only on north-facing slopes. However, the slopes are very gentle and the soils are rocky and well drained. Furthermore, the lower 95 percent confidence limit is 8.3°C which is significantly less than the 12°C lower limit for the Koeleria community. The Salix cascadensis community is subject to greater seasonal soil temperature fluctuation than the subalpine communities appear to be. High soil temperatures generally correspond with dry, well-drained habitats as well as with a steep southerly aspect.

The lowest soil temperatures were found in the wet sedge and willow community types. This is consistent with data reported in the literature (Bliss, 1956; Nimlos et al., 1965). The coldest soils were on valley bottoms or northerly aspects.

Summer soil temperatures recorded in the Southern Chilcotin Mountains follow the same general patterns reported in the literature. Low temperatures are characteristic of the wetter sites and high temperatures are generally found on well drained sites with a southerly aspect. No significant differences were found between alpine and subalpine community soil temperatures at -20 cm.

CHAPTER 6

Notes on the Flora of the Southern Chilcotin Mountains

The mountains on the lee side of the Coast Range in British Columbia have not been extensively explored by botanists largely because of their inaccessibility. It is not surprising, therefore, that a number of species collected in the Relay Creek area represent range extensions for the province. This area appears to be a transition not only between the coastal and interior zones but also between northern and southern floristic elements. These factors along with the diversity of habitats in these dry interior mountains contribute to the floristic richness of the area.

A total of 310 vascular plant species were identified from collections made in 1977. Forty-one families and 136 genera were represented. Bryophyte collections included 57 moss species (in 41 genera) and 10 liverworts (in 6 genera). Twenty-six genera of lichens and 29 species were identified. Eleven genera were not identified to the species level. Unidentifiable crustose lichens were divided into two groups - black crustose and other crustose lichens.

Although most of this flora is characteristic of alpine and subalpine environments throughout western North America, a number of species have a more restricted distribution and their occurrence in the Southern Chilcotin Mountains is noteworthy. These are briefly discussed below. The general range is taken from Hitchcock and Cronquist (1973) and Hulten (1974).

Carex illota* - This species was found at only one location on the Dash Plateau (plot 153). It is rare in B.C. and has been collected only in Garibaldi Park and in Strathcona Park on Vancouver Island, but is widespread south of B.C.

*authorities for plant species are given in Appendix A.

Carex limnophila - This species is said to be widespread in Washington and to occur in Alberta. It is known from B.C. in two locations other than the present collections (plots 2, 20 and 87). Specimens from near Hope and NW of Williams Lake are deposited in the UBC herbarium.

Carex paysonis - This is also a rare species in B.C. with collections from Mount Rowe in SE B.C. and the Elaho River and Meager Creek in SW B.C. It was collected on the Dash Plateau in the study area (plot 219). It is common in SW Alberta and further south.

Erigeron purpuratus - Although rare in B.C. this species has been collected both in the north (in the Spatsizi area) and south (in the Tchaikazan Valley, Glacier Park, and in the vicinity of Paradise Mine near Invermere) of the province. Prior to the Relay Mountain collection (plot 133) however, the southern collections were called Erigeron pallens Cronq. Detailed work by G.W. Douglas has shown this species to be synonomous with E. purpuratus, a species found in the Yukon and Alaska.

Eriophorum brachyantherum - A circumboreal species that is common throughout northern B.C. and occurs in the Rocky Mountains of southeastern B.C. It has not been reported previously from the southwest part of the province but was common in the Salix barrattiana shrub wetland of Two Lakes Basin (plot 230).

Festuca altaica - This species is very common in northern B.C., the Yukon and Alaska. It is also widespread in the Southern Chilcotin Mountains where it is apparently at the southern limits of its range.

Gentiana prostrata - A rare species in northern B.C. that is said to occur south in the Rocky Mountains. Previous collections have all been in northern B.C. It was rare in the study area and occurred only in Two Lakes Basin (plot 15).

Lupinus lepidus var. lobbii - This lupine is extremely common to the south of the study area but seems to be at the northern limits of its range in the Two Lakes area (plot 100). This species has been considered a community dominant in an alpine area in Washington (Del Moral, 1979). Only one stand was encountered in the study but Lupinus lepidus was the main dominant on this rocky, unstable slope.

Papaver radicatum - A rare species in B.C. previously collected as far south as the Hazelton area in the western part of the province and on Mount Assiniboine in the Rocky Mountains. Its occurrence on the eastern side of the Dash Plateau (in the vicinity of plot 57) is a significant range extension in B.C.

Poa lettermanii - This is a common species on the higher peaks in the Rocky Mountains and southwestern B.C. but was also collected on Birch Mtn. in northwestern B.C. It was collected at the top of Relay Mountain (plot 133). Dr. V.C. Brink (personal communication) believes that this grass may be found only on Nunatuks, or sites which escaped glaciation.

Populus trichocarpa - Black cottonwood is widespread at low elevations but is only occasionally found in the alpine. Specimens less than 15 cm in height were collected at 2190 m in Relay Valley (plot 28). The only high elevation collections in the U.B.C. herbarium are from Garibaldi Park where it is found at 1520 m.

Ranunculus gelidus - A rare species has been collected in northern B.C. (Mt. Edziza and the Gladys Lake Ecological Reserve) and in Snow Creek Pass in the Rocky Mountains. The collection of this species on Relay Mountain (plot 133) represents a considerable range extension.

Ranunculus inamoenus - This species is rare in B.C. but the previous collections represent a disjunt distribution. Two localities in southeastern B.C. (in the Flathead and Wall Lake regions) are within the range described by Hitchcock and Cronquist (1973). Collections from Anzus Lake and the Ilgachuz Mtns. however are considerably to the north and west. The presence of this species in Graveyard Valley ties the distribution together and suggests that this species may be more common than collections indicate.

Salix cascadensis - Cascade willow is a relatively common species in southeastern B.C. and in the Washington Cascades. It was widespread on the Dash Plateau (plots 150-154, 216, 220) where it is near the northern limits of its range.

Senecio elmeri - This species occurs at high elevations in Washington and southern B.C. It was collected on the rocky slopes of Relay Mountain (plots 133 and 74) and nearby ridges (plot 124), where it is at the apparent northern limit of its range.

Cinclidium stygium - This moss had not been collected previously in southwestern B.C. It is relatively common north of Prince George and was collected in the Rocky Mountains near Golden. It was found in only one location (plot 182) near Two Lakes Valley.

Introduced species - In spite of the long history of grazing in the Southern Chilcotin Mountains, very few weedy species are present. Taraxacum officinale is the only widespread introduced species. It is relatively common in meadows on valley bottoms and lower slopes. Horses, cattle and spruce grouse do utilize this species. Poa pratensis (Kentucky bluegrass) has become fairly common in the moist valley bottom meadows but it is abundant only in a few

heavily grazed stands. Trifolium hybridum (alsike clover) is frequent in the vicinity of Relay Cabin but had not spread into adjacent meadows. Matricaria matricarioides (pineapple weed), a native cordilleran weed, was found on the old mining road in Relay Valley. It did not appear to be spreading.

Chapter 7

DISCUSSION:

1. Distribution of Plant Community Types

The high elevation plant communities in the Southern Chilcotin Mountains lie in the alpine and subalpine zones. The division between these two zones is not always clearly evident. Krummholz generally occurs at the upper limits of tree growth but has been included in both zones by various authors (Luttmerding, 1976; Douglas and Bliss, 1977; Krajina, 1969; Love, 1970; among others). In the present study, alpine was considered to be the area above the occurrence of upright trees, thereby including krummholz in the alpine. Tree islands with upright trees in the center would then form the upper limit of the subalpine zone. This is referred to as timberline although it usually represents a region or zone of vegetation rather than a distinct line.

The lower limit of the alpine zone occurs at roughly 2,000 meters in the study area. This figure varies with aspect. On warmer and drier south-facing slopes timberline may be slightly higher while it may be fifty meters lower on north-facing slopes. Alpine plant communities were sampled at elevations up to 2350 m on the Dash Plateau. Only the rockland terrain unit was found above this. In regions where the topography is relatively gentle, there is a gradual shift from subalpine to alpine conditions. Such is the case in the Southern Chilcotin Mountains. In these regions there can be a substantial overlap between alpine and subalpine community types (Del Moral, 1979). This is confirmed by the distribution of plant communities in the present study.

Only three of the nineteen plant communities described are restricted to the alpine zone (see Figure 11). All are found on rocky, well-drained habitats. The Dryas octopetala community is the driest type found in the

study area aside from the rockland terrain unit. It is restricted to ridges and moderate to steep slopes that would be realtively snow-free in the winter. The Dryas-Festuca type develops on gentle to moderate alpine slopes with limited winter snowpack. Areas which have a greater snowpack and later snowmelt date (late June) but are well-drained, support the Salix cascadensis community type. This type was restricted to north-facing slopes.

Two communities are found in the alpine and at timberline. The Salix barrattiana shrub wetland is an alpine community for the most part but is found in Two Lakes Basin where cold air drainage probably results in alpine conditions below tree line. Seepage from surrounding slopes maintains a high moisture status throughout the summer in all Salix barrattiana stands. The Carex nigricans community is restricted to snowbed habitats at timberline and in the lower alpine zone. The growing season for plants in this type may not begin until mid to late July. These species are adapted for rapid growth and often reproduce by vegetative means.

Several community types are found in both alpine and subalpine habitats. These are the more mesic fescue grasslands and willow shrubfields. The Festuca altaica-Festuca brachyphylla meadow is the dominant grassland at high elevations on gentle to moderate slopes. It is more widespread in the alpine but several subalpine stands were sampled as well. On steeper slopes or at lower elevations the Festuca brachyphylla community is more prevalent. This type seems to be more common on rocky sites. The Salix brachycarpa-Salix barclayi shrubland is restricted to habitats with some seepage input. It occurs primarily on gentle lower slopes. The Salix brachycarpa-Festuca spp. shrub meadow is widespread in the alpine but occurs also in the upper subalpine. These shrubfields have good to moderate drainage.

Three meadow communities are generally found in the subalpine zone but are found occasionally at or just above timberline. The Carex aquatilis/rostrata wetland is rare in the study area. It is limited to depression areas with water saturated soils throughout the summer. A large stand of this vegetation type occurs in Two Lakes Basin which, because of the topography and elevation, supports alpine vegetation. This was the only timberline sedge wetland stand that was found. The Festuca brachyphylla-Phleum alpinum and Phleum alpinum-Carex phaeocephala community types are quite widespread in the subalpine but have a very limited occurrence above timberline. They are found where mesic conditions prevail. All four alpine plots that classify as one of these two communities showed signs of grazing.

Six community types are restricted to the subalpine zone. The spruce-fir forest is best developed on north-facing slopes or in draws where there is an adequate moisture supply. Drier slopes support the Pinus albicaulis-Juniperus communis forest type. At timberline, stunted whitebark pine and subalpine fir form an open parkland vegetation. Krummholz Abies lasiocarpa extends into the alpine in areas where there is sufficient protection from severe winter conditions. The Salix barclayi-Carex aquatilis shrub wetland community is restricted to valley bottoms along streams which keep the soil saturated throughout the summer. On slightly higher ground with better drainage the Salix brachycarpa-Phleum alpinum type predominates. Dry, south-facing slopes support the Arctostaphylos-Amelanchier shrubfield and the Koeleria cristata grass meadow. The shrubfield was generally on the coarser textured soils.

Well defined sequences of plant communities are not common in this area. Microtopographic variation alters drainage patterns and restricts the distribution of communities over the landscape. The result is a patchwork of

community types rather than a distinct toposequence. Nevertheless, generalized patterns help to illustrate the relationship between communities. Figures 12, 13 and 14 represent theoretical toposequences in Relay Valley and on the Dash Plateau.

The four broad habitat types discussed by Buttrick (1978) are evident in these toposequences. At the base of slopes and in depression areas, soils are saturated or moist throughout the growing season. This is a runoff or seepage habitat. The Carex aquatilis/rostrata community is found in the very wettest sites. The Salix barclayi-Carex aquatilis, Salix barrattiana and Salix brachycarpa-Salix barclayi shrub community types are also generally restricted to runoff habitats. The Salix brachycarpa type is sometimes found in more mesic conditions but this is where it grades into the Salix-Festuca shrub meadow.

The Carex nigricans and Salix cascadensis community types are found only in areas with late lying snow. They are generally on north-facing slopes. Late snowmelt results in a short growing season in snowbed habitats and once the snow has melted these sites can become very dry. Snowmelt is earlier in the dwarf willow stands (which are on more exposed slopes) than in the Carex type.

On slopes with moderate to good drainage the mesic meadow and shrubfield communities are found. These are the most widespread types. The zonal communities are included in these meadow and shrubfield habitats. The Festuca altaica-Festuca brachyphylla, Festuca brachyphylla, Festuca brachyphylla-Phleum alpinum and Phleum alpinum-Carex phaeocephala meadow communities are all found in this mesic habitat type. The Salix-Festuca spp. and Salix-Phleum alpinum shrubfields as well as the Picea-Abies forest are included in this habitat type.

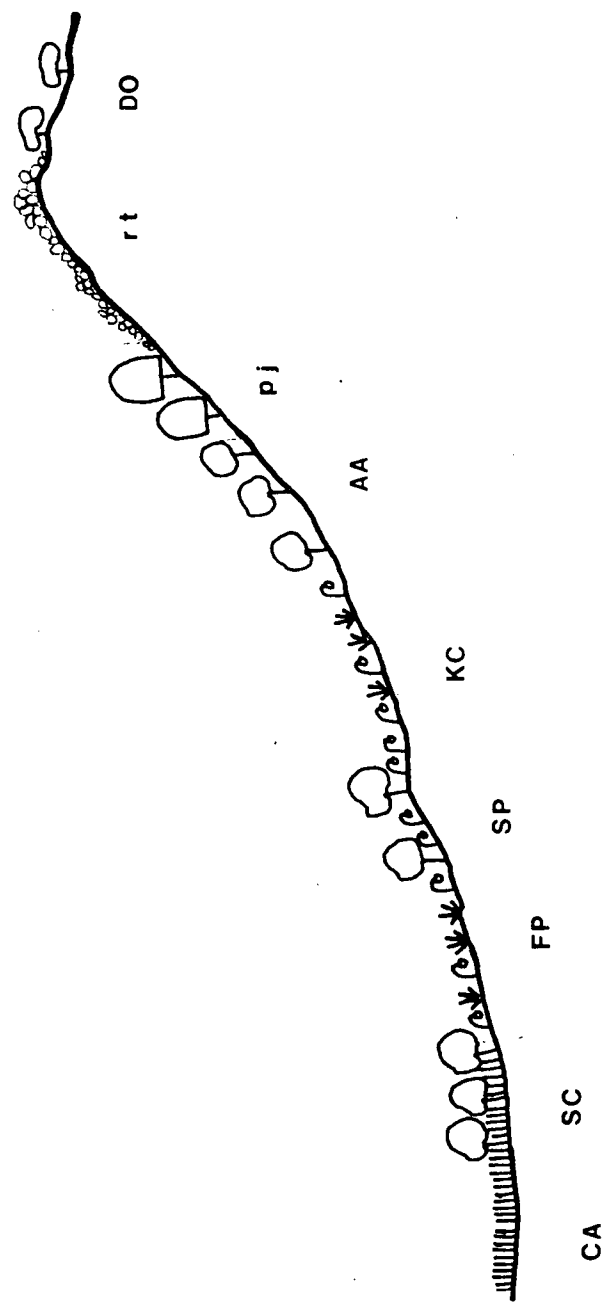


Figure 12. Schematic representation of a south-facing plant community toposequence in Relay Valley.

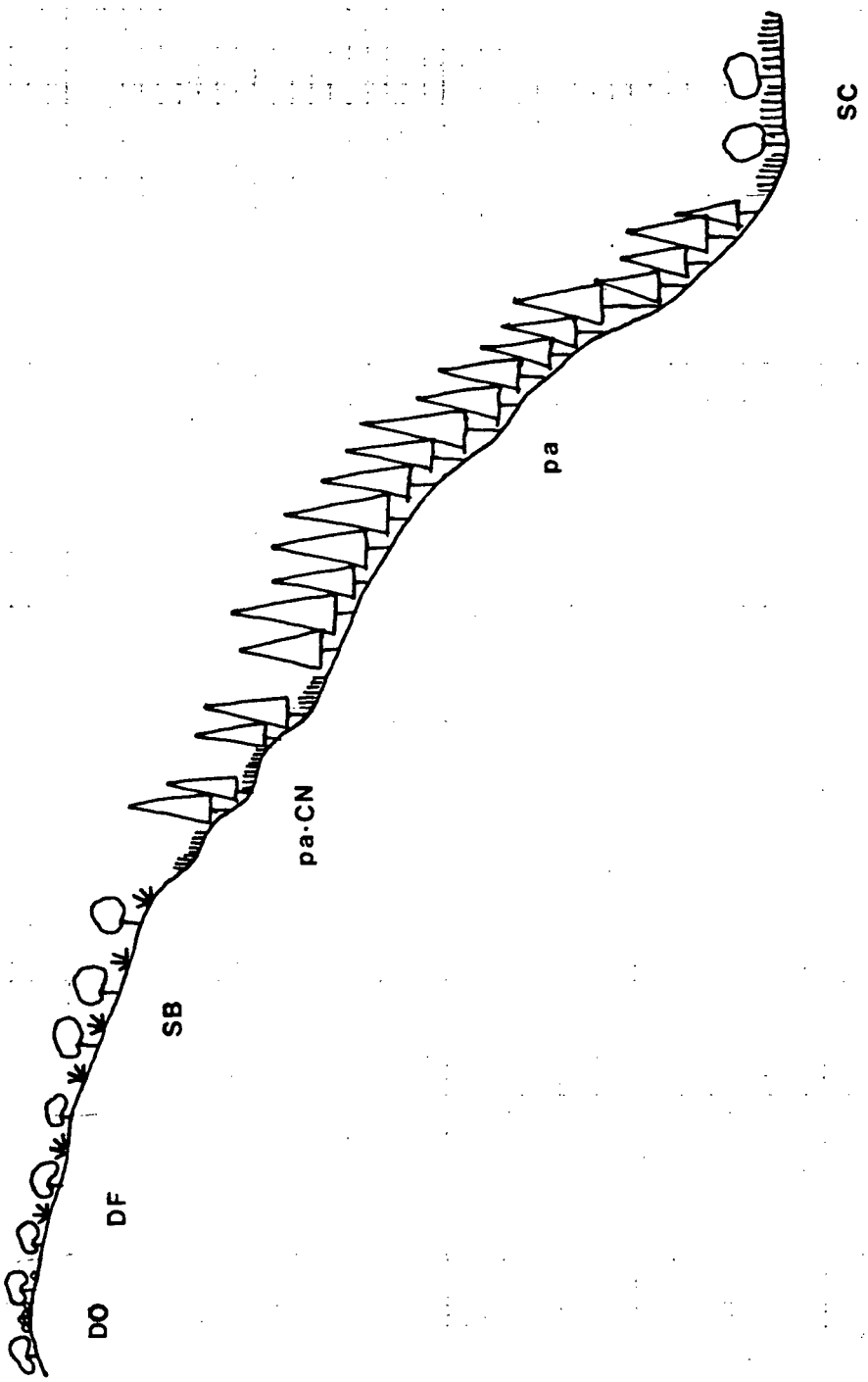


Figure 13. Schematic representation of a north-facing plant community toposequence in Relay Valley.

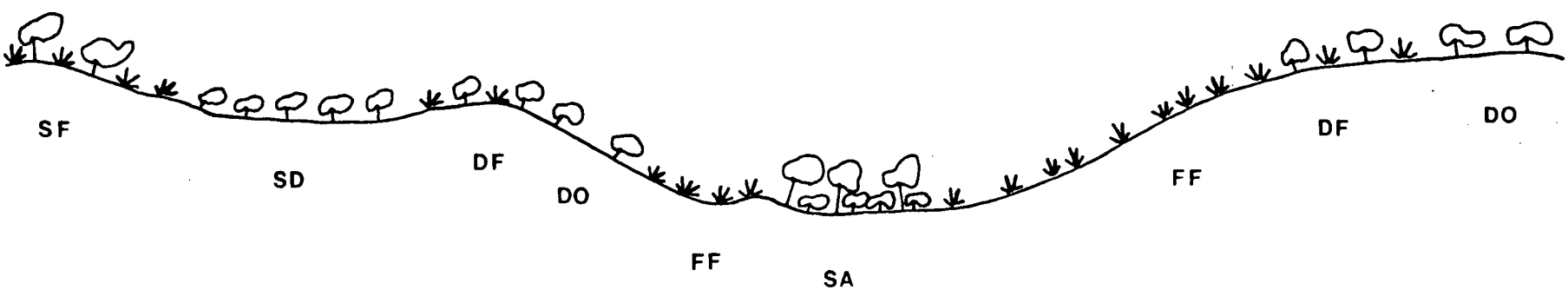


Figure 14. Schematic representation of an alpine plant community toposequence on the Dash Plateau.

Well-drained habitat types occur on ridges and fellfields in the alpine and on steep south-facing slopes in the subalpine. The Dryas octopetala, Dryas-Festuca altaica, Koeleria cristata, Arctostaphylos uva-ursi-Amelanchier alnifolia and Pinus albicaulis-Juniperus communis community types are all restricted to these xeric habitats. In addition, the crustose lichen type is found on rockland and talus terrain on ridgetops and steep upper slopes. Occasionally the Festuca brachyphylla and Festuca altaica-Festuca brachyphylla meadows occur on xeric fellfield habitats but their best development is on mesic sites.

2. Successional Relationships of Plant Communities

General patterns of succession can be determined by analyzing stand structure and changes in species composition. Exclosures or relic stands allow for a more precise comparison of the vegetation in areas subject to grazing pressure; however, lacking these, it is still possible to determine broad relationships between plant communities and to hypothesize successional patterns.

Mountain terrain generally provides a diversity of habitat types over the landscape, resulting in a corresponding mosaic of successional and climax types. The climax types are in dynamic equilibrium with the environment. The controlling factor may be climatic, topographic or edaphic; thus a number of climax communities may be recognized within one climatic region.

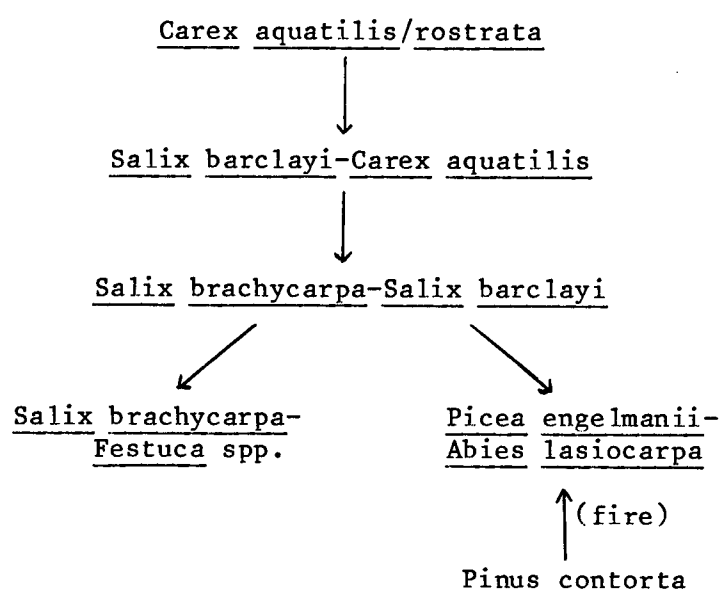
Successional stages are generally thought of as a linear progression towards a climax type. This is not necessarily the case. In the alpine, cyclical climaxes have been described in relation to cryoturbation and solifluction (Churchill and Hanson, 1956), processes which disrupt the

environmental balance. In habitats where these processes are active it may be possible to describe mini-successional sequences. Buttrick (1978) suggests that the same community patterns will occur even though the habitat positions on the landscape may change. In the present study, no attempt was made to document mini-successional patterns.

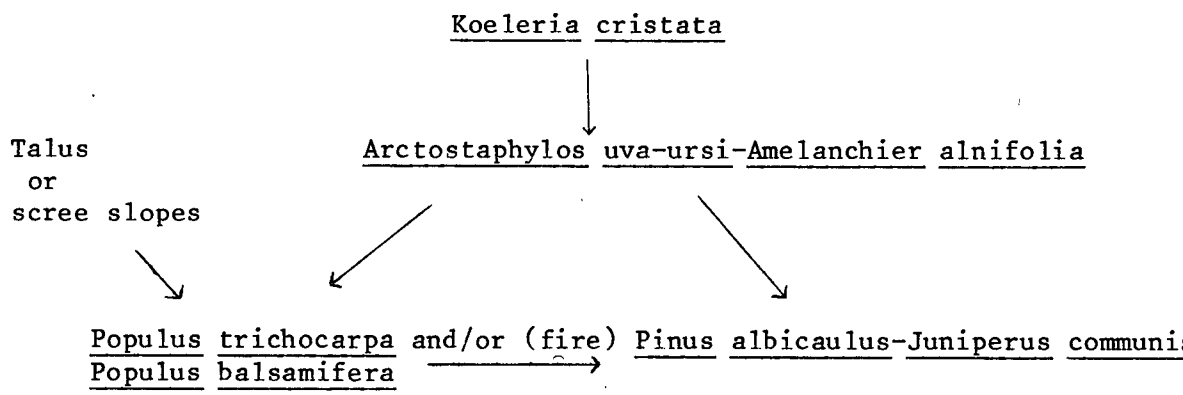
Rates of succession are generally slow, resulting from the short growing season and slow growth of woody species. Fire and grazing are the primary factors responsible for retrogressive changes. There was no evidence of fire in the alpine stands although a history of fire was apparent in the subalpine communities. Both zones have been grazed by domestic animals as well as by wildlife. There are no records to document levels of grazing throughout the study areas. Because directional changes in alpine vegetation are very slow, it is difficult to determine succession and climax stages. Certain relationships, however, are fairly evident. The crustose lichen vegetation on rockland and talus terrain units obviously includes the primary colonizers of this harsh environment. On scree slopes the Dryas octopetala community is an early invader. The ability of Dryas to fix nitrogen undoubtedly gives it an advantage in colonizing these sites. It is probably succeeded by the Dryas-Festuca type when greater soil development has occurred and the moisture status has improved. The climax of this progression appears to be the Festuca altaica-Festuca brachyphylla community although development would be extremely slow. This type is considered to be the zonal vegetation or climatic climax in this dry alpine region. Buttrick (1978) felt that the Festuca meadows were the zonal vegetation in the Atlin region because of low precipitation. In areas of greater precipitation, heath vegetation is generally considered climax (Archer, 1963; Krajina, 1965; Franklin and Dyrness, 1973; Pojar, 1977).

The other five communities found in the alpine zone seem to be fairly stable given present climatic conditions. The Carex nigricans timberline community is a topoedaphic climax in habitats with late lying snow and good water retention throughout the summer. The Salix cascadensis community is also found in snowbed habitats (as reported by Douglas and Bliss, 1977) but the substrate rapidly dries out. Given a shorter snow duration both of these communities might develop towards the fescue grassland. The alpine shrubland communities appear to be topoedaphic climaxes. They are dominant on sites with a better moisture status than in alpine grasslands. The Salix barrattiana type is found in basins with a seepage influence while Salix brachycarpa-Salix barclayi is found on moist slopes and the Salix brachycarpa-Festuca spp. type is characteristic of mesic slopes. The latter might be considered a zonal climax community.

Three successional sequences can be postulated for the subalpine zone. In moist habitats the following hydro-sequence appeared to predominate:



Wherever a sedge wetland occurred the other three communities could be found in close proximity and generally in a topographic sequence. Grazing on the edges of sedge wetlands has resulted in some soil compaction and channeling resulting from trampling damage (wet soils are especially sensitive to this). This may be increasing the rate of succession as willow species are able to invade on the tops of soil remnant "islands". Wherever fires have occurred, Pinus contorta stands precede the climax spruce-fir forest. In the upper subalpine the willow communities climax in a Salix-Fescue type. On dry, south-facing slopes the successional sequence seems to be as follows:



The dry junegrass meadow community is fairly common on the south-facing slopes of Relay Valley and may be maintained by fire. Encroachment by shrubs was evident but not abundant. The species characteristic of this grassland are generally also present in the dry Arctostaphylos-Amelanchier shrubland. In fact, Koeleria cristata is dominant in both community types. Stands with a fire history are usually dominated by Populus trichocarpa but the shrub and herb layers are that of the dry shrub and grassland communities. Fine talus or scree slopes may have a shrub stratum dominated by aspen or poplar. In this case the dry shrub community is a pioneer stage. These are generally on

steep, south-facing slopes and will probably be succeeded by the Pinus albicaulis-Juniperus communis forest. Several well established old pine stands were found on south-facing slopes of Relay Valley. The whitebark pine forest is a topoedaphic climax in this region.

The question of succession on the subalpine meadows is a more difficult one. The Salix-Festuca and Salix-Phleum communities suggest that many of the grasslands may be successional to shrub-dominated communities. Indeed, willow seedlings were present in some of the meadow stands studied. However, the meadow communities occupy drier habitats and under the present climatic regime these sites might not support extensive shrub growth. The mosaic of shrub and meadow communities indicates that there is a very fine line in the moisture requirements for the two communities. Annual fluctuations undoubtedly result in a dynamic balance. Both of these shrub and meadow types might well be considered topoedaphic climaxes.

3. Grazing Implications

Although vegetation changes slowly in response to grazing pressure, given sufficient time and levels of impact the composition of plant communities may change sufficiently to allow the identification of stages of retrogression or secondary succession. The range condition classes of Dyksterhuis (1949) are based on relative changes in species coverage and several studies have documented changes in species composition on high elevation fescue rangelands (Hanson, 1951; Looman, 1969; Forsling, 1931; Branson and Lommasson, 1958).

In the subalpine, grazing was more prevalent in the meadow and willow-grass communities. These types are found on valley bottoms and lower slopes and therefore provide the most readily accessible and easily available

forage. The wet shrublands were dominated generally by a dense overstory of shrubs and a ground cover of mosses, neither of which were utilized by cattle. Some forage was provided by small amounts of Phleum alpinum, Aster foliaceus and in the Salix-Carex community by Carex aquatilis. The spruce-fir forest was too dense and lacked an adequate herb stratum to provide an appreciable amount of forage. There was evidence of grazing in the open pine forests but this community was found generally on the less accessible upper slopes. Thus the cattle tend to be concentrated in a relatively few plant communities. Estimates of carrying capacity should take this into account.

Examination of the plant communities found in four of the main valley bottom meadows suggests that there might be a successional relationship between the meadow community types (Table XXIII). The large meadow at the base of Relay Mountain in Relay Basin is composed of the Festuca-altaica-Festuca brachyphylla community type. All five sample plots from this stand classify as this type. The elevation of this stand is about 2000 m. The main trail into Relay Basin leads to the west rather than into this meadow. The trail into this part of the basin was not well used and consequently was difficult to follow. The meadow obviously had been grazed by cattle but apparently by fewer animals or for fewer years. The dominant fescue bunchgrasses were generally in good condition and there were few bare spaces between plants. Some flowering stalks reached 45 cm in height.

The valley bottom meadow in Graveyard Valley classified as a composite of two community types. Four of the eight plots were in the Festuca brachyphylla community and four were in the Festuca brachyphylla-Phleum alpinum type. The elevation of this stand is about 1900 m. This valley has been grazed by cattle since the early 1940's (Wood, 1949). The trails into the valley were all well

TABLE XXIII: Summary floristic table showing characteristic species groups for four valley bottom meadows. Values are cover class.

	Relay Basin					Graveyard Valley								Two Lakes Valley					Relay Cabin				
Plot Number	129	130	131	132	185	115	103	107	105	104	110	114	117	10	7	8	6	5	2	1	3	4	41
Community Type	Fa Fb	Fa Fb	Fa Fb	Fa Fb	Fa Fb	Fb	Fb	Fb	Fb	Fb Pa	Fb Pa	Fb Pa	Fb Pa	Fb Pa	Fb Pa	Pa	19	19	19	Pa	Pa	Fb Pa	Pa
Group B 2/3																							
Festuca altaica	3	2	2	1	2									2									
Cetraria islandica	2	1	2		1					1	1												
Cladonia squamulose	3	1	2	1																			
Group 9 2/4																							
Festuca brachyphylla	1	1	1	3	2	2	2	3	1	2	2	2		1	4	2							
Penstemon procerus	2	2	1	2	2	2	1	2	1	1	2	2	1	2	1							1	
Polemonium pulcherrimum		1		1	1	1		1				1	1									1	
Geum triflorum		2			2	2		2			2	2	2	2									
Group 10 1/3																							
Phleum alpinum			2							2	2	2	2		2	2				2	2	2	3
Trisetum spicatum		1						1	1	1	1	1								1	2	2	
Arenaria capillaris	1	2	1	2									2	2		2							
Group 17 4/9																							
Cerastium arvense	1	2	1	1	1	2		2	1	2	2	1	1	1	2	2	1	1	1	2	1	2	
Achillea millefolium		1	1	1	1	1		1	1	1	1	1	2	1	1	1	2	2	3	3	2	2	2
Carex phaeocephala	2	2	2	2	1	3	1		2	4	2	2	2	1	2	2	2	2	2	2		2	
Taraxacum officinale						1		2				2					1		4	3	2	4	4
Potentilla diversifolia	2	2	1	2	2	2	1	2	1	2		3	1	1	1	2	2	2	2		1		
Fragaria virginiana											3		2	2					1	2	2	1	
Galium boreale						1								2						1	2		1
Tortula norvegica		1				1		1					2		1		1	1			1	1	
Poa pratensis																2	5	4	2				

worn and easy to follow. The present range condition must be considered poor (Fredell et al., 1974). The meadows are similar in appearance to xeric sites although they have a submesic hygrotope. There is a great deal of bare ground between plants and the best growth of plants rarely exceeds 15 cm rather than the 25+ cm of less disturbed stands. Festuca altaica was lacking from the valley bottom meadow but was found at the north end of the valley across the creek from the main meadow. Although Festuca brachyphylla was present, its vigor was generally poor, the bunches were small and growth was sparse. Phleum alpinum and Geum triflorum were far more prominent in Graveyard Valley than in Relay Basin. According to Looman (1969) both of these species would be expected to increase in grazed sites.

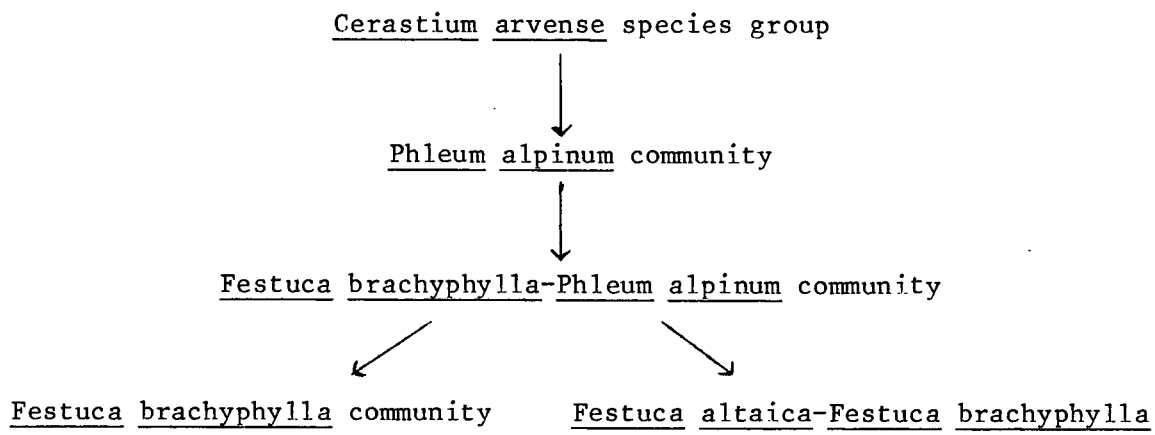
The valley bottom meadow in Two Lakes Basin is similar to that of Graveyard Valley but more restricted in area and it is adjacent to a watering pond. Such areas often receive a heavier concentration of use. This is reflected in the classification of sample plots from this stand. Of the six plots one was in the Festuca altaica-F. brachyphylla community, two were in the Festuca-Phleum alpinum type, one was in the Phleum alpinum and only two met the requirements for the Cerastium arvense (field chickweed) species groups (17). Poa pratensis (Kentucky bluegrass) was the dominant grass in the latter two plots, both of which were adjacent to the sedge wetland surrounding the small lake at the east end of the basin. The Phleum alpinum plot was also adjacent to water (the outflow creek) and the soil surface was irregular, possibly as a result of cattle trampling early in the season when the soils are still quite wet. This meadow is at an elevation of 1970 m and probably has been grazed by cattle for nearly as long as Graveyard Valley (Wood, 1949). The trail from Big Creek is well worn as is the trail from Relay Cabin. The quality of forage in this meadow is low. Festuca brachyphylla was dominant in only two

plots while Festuca altaica was present only in one plot. Phleum alpinum was relatively common but it is a low growing species that does not provide much forage. The abundance of Poa pratensis on the wetter sites is considered to be a result of heavy grazing (Hanson, 1951; McClean and Marchand, 1968; Looman, 1969).

The valley bottom meadow at Relay Cabin is somewhat unusual in that it is at a lower elevation (1640 m) and is fenced to provide pasture for horses and to serve as a holding area for cattle being driven into and out of the alpine rangelands. This results in severe grazing levels for short periods of time. The growing season is slightly longer here (in 1977 most forbs were in flower by mid-June) but the vegetation composition does not reflect the more favorable growing conditions. Only one plot was classified as the Festuca brachyphylla-Phleum alpinum type; three were in the Phleum alpinum community, and one met only the Cerastium arvense species group requirements with Taraxacum officinale (common dandelion) the dominant species in this and the other four stands. Fescue was not recorded in any plots. Alpine timothy and spike trisetum were the dominant grasses but their cover was always less than that of Taraxacum. Stipa columbiana (Columbia needlegrass) and Kentucky bluegrass were also important grasses. The concentration of grazing in this valley has produced a species poor forage in this meadow which may result in a lower carrying capacity.

Comparison of these four meadows is limited by the fact that they are not all at the same elevation and detailed records of past grazing use are not available. However, comparison is interesting in that it generates some hypotheses concerning grazing impacts that can be tested in the future. Assuming that Relay Basin has received the least amount of grazing pressure, the Relay Cabin meadow the heaviest grazing impact and Graveyard Valley and

Two Lakes Basin the longest use, but not as concentrated as in Relay Valley, it is possible to correlate grazing use with plant composition. Relay Basin has the best range condition. The Festuca altaica-Festuca brachyphylla type characterizes this rangeland. Many years of grazing has eliminated Festuca altaica from the Graveyard Valley meadow and resulted in relatively poorer range conditions with the decline of this desirable forage species. This area is characterized by the Festuca brachyphylla and Festuca-Phleum plant communities. These community types are found also in the Two Lakes valley bottom meadow, but in addition the Phleum alpinum type and the Cerastium arvense species group characterize sites which have been damaged by trampling. The meadow at Relay Cabin is predominantly the Phleum type (fescue has been eliminated) and is characterized by the weedy species in the Cerastium group (eg. dandelion). This meadow is in the poorest condition. Range recovery might involve the following hypothesized succession:



On steep, rocky slopes succession may end at the Festuca brachyphylla community. This is suggested by the results of plots 62 through 65 on the north slopes of Relay Valley. Four plots were sampled in this southwest-facing meadow at 1900 m because it showed little evidence of grazing. All were classified as the Festuca brachyphylla community and were included in the

rocky subassociation dominated by Oxytropus campestris (slender crazyweed). Koeleria cristata was an abundant grass in this stand, however, and it may be that, given sufficient time, this fescue meadow will be succeeded by the Koeleria meadow community and eventually will climax in a pine forest (which presently surrounds it). Grazing impacts are more severe on slopes. Terracing can occur and when plants are damaged the soil is subject to rapid erosion. Species such as Bromus tectorum and Hordeum jubatum were present on one badly disturbed site near Prentice Lake.

The pattern of plant community dominance in relation to grazing suggested by this work corresponds closely with that found by Looman (1969) in the foothills of the Rocky Mountains. Looman (1969) found the dominance pattern in a transect from heavy to moderate grazing shifted from Achillea millefolium to Phleum pratense L.-Poa pratensis-Achillea $\longrightarrow$ Phleum-Poa $\longrightarrow$ Poa-Phleum-Danthonia intermedia $\longrightarrow$ Danthonia-Poa-Phleum $\longrightarrow$ Danthonia-Festuca scabrella. A similar trend was reported by Hanson (1951) for rough fescue grasslands.

Overuse often results in a considerable increase in weedy forbs even though the original species may not be eliminated completely. This is a function of palatability since the most desirable forage species will be at a competitive disadvantage as they will be grazed more frequently than non-palatable species. The ability to reproduce quickly (often vegetatively), to colonize bare ground and to withstand trampling also give a competitive advantage to weedy species. These characteristics are found in most of the species included in the Cerastium arvense species group (17). Four out of nine species from this group are present in 105 plots. The widespread occurrence of this species group is probably a function of past grazing. It is found in all but the wettest and driest habitats. Both meadows and shrub-fields are characterized by a high frequency and cover of many of the species

in the Cerastium species group. This effectively decreases the distinction between community types and, as these species increase in cover, the productivity of the more valuable forage species decreases. This means that estimates of forage production should be adjusted according to the condition of the range. Unfortunately productivity studies were not included in this study. These data would be useful in establishing acceptable grazing levels for these high elevation dry rangelands since, according to the literature, productivity can range anywhere from 267 to over 1000 kg/ha (Bliss, 1956).

The distribution of livestock is another factor that should be considered in determining the carrying capacity of mountain rangelands. Not all plant communities are grazed. The open meadows and the mesic shrubfields are the most heavily utilized community types. These represent only a small percentage of the total area and are restricted largely to the lower slopes and well-drained valley bottomlands. These areas generally will be overutilized before the higher slopes are grazed. This explains the observation by Fredell et al. (1974) that the rangelands on the upper slopes were in good condition while the lower ones were in poor condition. It is almost impossible to obtain uniform utilization over such varied topography. Thus estimates of usable rangeland should include only readily accessible slopes that support vegetation which is generally utilized. The proper distribution of animals is one of the most important problems in cattle management on alpine rangelands (Thilenius, 1979).

The most effective means of controlling utilization of the rangelands requires regulation of the grazing season which often coincides with the rather short and unpredictable growing season. The initiation of growth varies between sites as well as from year to year. In the subalpine meadows of Relay

Valley, plant growth was well underway by mid-June in 1977. At higher elevations, however, patches of snow remained until the end of June and the adjacent soils were saturated. These wet soils are extremely susceptible to trampling damage. Delaying the start of the grazing season minimizes soil damage and makes allowance for the annual variation in the start of the growing season. Furthermore, recent work by Tiezea and Archer (1979) suggests that early season grazing may have detrimental effects on the net carbon balance, the effects of which will not be evident until subsequent growing seasons. In terms of the carbon balance, mid to late-season grazing was found to have the least effect on the plants. On the other hand, grazing must not extend too late into the fall because of the likelihood of snowstorms and the possibility of damage to the moist soils. Current allowed use (August 1-September 15) of the high elevation rangeland in the Relay area is well within these guidelines. The effect of alternate year use on the condition of the range should be evaluated - the results of this study provide the necessary baseline data as this grazing scheme was implemented in 1977.

Judging range condition in the alpine and subalpine requires a knowledge of the local ecology and a classification of the vegetation in relation to site and environmental variables (Thilenius, 1979). Each range type or plant community should have a set of criteria on which to judge its condition as cross community comparisons may not take into account the variability in site potential. Poor condition is reflected generally in a decline in plant vigor or herbage production as well as a decrease in ground cover (Lewis, 1970) but both of these criteria must be judged relative to the best condition for that plant community. An alpine fellfield will always look poor when compared with a fescue meadow since bare ground is present naturally. In addition,

different community types can tolerate different levels of grazing resulting in a composite of condition classes within small areas. Those types found on unstable soils and steep slopes such as the Dryas octopetala, Amelanchier alnifolia-Arctostaphylos uva-ursi and Koeleria cristata communities or on wet soils such as the sedge and shrub wetland types may be susceptible to damage at lower levels of grazing than the mesic meadow and shrubland types. Stands in poor condition may require special consideration such as fencing to protect them from further damage when adjacent range sites in good condition are still being grazed.

The use of indicator species in judging range condition has limitations. Changes in species composition require many years and are not easily documented. Even when they are known, these changes provide evidence for long term trend and can be used only in defining long term management objectives. In addition, all species may be desirable when the major concern is to prevent soil erosion (which is the first goal of good range management). Certain species may be important in indicating the quality of forage but a knowledge of user preference is required to classify species as desirable or undesirable. This information is not available for cattle or sheep on high elevation rangelands in British Columbia The results of the present study suggest that Festuca altaica is highly preferred by cattle but this observation requires documentation. Variation in vigor or productivity of key species may be a result of climatic conditions rather than grazing. According to Thilenius (1979), productivity in the alpine can fluctuate naturally by as much as 50 percent from year to year. Thus the range manager needs to become familiar with the annual variability in key range communities so that grazing levels and condition classes will be appropriately determined. This was beyond the scope of the present study.

4. Relationship of Plant Community Types from the Study Area With Those of Surrounding Areas

Many plant communities described for the Southern Chilcotin Mountains have ecological and floristic similarities with community types studied in northern British Columbia as well as in the Pacific Northwest. Very few vegetation studies have been done in the relatively dry alpine zone therefore suggested correlations are often of a general nature.

The two broad forest communities described are typical of the dry interior subalpine zone (Annas and Coupe, 1979). The four Abies lasiocarpa and Picea engelmanii tree island communities of Eady (1971) would be combined in the spruce-fir forest type. Very little Pinus albicaulis was found on Big White Mountain. Del Moral (1979) describes a Pinus albicaulis:Juniperus communis: Penstemon davidsonii community on dry ridges and a widespread P. albicaulis-Abies lasiocarpa:Vaccinium myrtillus community on south-facing slopes in the Enchantment Lakes Basin, Washington. Both of these are comparable to the Pinus albicaulus-Juniperus communis community type.

The tall willow shrub communities found in the study area are characteristic of northern B.C. but were not described in studies south of the Chilcotin Ranges (Kuramoto and Bliss, 1970; Eady, 1971; Douglas and Bliss, 1977; Del Moral, 1979). The Salix barclayi-Carex aquatilis community type is floristically and ecologically similar to the Salix barclayi-Betula glandulosa-Carex aquatilis-moss community found on poorly drained valley bottoms in the Gladys Lake Ecological Reserve (Pojar, 1977). Similarly the alpine Salix barrattiana shrub type corresponds to the Salix barrattiana-Petasites frigidus-Tomenthypnum nitens community of Pojar (1977). Both occur on wet sites in alpine valley bottoms. The Salix planifolia-Empetrum nigrum-Sphagnum runoff community on Birch Mountain described by Buttrick (1978) has some similarities

to the Salix barrattiana wet shrubland. Ogilvie (1969) described a similar Salix barrattiana community for the Rocky Mountains of Alberta. Although there are floristic differences, the Salix brachycarpa-S. barclayi community has the closest affinity to the Salix (glauca. barclayi, planifolia)-Festuca altaica-Rubus arcticus-Petasites frigidus-Aulacomnium palustre community described by Pojar (1977). The latter is floristically richer than its southern counterpart and Salix glauca takes the place of Salix brachycarpa; however, they do occupy similar habitats. It is also similar to the Astero (yukonensis)- Junco (arctici)-Salicetum brachycarpae association described by Hoefs et al., 1975. The Salix glauca community of Ogilvie (1969) is also equivalent.

The drier willow shrub communities also have their counterparts in the north. The Salix brachycarpa-Festuca spp. shrubfield is comparable to the Gladys Lake Betula glandulosa-Festuca altaica-cryptogam community while the Salix brachycarpa-Phleum alpinum type in this study is more or less equivalent to the Salix glauca-Betula glandulose-Festuca altaica community (Pojar, 1977). The latter are prevalent on valley bottoms and lower slopes while the former are characteristic of the upper slopes. The abundance of Phleum alpinum rather than Festuca altaica or F. brachyphylla may be a function of the grazing history in the Southern Chilcotin Mountains.

The Arctostaphylos uva-ursi-Amelanchier alnifolia dry shrub community is most similar to the Arctostaphylos uva-ursi community described by Douglas and Bliss (1977) in the North Cascades. The Juniperus communis-Arctostaphylos uva-ursi-grass community in the Spatsizi (Pojar, 1977) and the Juniperus-Arctostaphylos community characterized by Douglas (1974) in the Yukon are ecologically and floristically similar similar as well. All of these plant communities are found on dry, steep, south-facing slopes.

The Salix cascadensis dwarf willow community type is not widespread in British Columbia. Douglas and Bliss (1977) and Taylor and Bliss (1978) describe a similar community in both the western and eastern North Cascades. The habitat in the eastern part of the range is identical to that found in the present study. Although Salix cascadensis was found in the Enchantment Lakes Basin, Del Moral (1979) did not consider it a community dominant.

Dryas octopetala is a circumboreal species that is dominant over extensive areas in the north and in the Cascades. It was very common in the study area but had a limited occurrence on Big White Mountain (Eady, 1971) and in the Enchantment Lakes Basin (Del Moral, 1979), both of which are also in the relatively dry alpine zone. Douglas and Bliss (1977) describe a Dryas octopetala community of similar composition and habitat to that of the study area. The Dryas hookeriana-Oxytropis porocarpa-Cetraria community of Ogilvie (1969) is also comparable. The Cetraria nivalis-Vaccinium uliginosum fell-field described by Buttrick (1978) is ecologically equivalent to the Dryas-Festuca altaica community and is floristically similar, with Dryas and Festuca altaica, both dominants in the community.

Hrapko and LaRoi (1978) describe a Dryas octopetala-Festuca brachyphylla community type on Signal Mountain, Alberta which is comparable to the Dryas-Festuca altaica community in which F. brachyphylla is also a dominant.

Both of the Carex meadow communities have been described in other areas. The Carex aquatilis or C. rostrata wetlands were found in the subalpine by Pojar (1977) in the Gladys Lake Ecological Reserve. Brooke et al. (1970) described the Eriophoro-Sphagnetum association in the Subalpine Mountain Hemlock Zone. This community is dominated by Carex aquatilis and is found in hydric to hygric habitats as are the sedge wetlands in the study area. The

Carex nigricans community is widespread in the Pacific Northwest but was not found in Northern British Columbia. It always occupies late melting snow sites and is common, although of limited distribution, in the subalpine and low alpine zones. Carex nigricans community types have been described by Del Moral (1979), Hrapko and LaRoi (1978), Douglas and Bliss (1977), Kuramoto and Bliss (1970), Brooke et al. (1970), Ogilvie (1969), and Archer (1963).

Grass-dominated meadows are prevalent in the drier climate regions of British Columbia and the Pacific Northwest. Five grassland communities were described for the Southern Chilcotin Mountains while lush forb meadows characteristic of lower elevations or wetter subalpine conditions (Archer, 1963; Brooke, 1970; Kuramoto and Bliss, 1970; Pojar, 1977) were not found. The Festuca altaica-Festuca brachyphylla community type is comparable to the Festuca altaica-Potentilla diversifolia described by Buttrick (1978). Festuca meadows were considered the zonal vegetation on Birch Mountain. Pojar (1977) includes both alpine and subalpine Festuca altaica grassland communities. Both would be similar to the F. altaica-F. brachyphylla community described in this study although the subalpine type (which extends into the alpine) is more closely related. Festuca saximontana replaces F. brachyphylla as a prominent member of the herb stratum. The rough fescue (Festuca scabrella) grasslands in the Southern Rocky Mountains of Alberta appear to be similar in composition (aside from the species of fescue) and ecology (Jaques, 1976). The Festuca viridula-Lupinus latifolius community in the North Cascades (Douglas and Bliss, 1977) and the Festuca idahoensis type in the Olympic Mountains (Kuramoto and Bliss, 1970) are also similar.

The Koeleria cristata dry grassland community type is comparable to the Poa glauca-Carex supina-Potentilla pennsylvanica-Artemesia borealis boreal

steppe grassland described by Pojar (1977). Poa glauca is replaced by Poa interior in this study area. Both are restricted to dry, steep, south-facing slopes. There were no other reports of similar communities in the literature. No reports of communities comparable to the Festuca brachyphylla and Phleum alpinum community types were found. It is possible that they are a function of past grazing use and represent various levels of range condition in the subalpine grasslands. Looman (1969) found that a Phleum pratense-Poa pratensis-Achillea millefolium combination replaced the Festuca scabrella-Danthonia intermedia community with heavy grazing. Intermediate combinations were also found. These appear to be comparable to the Phleum alpinum-Festuca brachyphylla and Phleum alpinum community types described in the present study.

The Rockland or talus terrain unit that is dominated by crustose lichens often is not included in vegetation studies because there are so few herbaceous plants present. Buttrick (1978) described an Umbilicaria blockfield having no vascular species that is comparable to the crustose lichen terrain unit type. Pojar (1977) describes a subalpine talus-lichen-moss terrain unit dominated by cryptogams as well as an alpine fellfield terrain unit. Both are similar to the terrain unit described in the present study. Much more detailed work would be requied to fully characterize this terrain unit type.

The plant community types described for the Southern Chilcotin Mountains are not unique to that area. Similar communities are found in northern British Columbia, southwestern British Columbia, Washington and southwestern Alberta. The Carex nigricans and Salix cascadensis community types have counterparts only to the south while the willow shrublands are characteristic to the north and in the Rocky Mountains of Alberta. The other communities were found both to the north and south of the study area.

5. Relationship to Previous High Elevation Range Studies

Mountain systems supply man with a variety of products. Forage production is of prime interest to the range manager although the storage and supply of water is of equal importance. According to Ellison (1944), range in good condition will supply man with a maximum of the products he needs. Thus range condition is the present health of the range in relation to its potential to supply the desired products (i.e. forage and water). The potential must be determined on a site specific basis. The site potential may not be the "climax" state as the climax community type may not provide a maximum of the desired products. Furthermore, it is not always possible to determine the climax type for high elevation rangelands. Even when it is possible to determine the theoretical climax type, it may not be realistic to expect to achieve broad species combination goals as harsh environmental conditions result in a slow successional rate.

Range condition is generally evaluated in terms of species composition in relation to the climax potential (Dyksterhuis, 1949). Four condition classes (excellent, good, fair, and poor) derived from the proportion of decreasers, increasers, and invaders (Dyksterhuis, 1949) are frequently used to classify the condition of a rangeland. In the alpine, however, changes in species composition occur slowly and the relative amounts of decreasers, increasers and invaders may not provide the best indication of range condition, although they may reflect long term changes. Furthermore, the responses of high elevation species to grazing have not been documented so that this classification would be purely subjective. Other indicators of range condition should be evident before changes in species composition have occurred. Plant distribution, vigor, and soil stability are the most

important factors to consider in assessing high elevation range condition. These will be discussed in terms of the condition classes proposed for mountain rangelands.

The goal of the range manager is to maintain the balance between topography, climate, soil, plants, and animals (Ellison, 1944). This balance is the normal condition of the range. There is a dynamic equilibrium between all of the components of the system. This balanced condition is equivalent to good or excellent range condition. Plants are evenly distributed and provide a ground cover of at least 65-70 percent, with small, and well dispersed areas of bare soil (Ellison, 1960). In meadows or herblands, a good mixture of forbs, grasses and sedges, provides an almost complete cover of vegetation and litter. Plant vigor is also an important indicator of range condition. Herbage production is variable and difficult to assess but plant height, size of bunches, flowering, seed set, and cover of key forage species gives an indication of range health. Further research is needed to correlate these criteria with productivity.

A stable soil is another factor required for balanced range condition. Soil stability is largely a function of slope, moisture, and vegetative cover. Soils on steep slopes are easily eroded when the vegetative cover is damaged. Similarly, wet soils are most susceptible to damage. In general, loamy textured soils have the optimal resistance to water erosion and soils with a clay texture are the most susceptible as they hold the most water. Soils with a high silt or sand content have poor structural qualities and are therefore easily eroded (Trottier and Scotter, 1973). More detailed soils information from the Relay area would be useful in determining erosion potential. Many of the soils in the Relay area occur on slopes greater than 20 percent and are

therefore more easily eroded when the vegetation is removed. If these slopes are heavily sodded they are not susceptible to damage (Lewis, 1970). Most of the soils in the study area are well to moderately well drained which reduces the erosion hazard. Where soils are imperfectly drained (in Two Lakes Basin, along creeksides, in late snow depressions, and in concave depressions on the Dash Plateau) care should be exercised in order to maintain a balance between the vegetation and soils.

There are basically two types of range deterioration or unbalanced range condition. Both may correspond to either fair or poor range condition depending on the degree of change from a balanced state. The first type includes criteria which can be assessed soon after overgrazing of a range occurs. Species are thinned out, there is a decline in plant vigor, and there is an increase in the size of patches and in the amount of bare ground to over 30 percent of the ground cover (Lewis, 1970). Evidence of soil erosion may also be present (e.g. gullies, soil remnants, etc.). This unbalanced range condition may later be masked by an increase in the cover of species that are not readily grazed. The range still appears to be balanced although it may no longer supply a maximum amount of forage. Given sufficient time, weedy species may replace the more desirable forage species as the community dominants. This is the second type of unbalanced range. The growth form of these species limits the herbage production available to the grazing animals. The main species in the Relay area that appeared to have become prominent as a result of grazing were Taraxacum officinale, Cerastium arvense, Fragaria virginiana, Geum triflorum, Achillea millefolium, Potentilla diversifolia, and Cerastium hookerianum. These species might be considered increasers or invaders; however, this cannot be substantiated by the present study as no data are

available to determine the abundance of these species in ungrazed parts of the Southern Chilcotin Mountains. The presence of these perennial species is more desirable than bare ground as they help to stabilize the soil and prevent erosion. However, in relation to the site potential they generally do not indicate balanced range condition unless they are found in conjunction with more desirable range species.

The diversity of topography and vegetation in mountain rangelands raises the question of the suitability of community types for grazing. This should be based on the limitations of the sites and on the habits of the animals (Lewis, 1970). Soils which are sensitive to erosion should be avoided as should slopes of greater than 20 percent (unless they are well sodded). A protective ground cover of vegetation and litter must be maintained or the stand should not be grazed (Lewis, 1970). Wet soils should not be subjected to unnecessary trampling pressure. The observed distribution patterns of the grazing animals gives perhaps the best indication of the suitability of stands for grazing. Cattle appeared to have preferred the subalpine valley bottom meadows and lower slopes. The drier shrubfield types were also grazed. In the alpine the Festuca meadows were preferred although the Dryas-Festuca type also received some grazing use. On the Dash Plateau the stands closest to Dash Creek received the heaviest use.

The grazing capacity of these high elevation rangelands is difficult to determine because of the mosaic of vegetation types; however, the vegetation map of the area (Appendix C) should be of value. Estimates of carrying capacity should be based on preferred grazing areas and not on the total available acreage. These prime meadow and shrubfield types represent perhaps 25 percent of the area and are basically confined to the main drainage courses.

These areas have often been heavily grazed before the upper slopes receive light use. High elevation range cannot sustain heavy use because of the short growing season and generally low productivity. The difficulty in distributing cattle evenly over the range also imposes limitations on the grazing capacity. The grazing plan should be easy to follow and grazing units should be tied to well defined natural areas (Lewis, 1970) in order to more easily control range use.

Cattle should not be left to graze unattended for any length of time and the grazing route should backtrack as little as possible so that plants have an opportunity to recover from previous grazing. Flowering and seed set must be ensured in order to maintain a protective vegetation cover. To meet this objective, light grazing of no more than 30 percent on dry meadows and 40 percent on wet meadows is recommended (Lewis, 1970). This is essential since the growing season corresponds with the grazing season. The period of use should be in July and August. Grazing too early in the season might damage the soils as they are still saturated from snow melt. The valley bottoms and north-facing slopes are ready for use later than the south-facing slopes. North-facing alpine slopes should generally be avoided as these areas are subjected to solifluction processes which make them inherently unstable. The Dash Plateau should not be grazed before the end of July and even then should receive only very light use because of the sparse growth of desirable forage species. The grazing season throughout the study area should not extend into the fall as an adequate mulch might not be left to protect the soil.

These recommendations are based on a knowledge of the local climate, vegetation ecology and past grazing use of the Relay area and are believed to be acceptable levels of use for an area of low productivity with a short

growing season. Further research is required to document the effects of various grazing practices on different community types. Without more detailed information on plant development and herbage production, it is best to be conservative in our use of the resource. High elevation plants may be adapted to survive in harsh conditions but we do not have an adequate knowledge of how much grazing pressure they can withstand. Further research is required to document the effects of grazing on alpine and subalpine vegetation in the southern interior mountains where high elevation meadows are accessible and have been utilized for the grazing of domestic animals. In order to provide a data base for future regulation of alpine grazing units, study of a representative pristine alpine area should be undertaken prior to the issuance of grazing permits. Changes in the vegetation and soils can then be monitored when grazing occurs. Such a study would of necessity be long term but the results would be invaluable in shaping future grazing policy. The resource is available. If we use it wisely, it will continue to provide a maximum of products.

CHAPTER 8

Summary

1. The alpine and subalpine vegetation of the Southern Chilcotin Mountains in southwestern British Columbia was studied during the summer of 1977.
2. The study area is located on the lee side of the Coast Range. The geology is primarily sedimentary with volcanic intrusions.
3. Soil development is generally poor. Regosols and Brunisols are predominant over most of the landscape. Rego Gleysols have developed in areas with a high water table and poor drainage.
4. The study area lies in a rain shadow and the winter snowpack is relatively light. However, there is generally an adequate supply of water during the growing season because of convectional summer showers characteristic of a continental climate. The mean annual temperature is less than $4^{o}C$ in the subalpine and probably less than $0^{o}C$ in the alpine.
5. Homogeneous map units were delineated on 40 chain air photos prior to the field season. Plots were located randomly within map units. Data were collected from 239 sample plots.
6. Sample plots were combined into 19 plant community types on the basis of physiognomy, dominant species and similar environmental conditions. Characteristic species group combinations were used to identify community types.
7. The community types identified were: Picea engelmanii-Abies lasiocarpa forest, Pinus albicaulis-Juniperus communis dry forest, Salix barclayi-Carex aquatilis shrub wetland, Salix barrattiana alpine shrub wetland, Salix brachycarpa-Salix barclayi shrubland, Salix brachycarpa-Festuca spp. shrubfield, Salix brachycarpa-Phleum alpinum shrubfield, Arctostaphylos

uva-ursi-Amelanchier alnifolia dry shrubland, Salix cascadensis dwarf willow shrubland, Dryas octopetala fellfield, Dryas octopetala-Festuca altaica alpine grassland, Carex aquatilis/rostrata wetland, Carex nigricans late snowbed meadow, Festuca altaica-Festuca brachyphylla meadow, Festuca brachyphylla meadow, Festuca brachyphylla-Phleum alpinum meadow, Phleum alpinum-Carex phaeocephala meadow, Koeleria cristata dry meadow, and crustose lichen rockland or talus terrain unit.

8. Soil temperature was correlated with soil moisture or hygrotope which seemed to be a factor in determining the distribution of plant community types only at the extremes.

9. Community types restricted to runoff or seepage habitats are the Carex aquatilis/rostrata wet meadow, the Salix barclayi-Carex aquatilis shrub wetland, the Salix barrattiana alpine shrub wetland, and the Salix brachycarpa-Salix barclayi shrubland.

10. Snowbed habitats support the Carex nigricans type in the subalpine and the Salix cascadensis type in the alpine.

11. Mesic types include the Festuca altaica-Festuca brachyphylla, Festuca brachyphylla, Festuca brachyphylla-Phleum alpinum and Phleum alpinum-Carex phaeocephala meadow types. In addition the Salix brachycarpa-Festuca spp. and Salix brachycarpa-Phleum alpinum shrubfields as well as the Picea engelmanii-Abies lasiocarpa forest type are found in habitats with moderate to good drainage.

12. A number of community types are found only on well drained ridges, fellfields or dry, south-facing slopes. The Dryas octopetala fellfield and Dryas octopetala-Festuca altaica meadow are restricted to the alpine zone. The Koeleria cristata dry meadow, Arctostaphylos uva-ursi-

Amelanchier alnifolia dry shrubland and Pinus albicaulis-Juniperus communis dry forest types are found in the subalpine zone.

13. The heaviest grazing occurred on valley bottoms and lower slopes although evidence of grazing was found in the alpine plant communities as well.

14. Grazing influences high elevation vegetation in two primary ways. 1) In wet habitats trampling damage was prevalent. This has created soil remnant microsites on which species requiring less moisture become established. 2) After many years of use Festuca altaica appears to have been eliminated from heavily grazed meadows. Weedy species have become more abundant in all community types. Given time, this change in species composition might result in a decrease in the productivity of the rangelands.

15. Many of the community types are floristically and/or ecologically comparable with plant communities described from other high elevation areas in British Columbia, the southern Yukon, and the Pacific Northwest of the U.S. Strong affinities with both the Spatsizi Plateau to the north and the Northern Cascades to the south indicate the transitional nature of the study area.

16. The vegetation classification and inventory map presented in this study provide the baseline data necessary for proper land management. These data can be used in assessing the results of the grazing scheme implemented in 1977 and in future planning to coordinate multiple use in this scenic alpine and subalpine environment.

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APPENDIX A

PLANTS COLLECTED IN THE SOUTHERN CHILCOTIN MOUNTAINS

VASCULAR PLANTS

ABIES	LASIOCARPA	(HOOK.) NUTT.
ACHILLEA	MILLEFOLIUM	L.
AGOSERIS	AURANTIACA	(HOOK.) GREENE
AGOSERIS	GLAUCA	(PURSH) RAF.
AGROPYRON	CANINUM	(L.) BEAUV.
VAR.	LATIGLUME	(SCRIBN. & SMITH) HITCHC.
VAR.	UNILATERALE	(VASEY) HITCHC.
AGROPYRON	SPICATUM	(PURSH) SCRIBN. + SM.
AGROSTIS	BOREALIS	HARTM.
AGROSTIS	SCABRA	WILLD.
AGROSTIS	VARIABILIS	RYDB.
ALLIUM	CERNUUM	ROTH
AMELANCHIER	ALNIFOLIA	(NUTT.) NUTT.
ANENOME	DRUMMONDII	WATS.
ANENOME	MULTIFIDA	POIR
ANENOME	OCCIDENTALIS	S. WATS.
ANDROSACE	SEPTENTRIONALIS	L.
ANTENNARIA	ALPINA	(L.) GAERTN.
ANTENNARIA	MICROPHYLLA	RYDB.
ANTENNARIA	NEGLECTA	GREENE
ANTENNARIA	PULCHERRIMA	(HOOK.) GREENE
ANTENNARIA	UMBRINELLA	RYDB.
AQUILEGIA	FORMOSA	FISCH.
ARABIS	DIVARICARPA	A. NELS
ARABIS	DRUMMONDII	GRAY
ARABIS	HIRSUTA	(L.) SCOP.
ARABIS	HOLBOELLII	HORNEM.
ARABIS	LEMMONII	WATS.
ARABIS	LYALLII	WATS.
ARCTOSTAPHYLOS	UVA-URSI	(L.) SPRENG.
ARENARIA	CAPILLARIS	POIR.
ARENARIA	LATERIFLORA	L.
ARENARIA	OBTUSILOBA	(RYDB.) FERN.
ARENARIA	RUBELLA	(WAHLENB.) J.E. SMITH
ARNICA	ALPINA	(L.) OLIN
ARNICA	CHAMISSONIS	LESS.
ARNICA	CORDIFOLIA	HOOK.
ARNICA	DIVERSIFOLIA	GREENE
ARNICA	LATIFOLIA	BONG.
ARNICA	MOLLIS	HOOK.
ARNICA	PARRYI	GRAY
ARNICA	RYDBERGII	GREENE
ARNICA	SORORIA	GREENE
ARTEMESIA	CAMESTRIS	L.
VAR.	WORMSKIOLDII	(BESS.) CRONQ.

ARTEMESIA	FRIGIDA	WILLD.
ARTEMESIA	MICHAUXIANA	BESS.
ARTEMESIA	NORVEGICA	FRIES
ASTER	FOLIACEUS	LINDL.
ASTER	MODESTUS	LINDL.
ASTER	SIBIRICUS	L.
ASTRAGALUS	ALPINUS	L.
ASTRAGALUS	AMERICANUS	(HOOK.) JONES
ASTRAGALUS	EUCOSMOS	ROBINS.
ASTRAGALUS	ROBBINSII	(OAKES) GRAY
VAR.	MINOR	(HOOK.) BARNEBY
ASTRAGALUS	MISER	DOUGL.
ATRIPLEX	PATULA	L.
BALSAMORHIZA	SAGITTATA	(PURSH) NUTT.
BETULA	GLANDULOSA	MICHX.
BOTRYCHIUM	LUNARIA	(L.) SWARTZ
BROMUS	ANOMALUS	RUPR.
BROMUS	CARINATUS	H. & A.
BROMUS	INERMIS	LEYS.
BROMUS	TECTORUM	L.
CALAMAGROSTIS	CANADENSIS	(MICHX.) BEAUV.
CALAMAGROSTIS	PURPURASCENS	R. BR.
CALTHA	BIFLORA	DC.
CAPSELLA	BURSA-PASTORIS	(L.) MEDIC.
CARDAMINE	BELLIDIFOLIA	L.
CARDAMINE	OLIGOSPERMA	NUTT.
CAREX	ALBONIGRA	MACK.
CAREX	AQUATILIS	WAHL.
CAREX	ATRATA	L.
CAREX	AUREA	NUTT.
CAREX	BIPARTITA	ALLIONI
CAREX	CANESCENS	BAILEY
CAREX	CAPITATA	L.
CAREX	CONCINNA	R. BR.
CAREX	CONCINNOIDES	MACK.
CAREX	DIOICA	L.
CAREX	DISPERMA	DEWEY
CAREX	HOODII	BOOTT
CAREX	ILLOTA	BAILEY
CAREX	LIMNOPHILA	HERMANN
CAREX	MICROPTERA	MACK.
CAREX	NARDINA	FRIES
CAREX	NIGRICANS	RETZ.
CAREX	NORVEGICA	RETZ.
CAREX	PACHYSTACHYA	CHAM.
CAREX	PAYSONIS	CHAM.
CAREX	PHAEOCEPHALA	PIPER
CAREX	PYRENAICA	WAHL.
CAREX	ROSSII	BOOTT
CAREX	ROSTRATA	STOKES
CAREX	SCIRPOIDEA	MICHX.
CAREX	SPECTABILIS	DEWEY
CASSIOPE	TETRAGONA	(L.) D. DON

CASSIOPE	MERTENSIANA	(BONG.) G. DON
CASTILLEJA	MINIATA	DOUGL.
CASTILLEJA	PARVIFLORA	BONG.
CERASTIUM	ARVENSE	L.
CERASTIUM	BERRINGIANUM	CHAM. + SCHLECT.
CHENOPODIUM	LEPTOPHYLLUM	(MOQ.) WATS.
CHRYSOSPLENIUM	TETRANDUM	(LUND) FRIES
CIRSIUM	EDULE	NUTT.
CIRSIUM	HOOKERIANUM	NUTT.
CLAYTONIA	LANCEOLATA	PURSH
COLLINSIA	PARVIFLORA	LINDL.
CORNUS	CANADENSIS	L.
CREPIS	NANA	RICH.
CREPIS	OCCIDENTALIS	NUTT.
DANTHONIA	INTERMEDIA	VASEY
DELPHINIUM	GLAUCUM	WATS.
DESCHAMPSIA	ATROPURPUREA	(WAHL.) SCHEELE
DRABA	AUREA	VAHL
DRABA	CRASSIFOLIA	R. GRAH.
DRABA	INCERTA	PAYS.
DRABA	LANCEOLATA	ROYLE
DRABA	NIVALIS	LILJEBL.
DRABA	OLIGOSPERMA	HOOK.
DRABA	PAYSONII	MACBR.
DRABA	PRAEALTA	GREENE
DRABA	STENOLOBA	LEDEB.
DRABA	SPP.	L.
DRYAS	OCTOPETALA	L.
ELYMUS	GLAUCUS	BUCKL.
EPILOBIUM	ALPINUM	L.
EPILOBIUM	ANGUSTIFOLIUM	L.
EPILOBIUM	LATIFOLIUM	L.
EQUISETUM	ARVENSE	L.
EQUISETUM	PALUSTRE	L.
EQUISETUM	SCIRPOIDES	MICHX.
EQUISETUM	VARIEGATUM	SCHLEICH.
ERIGERON	ACRIS	L.
VAR.	DEBILIS	GRAY
ERIGERON	COMPOSITUS	PURSH
ERIGERON	HUMILIS	GRAHAM
ERIGERON	PEREGRINUS	(PURSH) GREENE
SSP.	CALLIANTHEMUS	(GREENE) CRONQ.
ERIGERON	PURPURATUS	GREENE
ERIGERON	SPECIOSUS	(LINDL.) DC.
ERIOGONUM	UMBELLATUM	TORR.
VAR.	MAJUS	HOOK.
ERIOPHORUM	BRACHYANTHERUM	TRAUTV. + MEY.
ERIOPHORUM	POLYSTACHION	L.
FESTUCA	ALTAICA	TRIN.
FESTUCA	BRACHYPHYLLA	SCHULT.
FESTUCA	SAXIMONTANA	RYDB.
FRAGARIA	VIRGINIANA	DUCHESNE
GALIUM	BOREALE	L.

GALIUM	TRIFIDUM	L.
GENTIANA	PROPINQUA	RICHARDS.
GENTIANA	PROSTRATA	HAENKE
GENTIANA	AMARELLA	L.
GERANIUM	RICHARDSONII	FISCH. + TRAUTV.
GEUM	MACROPHYLLUM	WILLD.
GEUM	TRIFLORUM	PURSH
HABENARIA	OBTUSATA	(BANKS) RICHARDS.
HACKELIA	FLORIBUNDA	(LEHM.) JOHNST.
HAPLOPAPPUS	LYALLII	GRAY
HERACLEUM	LANATUM	MICHX.
HIERACIUM	CYNOGLOSSOIDES	ARV.-TOUV.
HIERACIUM	GRACILE	HOOK.
HIERACIUM	SCOULERI	HOOK.
HIEROCHLOE	ODORATA	(L.) BEAUV.
HORDEUM	JUBATUM	L.
JUNCUS	DRUMMONDII	E. MEYER
JUNCUS	MERTENSIANUS	BONG.
JUNCUS	PARRYI	ENGELM.
JUNIPERUS	COMMUNIS	L.
VAR.	MONTANA	AIT.
KALMIA	MICROPHYLLA	(HOOK.) HELLER
KOELERIA	CRISTATA	PERS.
KOBRESIA	MYOSUROIDES	(VILL.) FIORI
LEDUM	GLANDULOSUM	NUTT.
?X? LEDUM	GROENLANDICUM	OEDER
LEPIDIUM	VIRGINICUM	L.
LILLIUM	COLUMBIANUM	HANSON
LINNAEA	BOREALIS	L.
LISTERA	BOREALIS	MORONG
LITHOSPERMUM	RUDERALE	DOUGL.
LOMATIUM	NUDICAULI	(PURSH) COULT. + ROSE
LONICERA	INVOLUCRATA	(RICH.) BANKS
LUPINUS	LEPIDUS	DOUGL.
VAR.	LOBBII	(GRAY) HITCHC.
LUPINUS	NOOTKATENSIS	DONN.
LUZULA	GLABRATA	(HOPPE) DESV.
LUZULA	PARVIFLORA	(EHRH.) DESV.
LUZULA	PIPERI	(COV.) JONES
LUZULA	SPICATA	(L.) DC.
MATRICARIA	MATRICARIODES	(LESS.) PORTER
MIMULUS	TILINGII	REGEL
VAR.	CAESPITOSUS	(GREENE) GRANT
MITELLA	PENTANDRA	HOOK.
MONESES	UNIFLORA	L.
MYOSOTIS	ALPESTRIS	F.W. SCHMIDT
OSMORRHIZA	CHILENSIS	H. + A.
OXYTROPUS	CAMPESTRIS	(L.) DC.
VAR.	GRACILIS	(NELS.) BARNEBY
OXYTROPUS	DEFLEXA	(PALL.) DC.
OXYRIA	DIGYNA	(L.) HILL.
PACHISTIMA	MYRSINITES	(PURSH) RAF.
PAPAVER	RADICATUM	ROTT.

PARNASSIA	FIMBRIATA	KONIG.
PARNASSIA	PALUSTRIS	L.
PEDICULARIS	BRACTEOSA	BENTH.
PEDICULARIS	LANGSDORFII	FISCH.
PEDICULARIS	ORNITHORHYNCHA	BENTH.
PENSTEMON	FRUTICOSUS	(PURSH) GREENE
VAR.	SCOULERI	(LINDL.) CRONQ.
PENSTEMON	PROCERUS	DOUGL.
PETASITES	FRIGIDUS	(L.) FRIES
VAR.	FRIGIDUS	
VAR.	NIVALIS	(GREENE) CRONQ.
VAR.	PALMATUS	(AIT.) CRONQ.
PETASITES	SAGITTATUS	(BANKS) GRAY
PHACELIA	SERICEA	(GRAH.) GRAY
PHLEUM	ALPINUM	L.
PHYLLODOCE	EMPETRIFORMIS	(SW.) D. DON
PHYLLODOCE	GLANDULIFLORA	(HOOK.) COV.
PICEA	ENGELMANII	PARRY
PINUS	ALBICAULIS	ENGELM.
PINUS	CONTORTA	DOUGL.
PLATANTHERA	DILATATA	(PURSH) LINDL.
POA	ALPINA	L.
POA	ARCTICA	R. BR.
POA	CANBYI	(SCRIBN.) PIPER
POA	CUSICKII	VASEY
POA	FENDLERIANA	(STEUD.) VASEY
POA	GLAUCA	M. VAHL
POA	INTERIOR	RYDB.
POA	LEPTOCOMA	TRIN.
VAR.	LEPTOCOMA	
VAR.	PAUSISPICULA	(SCRIBN. & MERR.) HITCHC.
POA	LETTERMANII	VASEY
POA	NERVOSA	(HOOK.) VASEY
POA	PALUSTRIS	L.
POA	PRATENSIS	L.
POA	RUPICOLA	NASH
POA	SANDBERGII	VASEY
POLEMONIUM	PULCHERRIMUM	HOOK.
POLYGONUM	DOUGLASII	GREENE
POLYGONUM	VIVIPARUM	L.
POLYGONUM	SPERGULARIAEFORME	MEISN.
POPULUS	TREMULOIDES	MICHX.
POPULUS	TRICHOCARPA	T. + G.
POTENTILLA	ARGUTA	PURSH
POTENTILLA	DIVERSIFOLIA	LEHM.
POTENTILLA	DRUMMONDII	LEHM.
POTENTILLA	GRACILIS	DOUGL.
POTENTILLA	NIVEA	L.
POTENTILLA	QUINQUEFOLIA	RYDB.
POTENTILLA	VILLOSA	PALL.
PRUNUS	EMARGINATA	(DCUGL.) WALP.
PYROLA	ASARIFOLIA	MICHX.
PYROLA	MINOR	L.

PYROLA	SECUNDA	L.
RANUNCULUS	ESCHSCHOLTZII	SCHLECHT.
RANUNCULUS	GELIDUS	KAR. + KIR.
RANUNCULUS	INAMOENUS	GREENE
RANUNCULUS	UNCINATUS	D. DON
RIBES	LACUSTRE	(PERS.) POIR.
RIBES	VISCOSISSIMUM	PURSH
RHINANTHES	CRISTA-GALLI	L.
RHODODENDRON	ALBIFLORUM	HOOK.
ROSA	ACICULARIS	LINDL.
RUBUS	ACAULIS	MICHX.
RUMEX	ACETOSA	L.
SALIX	BARCLAYI	ANDERSS.
SALIX	BARRATTIANA	HOOK.
SALIX	BRACHYCARPA	NUTT.
SALIX	CASCADENSIS	COCKERELL
SALIX	GLAUCA	L.
SALIX	NIVALIS	HOOK.
SALIX	SCOULERIANA	BARRATT
SALIX	SITCHENSIS	SANSON
SALIX	SPP.	L.
SANICULA	GRAVEOLENS	POEPP.
SAXIFRAGA	ADSCENDENS	L.
SAXIFRAGA	CAESPITOSA	L.
SAXIFRAGA	BRONCHIALIS	L.
VAR.	AUSTROMONTANA	(WIEG.) JONES
SAXIFRAGA	CERNUA	L.
SAXIFRAGA	DEBILIS	ENGELM.
SAXIFRAGA	LYALLII	ENGL.
SAXIFRAGA	OCCIDENTALIS	WATS.
SAXIFRAGA	ARGUTA	D. DON
?X? SAXIFRAGA	LYALLII	ENGL.
SAXIFRAGA	TRICUSPIDATA	ROTTB.
SEDUM	LANCEOLATUM	TORR.
SELAGINELLA	DENSA	RYDB.
SENECIO	CANUS	HOOK.
SENECIO	ELMERI	PIPER
SENECIO	FREMONTII	T. + G.
SENECIO	INTEGERRIMUS	NUTT.
SENECIO	LUGENS	RICH.
SENECIO	PAUCIFLORUS	PURSH
SENECIO	STREPTANTHIFOLIUS	GREENE
SENECIO	TRIANGULARIS	HOOK.
SHEPHERDIA	CANADENSIS	(L.) NUTT.
SIBBALDIA	PROCUMBENS	L.
SILENE	ACAULIS	L.
SILENE	DOUGLASII	HOOK.
SILENE	PARRYI	(WATS.) HITCHC. + MAG.
SITANION	HYSTRIX	(NUTT.) SMITH
SMILACINA	STELLATA	(L.) DESF.
SOLIDAGO	MULTIRADIATA	AIT.
STELLARIA	CRISPA	CHAM. + SCHLECHT.
STELLARIA	LONGIPES	GOLDIE

STIPA	COLUMBIANA	MACCUN
STIPA	RICHARDSONII	LINK
SYMPHORICARPOS	ALBUS	(L.) BLAKE
VAR.	LAEVIGATUS	FERN.
TARAXACUM	LAEVIGATUM	(WILLD.) DC.
TARAXACUM	OFFICINALE	WEBER
THALICTRUM	OCCIDENTALE	GRAY
THLASPI	ARVENSE	L.
TRIFOLIUM	REPENS	L.
TRISETUM	SPICATUM	(L.) RICHTER
TROLLIUS	LAXUS	SALISB.
VACCINIUM	CAESPITOSUM	MICHX.
VACCINIUM	DELICIOSUM	PIPER
VACCINIUM	PARVIFOLIUM	SMITH
VALERIANA	DIOICA	L.
VAR.	SYLVATICA	(RICH.) WATS.
VALERIANA	SITCHENSIS	BONG.
VERONICA	AMERICANA	SCHWEIN.
VERONICA	SERPYLLIFOLIA	L.
VERONICA	WORMSKJOLDII	ROEM. + SCHULT.
VIOLA	NEPHROPHYLLA	GREENE
WOODSIA	SCOPULINA	D.C. EAT.

MOSSES

AMBLYSTEGIUM	SAXATILE	SCHIMP.
AMBLYSTEGIUM	SERPENS	(HEDW.) B.S.G.
AULACOMNIUM	PALUSTRE	(HEDW.) SCHWAEGR.
BARTRAMIA	ITHYPHYLLA	BRID.
BLINDIA	ACUTA	(HEDW.) B.S.G.
BRACHYTHECIUM	ALBICANS	(HEDW.) B.S.G.
BRACHYTHECIUM	COLLINUM	(C. MUELL.) B.S.G.
BRACHYTHECIUM	SPP.	B.S.G.
BRYOERITHROPHYLLUM	RECURVIROSTRUM	(HEDW.)CHEN
BRYUM	CAESPITICIUM	HEDW.
BRYUM	WEIGELII	SPRENG.
BRYUM	SPP.	HEDW.
CALLIERGON	GIGANTEUM	(SCHIMP.) KINDB.
CALLIERGON	STRAMINEUM	(BRID.) KINDB.
CAMPYLIUM	POLYGAMUM	(B.S.G.) C. JENS.
CAMPYLIUM	STELLATUM	(HEDW.) C. JENS.
CERATADON	PURPUREUS	(HEDW.) BRID.
CINCLIDIUM	STYGIUM	SW.
CLIMACIUM	DENDROIDES	(HEDW.) WEB. + MOHR
CRATONEURON	COMMUTATUM	(HEDW.) ROTH
CRATONEURON	FILICINUM	(HEDW.) SPRUCE
DESMATADON	LATIFOLIUS	(BRID.) BRID.
DICRANUM	FUSCESCENS	TURN.
DICRANUM	MUEHLENBECKII	B.S.G.
DICRANUM	SCOPARIUM	HEDW.
DISTICHIUM	CAPILLACEUM	(HEDW.) B.S.G.
DITRICHUM	FLEXICAULE	(SCHWAEGR.) HAMPE

DREPANOCLADUS	ADUNCUS	(HEDW.) WARNST.
DREPANOCLADUS	REVOLVENS	(SW.) WARNST.
DREPANOCLADUS	UNCINATUS	(HEDW.) WARNST.
ENCALYPTA	VULGARIS	HEDW.
EURYNCHIUM	PULCHELLUM	(HEDW.) JENN.
HELODIUM	BLANDOWII	(WEB. + MOHR) WARNSF.
HYLOCOMIUM	SPLENDENS	(HEDW.) B.S.G.
HYPNUM	CIRCINALE	HOOK.
HYPNUM	REVOLUTUM	(MITT.) LINDB.
ISOPTERYGIUM	PULCHELLUM	(HEDW.) JAEG. + SAUERB.
KIAERIA	STARKEI	(WEB + MOHR) I. HAG.
LEPTOBRYUM	PYRIFORME	(HEDW.) WILS.
LESCURAEA	RADICOSA	(MITT.) MOENK.
MNIUM	THOMPSONII	SCHIMP.
ORTHOTRICHUM	SPECIOSUM	NEES EX STURM
PHILONOTIS	FONTANA	(HEDW.) BRID.
PLAGIOMNIUM	ELLIPTICUM	(BRID.) KOP.
PLAGIOMNIUM	ROSTRATUM	(SCHRAD.) KOP.
PLEUROZIUM	SCHREBERI	(BRID.) MITT.
POHLIA	CRUDA	(HEDW.) LINDB.
POHLIA	NUTANS	(HEDW.) LINDB.
POHLIA	SPP.	HEDW.
POLYTRICHUM	JUNIPERINUM	HEDW.
POLYTRICHUM	PILIFERUM	HEDW.
POLYTRICHUM	STRICTUM	BRID.
RHACOMITRIUM	CANESCENS	(HEDW.) BRID.
SPHAGNUM	RECURVUM	P. BEAUV.
SPHAGNUM	WARNSTORFII	RUSS.
THUIDIUM	ABIETINUM	(HEDW.) B.S.G.
TIMMIA	AUSTRIACA	HEDW.
TOMENTHYPNUM	NITENS	(HEDW.) LOESKE
TORTELLA	FRAGILIS	(HOOK. + WILS.) LIMPR.
TORTULA	NORVEGICA	(WEB.) WAHLENB. EX LINDB.

LIVERWORTS

BLEPHARASTOMA	TRICHOPHYLLUM	(L.) DUM.
CALYPOGEIA	MUELLERIANA	(SCHIFFN.) K. MULL.
CEPHALOZIA	? BICUSPIDATA	(L.) DUM.
LOPHOZIA	FLOERKEI	(WEB. ET MOHR) SCHIFFN.
LOPHOZIA	HATCHERI	(EVANS) STEPH.
LOPHOZIA	? INCISA	(SCHRAD.) DUM.
LOPHOZIA	? OBTUSA	(LINDB.) DUMORT.
LOPHOZIA	? WENZELII	(NEES) STEPH.
LOPHOZIA	SPP.	DUM. EMEND. K. MULL.
MARCHANTIA	POLYMORPHA	L.
PLAGIOCHILA	ASPLENIOIDES	(L. EMEND. TAYL.) DUM.

LICHENS

ACAROSPORA	CHLOROPHANA	(WALENB. EX ACH.) MASS

ALECTORIA	OCHROLEUCA	(HOFFM.) MASS.
BLACK	CRUSTOSE	LICHENS
CALOPLACA	SPP.	TH. FR.
CANDELARIELLA	SPP.	MULL.
CETRARIA	CUCULLATA	(BELL.) ACH.
CETRARIA	ERICITORUM	OPIZ.
CETRARIA	ISLANDICA	(L.) ACH.
CETRARIA	NIVALIS	(L.) ACH.
CETRARIA	PINASTRI	(SCOP.) S. GRAY
CLADINA	MITIS	SANDST.
CLADONIA	COCCIFERA	(L.) WILLD.
CLADONIA	ECMOCYNA	(ACH.) NYL.
CLADONIA	NEMOXYNA	(ACH.) NYL.
CLADONIA	PYXIDATA	(L.) HOFFM.
CLADONIA	SQUAMULOSE	HILL EX WEB.
CLADONIA	SPP.	HILL EX WEB.
CORNICULARIA	ACULEATA	(SCHREB.) ACH.
CORNICULARIA	MURICATA	(ACH.) ACH.
CRUSTOSE	LICHENS	
DACTYLINA	ARCTICA	(HOOK.) NYL.
HYPOGYMNIA	SPP.	(NYL.) NYL.
LECANORA	SPP.	ACH.
LETHARIA	COLUMBIANA	(NUTT.) THOMPSON
OCHROLECHIA	UPSALIENSIS	(L.) MASS.
PANNARIA	SPP.	DEL.
PARMELIA	TASMANICA	HOOK. P TAYL.
PELTIGERA	APTHOSA	(L.) WILLD.
PELTIGERA	? CANINA	(L.) WILLD.
PELTIGERA	MALACEA	(ACH.) FUNCK.
PELTIGERA	RUFESCENS	(WEISS) HUMB.
PELTIGERA	SPURIA	(ACH.) DC.
PERTUSARIA	SPP.	LAM. & DC.
PHYSCONIA	MUSCIGENA	(ACH.) POELT
PSEUDEPHEBE	SPP.	CHOISY
PSOROMA	SPP.	NYL.
RHIZOCARPON	GEOGRAPHICUM	(L.) DC.
RINODINA	SPP.	ACH.
SOLORINA	CROCEA	(L.) ACH.
SOLORINA	BISPORA	NYL.
STEREOCAULON	SPP.	HOFFM.
THAMNOLIA	SUBULIFORMIS	(EHRH.) CULB.
UMBILICARIA	SPP.	HOFF.
XANTHORIA	ELEGANS	(LINK) TH. FR.

APPENDIX B

COLLECTING SITES FROM THE SOUTHERN CHILCOTIN MOUNTAINS, 1977

Latitude and longitude for major regions within the study area:

Dash Plateau 51° 12' 123°
Graveyard Valley 51° 09' 123° 06'
Little Paradise Valley 51° 09' 122° 58'
Prentice Lake 51° 11' 122° 54'
Relay Basin 51° 08' 123°
Relay Valley & Cabin 51° 11' 122° 58'
Two Lakes Basin 51° 12' 123° 04'

June 23 (1-4) Horse pasture at Relay Cabin in Relay Valley; elev. 1640 m; flat meadow dominated by Taraxacum officinale and Achilla millefolium with assorted grasses; rocky soil

July 11 (5) Two Lakes Meadow. 30 m SE of East Lake in Two Lakes Basin; elev. 1950 m; gentle convex slope with N aspect

July 12 (6-7) Two Lakes Meadow - as 5

July 13 (8) Two Lakes Meadow; grassy meadow E of east lake in Two Lakes Basin; elev. 1955 m; convex, S-facing slope, slightly hummocky

(9-10) Two Lakes Meadow; rocky, S-facing slope NE of East Lake; elev. 1960 m; dry grass slope

(11) Two Lakes Sedge Wetland; E end of East Lake; elev. 1950 m; hydric

(12) Two Lakes Meadow; N side of creek that runs west out of West Lake; elev. 1945 m; steep rocky slope with a SW aspect

(13) Two Lakes Meadow; flat meadow west of West Lake; elev. 1955 m

(14) Two Lakes Meadow; steep, S-facing slope west of West Lake; elev. 1955 m; dominated by forbs; very rocky and well drained

(15) Two Lakes - Birch-Willow Shrub type; 20 yards N of West Lake; elev. 1955 m; hygric; hummocky; growth 30 cm with occasional Pinus contorta to 6.5 m; S-facing gentle slope

(16-17) Two Lakes Sedge meadow; between 2 lakes; elev. 1960 m; hydric; Carex aquatilis dominant sps.

July 14 (18) Two Lakes Birch-Willow Shrub; on S side of East Lake; elev, 1965 m; NW-facing, gentle slope; growth 1 m; hygric

(19) Two Lakes Birch-Willow-Sedge Wetland; on S side of East Lake; elev. 1960 m; hydric; shrub height about 6 m

(20) Two Lakes Willow-Birch Wetland; E end of basin, north of outflow creek; elev. 1955 m; disturbed habitat - very hummocky with wet depressions; growth of shrubs .3-.6 m

July 15 (21) Relay Cabin; heavily grazed meadow on S-facing slope above cabin between 2 large gullies; elev. 1680 m; well drained

(22) Relay Cabin S-facing meadow as 21 but elev. 1710 m

(23) Relay Cabin SE-facing seepage meadow; E-facing side of ravine slightly NW of cabin; elev. 1700 m; steep slope; mesic

July 17 (25) Juniper-Arctostaphylos stand on S-facing slope NW of Relay Cabin; steep; elev. 2005 m; xeric

(26) Fellfield W of saddle above cabin; elev. 2075 m; xeric; ESE aspect; scattered forbs

(27) Fellfield below saddle; E-facing; elev. 2085 m; lichens abundant

(28) Saddle above cabin; W-facing rocky slope; elev. 2190 m; windswept; sparse, low growth

(29) Ravine subalpine meadow below saddle - Low Salix shrub; SE-facing; elev. 2030 m; gentle slope; Salix growth less than 25 cm

(30) Subalpine meadow above cabin; SW facing; elev. 1920 m; concave, gentle slope; mesic

(31) Subalpine meadow above cabin; SE-facing; elev. 1760 m; a few scattered aspen (to 4.5 m in height)

July 18 (32) Aspen meadow E of cabin; old burn site with a S aspect; elev. 1670 m; good growth of grasses

(33) Elymus stand E of cabin; 1 mile below trail; elev. 1670 m; steep, badly eroded slope; rocky soil; growth to .6 m

(34) Talus slope 1.6 km E of cabin, above trail; elev. 1720 m; dominants are aspen, Juniperus communis and Rosa acicularis. Pinus albicaulis dotted over slope. S-facing, steep slope

(35) Rocky Populus tremuloides-Arctostaphylos uva-ursi stand just E of 34; elev. 1740 m; an old burn site; SE-facing steep slope

(36) Pinus albicaulis-Shepherdia canadensis-grass stand on steep S-facing slope above trail 2.5 km east of cabin; elev. 1730 m

(37) Sedge meadow 2.5 km E of cabin on N side of Relay Creek; elev. 1620 m; hydric

(38) Salix-Betula-Carex wetland; elev. 1620 m; shrubs .75-.9 m on N side of Relay Creek 2.5 km E of cabin

July 19 (39) Taraxacum meadow just E of cabin on valley floor; elev. 1630 m; Phleum alpinum and Geum triflorum are abundant

(40) Salix shrub stand E of cabin; elev. 1632 m; Salix 1-2 m tall; gentle slope to creek

July 20 (41) Grassy meadow just W of horse pasture at Relay Cabin; elev. 1700 m; 10 percent slope with SE aspect; mesic; old burn site

(42) Well drained meadow W of Relay Cabin horse pasture; elev. 1785 m; steep, S-facing slope; convex, xeric; a lot of bare ground

(43) As in #42; 1795 m; 30 percent slope

(44) Grass-forb meadow; 1.6 km W of Relay cabin; elev. 1845 m; aspect 120°; 30 percent slope; slightly convex; xeric, erosion is evident

(45) Arctostaphylos-grass meadow; 2.5 km W of cabin; elev. 1800 m; S-facing, steep (30 percent) slope; rocky soil; xeric; convex

July 21 (46) Juniperus-Arctostaphylos-Shepherdia shrub community; 3.2 km E of cabin; elev. 1815 m; S-facing; very steep (40 percent) slope; rocky soil; convex; subxeric

(47) Subalpine parkland 3.2 km E of Relay Cabin; elev. 1940 m; E-facing (100°); 20 percent slope

(48) Juniperus-Arctostaphylos-Sherpherdia shrub type; 4 km E of Relay Cabin; elev. 1900 m; S-facing, steep slope (30 percent); very rocky; xeric

(49) Grass-forb meadow; 4.5 km E of Relay Cabin; elev. 1920 m; S-facing, medium slope (18 percent); very rocky; exposed; dominants are Poa spp. & Oxytropus campestris

(50) Heath meadow 4.5 km E of Relay Cabin; elev. 1910 m; on N-facing ridge with moderate slope (23 percent); mesic-hygric

July 22 (51) Grass meadow in Little Paradise Basin; elev. 1935 m; W-facing, mesic, valley bottom; deep, loamy soil

(52) Salix shrub type in Little Paradise Basin; elev. 1970 m; N-facing valley bottom; submesic; gently convex

(53) Salix-wetland type in Little Paradise; elev. 1975 m; N-facing; gentle slope; hygric-hydric

(54) Salix nivalis-grass meadow in Little Paradise; elev. 2130 m; ENE aspect with moderate-steep slope (16°); very hummocky; submesic; krummholz Abies lasiocarpa in vicinity

(55) Alpine rocky ridge on W side of Little Paradise; elev. 2205 m; WNW-facing with steep slope (18°); xeric

(56) Subalpine heath meadow on W side of Little Paradise; elev. 2070 m; NE-facing, steep slope (23°); slightly concave; mesic; late snow area (growth just begun)

July 23 (57) Alpine tundra on N-facing side of ridge to north of cabin; elev. 2220 m; steep slope (25°); very rocky; xeric; Cetraria nivalis & C. islandica are dominants (also Kobresia myosuroides)

(58) Alpine heath meadow on N-facing side of ridge to N of cabin; elev. 2200 m; steep (32°), NW-facing slope; rocky soil; xeric; concave (prob. a late snow depression area); with Dryas octopetala

(59) Dryas-Salix nivalis; concave depression areas amidst heath meadow (plot 58); elev. 2130 m; NW-facing moderate slope (18°); submesic (not as rocky)

(60) Subalpine parkland on N-facing side of ridge to N of cabin; elev. 2070 m; WNW aspect; steep slope (34°); submesic

(61) Salix wetland on N side of ridge to N of cabin.; elev. 2065 m; N-facing, gentle slope (9°); concave; hygric

July 24 (62-65) Well drained meadow above the trail to Prentice Lake in Relay Valley; elev. 1855 m; aspect 240°; fairly steep slope (24°); dominants are forbs; soil is very rocky

(66) Arctostaphylos-grass meadow above the trail to Prentice Lake in Relay Valley; elev. 1945 m; moderate slope (18°); W-facing; xeric

July 26 (67) Talus slope 2.5 km from the cabin along the trail to Relay Basin; elev. 1845 m; steep slope (42°); NE aspect

(68) Juniper scrub on talus slope 2.5 km from cabin on Relay Basin trail; elev. 1900 m; moderate slope (24°); NE aspect; lichens are dominant

(69) Talus slope 2.5 km SW of Relay Cabin in Relay Basin; elev. 2000 m; steep slope (31°); NE aspect; dominated by crustose lichens

(70) Subalpine forest 3.2 km SW of Relay Cabin below the little lake on the W side of Relay Basin; elev. 2015 m; gentle slope (11°); E-facing; rocky soil; xeric; dominants are Pinus albicaulis & Abies lasiocarpa

(71) Talus slope above little lake on W side of Relay Basin; 3.2 km SW of Relay Cabin; elev. 2105 m; steep slope (33°); xeric

(72) Seepage meadow above treeline on W side of Relay Basin; 2.5 km from cabin; elev. 2080 m; gentle slope (7°); concave; mesic; excellent growth

July 27 (73) Alpine tundra 2.5 km SW of Relay Cabin at junction of Relay Valley & Relay Basin; elev. 2220 m; gentle slope (13°); E aspect; Dryas octopetala & Cetraria islandica are dominants

(74) Alpine tundra 2.5 km SW of Relay Cabin; elev. 2120 m; moderate-steep slope (25°); N-facing; convex; xeric; sparse vegetation

(75) Ridgetop meadow (subalpine) 2 km SW of Relay Cabin; elev. 1990 m; gentle slope (9°); SW aspect; heavily grazed

(76) Well drained forb meadow 2 km SW of Relay Cabin; elev. 1990 m; SE aspect; steep slope (28°); concave; mesic

(77) Willow shrub meadow 2 km SW of Relay Cabin; elev. 1970 m; E aspect; gentle slope (5°) on valley bottom; slightly concave; submesic; Salix height .3 m

(78) Arctostaphylos shrub meadow 1.6 km SW of Relay Cabin; elev. 1980 m; SE aspect; moderate slope (23°); convex; xeric

(79) Subalpine meadow 1.6 km SW of Relay Cabin; elev. 1895 m; SE aspect; moderate slope (22°); slightly concave; mesic; growth to .3 m

(80) Arctostaphylos-grass meadow 1.6 km SW of Relay Cabin; elev. 1835 m; SE aspect; steep slope (37°); slightly convex; xeric

July 28 (81) Grass meadow 3.2 km W of cabin in Relay Valley; elev. 1815 m; S-facing, moderate slope (14°); concave; mesic

(82) Tall willow shrub on valley bottom 3.2 km W of cabin in Relay Valley; elev. 1800 m; moderate slope (16°); N-facing; mesic to subhygric; undulating terrain; Salix to 1.2 m

(83) Low willow shrub on floodplain of Relay Creek 3.2 km W of cabin; elev. 1790 m; N-facing; sub-hygric; Salix to .75 m

(84) Shepherdia-Juniperus shrub type 3.2 km W of cabin in Relay Valley; elev. 1830 m; on S-facing, steep (33°) slope; convex; mesic; an old burn site

(85) Well drained meadow 3.2 km W of cabin in Relay Valley; elev. 1830 m; steep (32°), S-facing slope; rocky; dominated by forbs

(86) Arctostaphylos-grass meadow on steep (30°), S-facing slope 2.5 km W of cabin in Relay Valley; elev. 1765 m

July 29 (87) Willow-birch shrub wetland 1.6 km E of cabin; elev. 1615 m; level to slightly concave; hygric to sub-hygric; mosses abundant

(88) Spruce bog 1.6 km E of cabin; elev. 1600 m; hygric

(89) Even-aged lodgepole pine stand 1.6 km SW of cabin; elev. 1670 m; some Abies regeneration; N aspect; on a bench above Relay Creek; sparse ground cover; a lot of windfall

July 30 (90) Grass-forb meadow 2.5 km W of Relay Cabin 45 m above Relay Creek; elev. 1755 m; SSE aspect; gentle slope to creek; mesic

(91) Aspen grove 1.6 km W of Relay Cabin; elev. 1760 m; SE aspect; steep slope (26°); mesic; undulating topography, an old burn site with a lot of dead trees; trees to 6 m tall

July 31 (92) Low shrub meadow at timberline below saddle to N of cabin; elev. 2125 m; moderate slope (15°); E aspect; submesic

(93) Betula-Dryas alpine meadow below saddle to N of cabin; elev. 2150 m; moderate slope (11°); N aspect; submesic-xeric

(94) Seepage meadow below fellfield on N side of saddle to N of cabin; elev. 2975 m; N-facing, moderate slope (11°); rocky; mesic; concave basin

(95) Wetland meadow below saddle to N of cabin on N-facing slope; elev. 2065 m; moderate slope (15°); the moss strata is dominant

(96) Alpine meadow below ridge (on N side) to N of cabin; elev. 2120 m; medium slope (20°); ENE aspect; concave, subxeric; somewhat rocky

(97) Alpine shrubland meadow on N side of ridge to N of cabin; elev. 2170 m; ENE aspect; moderate slope (15°); concave; submesic xeric; very rocky, dominated by Arctostaphylos uva-ursi & Kobresia myosuroides

(98) Alpine grassland in saddle to N of cabin; elev. 2165 m; level; very rocky; stone stripes are apparent

Aug. 1 (99) Low willow shrubland above Two Lakes; on N-facing slope just E of the saddle in the ridge; elev. 2100 m; steep slope (31°); convex; slightly rocky, xeric

(100) Fellfield on S side of ridge to N of Two Lakes just W of saddle; elev. 2080 m; SSW aspect; gentle slope (13°); undulating terrain; rocky; xeric; dominated by Arctostaphylos uva-ursi & Lupinus lepidus

Aug. 2 (101) Shrubland on rocky slope above headwaters of Graveyard Creek; elev. 1930 m; subalpine steep slope (35°); SW aspect; convex; xeric; a lot of bare ground and rock

(102) Tall willow shrubland at SE end of Graveyard Valley; elev. 1900 m; on valley bottomland; submesic; rocky soil; Salix to 1.5 m

(103-104) Grass meadow at S end of Graveyard Valley; elev. 1900 m; valley bottom (old lake bed); submesic

(105) Well drained grass meadow on E facing hillside on SW side of Graveyard Valley; elev. 1905 m; steep slope (33°); slightly concave; xeric

(106) Salix wetland in small valley off W side of Graveyard Valley; elev. 1930 m; E-facing, gentle slope (8°); concave; hygric

(107) Grass meadow in Graveyard Valley on valley floor; elev. 1900 m; submesic; growth to 15 cm

(108) Low willow shrubland on E side of Graveyard Creek about mid-valley; elev. 1900 m; on gently rolling valley bottom; mesic-subhygric

(109) Grass meadow on W side of Graveyard Valley on an alluvial fan; elev. 1905 m; ENE aspect; gentle slope (6°); xeric

Aug. 3 (110) Grass meadow in middle of Graveyard Valley; elev. 1870 m; valley bottom (lacustrine); submesic

(111) Old burn site with Pinus albicaulis regeneration on western slopes of Graveyard Valley; elev. 1970 m; ENE aspect; steep slope (36°); convex; rocky; xeric

(112) Willow-birch shrubland on western side of Graveyard Valley; elev. 1920 m; E-facing, moderate slope (17°); concave; hygric

(113) Sedge meadow in middle of Graveyard Valley; elev. 1860 m; on valley floor below Pinus contorta forest; hygric-mesic

(114-115) Grass meadow in center of Graveyard Valley; elev. 1860 m; on valley floor; mesic; growth 10-12 cm

(116) Well drained meadow at N end of Graveyard Valley; elev. 1865 m; E-facing, gentle slope (10°); hummocky; submesic

(117) Forb meadow on E side of Graveyard Valley; elev. 1920 m; SW aspect; moderate slope (21°); concave; mesic; Epilobium angustifolium is common

Aug. 4 (118) Grass meadow 1.6 km E of Graveyard Valley on way to Relay Basin; elev. 1960 m; SW aspect; gentle slope (11°); concave; mesic

(119) Willow-birch shrubland on allluvial fan 2 km E from Graveyard Valley on way to Relay Basin; elev. 1965 m; convex; hygric; SW aspect

(120) Shrub-meadow complex .8 km W of pass to Relay Basin from Graveyard Valley; elev. 2035 m; alpine; SW aspect; hummocky; subhygric

(121) Well drained alpine meadow in pass from Graveyard Valley to Relay Basin; elev. 2155 m; S-facing, steep slope (26°); convex; submesic

Aug. 5 (122) Alpine meadow on S side of small lake (pond) E of pass from Graveyard Valley to Relay Basin; elev. 2145 m; flat; very rocky; mesic

(123) Alpine shrub meadow (Salix nivalis-Dryas-Festuca) E of pass from Graveyard Valley to Relay Basin; elev. 2170 m; N-facing, moderate slope (10°); convex; xeric

(124) Alpine meadow SE of pass from Graveyard Valley to Relay Basin; elev. 2225 m; NE aspect; gentle slope (5°); very rocky; slightly convex; mesic

(125) Low willow shrubland in valley bottom E of pass from Graveyard Valley to Relay Basin; elev. 2070 m; E-facing; slightly concave; mesic

(126) Well drained meadow in valley bottom E of pass from Graveyard Valley to Relay Basin; elev. 2075 m; S-facing; gentle slope (12°); very rocky; hummocky; submesic to xeric

(127) Well drained meadow on W side of Relay Basin; elev. 2100 m; S-facing, moderate slope (18°); convex; xeric

(128) Willow-birch shrubland on W side of Relay Basin; elev. 2070 m; ESE aspect; gentle slope (10°); undulating terrain; mesic

(129-132) Subalpine meadow in E side of Relay Basin on large alluvial fan at base of Relay Mountain; elev. 2015 m; W-facing, very gentle slope (6°); slightly convex; mesic-submesic

Aug. 6 (133) Rockland on peak of Relay Mtn.; volcanic rock; elev. 2790 m; dominated by crustose lichens; convex; xeric

Aug. 8 (134) Well drained meadow 6.4 km E of cabin & above trail to Prentice Lake; elev. 1720 m; ESE aspect; moderate-steep slope (23°); poor condition; convex; xeric

(135) Well drained meadow 6.4 km E of cabin and above trail to Prentice Lake; elev. 1780 m; ESE aspect; steep slope (30°); convex; xeric

(136) Subalpine parkland (Pinus albicaulis) 5.5 km E of cabin on N side of Relay Valley; elev. 1790 m; S-facing; steep slope (40°); convex; xeric, with Arctostaphylos & Juniperus shrubs

(137) Subalpine meadow 4.8 km E of cabin on N side of Relay Valley; elev. 1785 m; E aspect; moderate slope (21°); concave; mesic; rocky; dominant trees are Pinus albicaulis & P. contorta

(138) Arctostaphylos-Juniperus shrubland on S-facing slope above Prentice Lake cutoff (4.8 km E of Relay cabin); elev. 1775 m; steep slope (38°); very rocky; convex; xeric; old burn site

Aug. 9 (139) Arctostaphylos-grass meadow on the S side of knoll to S of Relay Cabin; elev. 2040 m; moderately steep slope (24°); SW aspect; slightly concave; mesic

(140) Birch-willow shrubland on S side of knoll to S of Relay Cabin; elev. 2070 m; gentle slope (13°); SW aspect; concave; mesic hygric

(141) Dryas fellfield on S side of knoll to S of Relay Cabin; elev. 2160 m; gentle slope (13°); SW aspect; concave; xeric

(142) Lichen fellfield on S side of knoll to S of Relay Cabin; elev. 2180 m; gentle slope (10°); W aspect; convex; xeric; rocky

(143) Alpine meadow on S side of knoll to S of cabin on W facing side of pass; moderate slope (16°); elev. 2170 m; concave; mesic

(144) Dryas meadow on W side of ridge to W of knoll S of cabin; elev. 2155 m; ENE aspect; steep slope (26°); convex; mesic

(145) Willow-birch shrubland on eastern slope of knoll to S of cabin; elev. 2120 m; E aspect; concave; subhygric

(146) Dryas fellfield on N side of knoll S of Relay Cabin; elev. 2115 m; NE aspect; moderate slope (22°); concave; rocky; xeric

Aug. 10 (147) Alpine meadow in cirque on E side of Dash plateau to W of saddle above Relay Cabin; elev. 2260 m; NE aspect; gentle slope (13°); convex; very rocky; submesic

(148) Birch wetland in depression area of cirque to the W of the saddle above Relay Cabin; elev. 2230 m; slightly concave; hygric

(149) Alpine meadow NW of cirque to W of saddle above Relay Cabin; elev. 2210 m; gentle slope (9°); ENE aspect; concave; mesic

(150) Alpine fellfield NW of cirque to W of saddle above Relay Cabin; elev. 2230 m; gentle slope (8°); N. facing; convex; xeric

(151) Alpine meadow on E side of Dash plateau above cirque; elev. 2240 m; slope very gentle (4°); NE aspect; slightly concave; submesic

(152) Alpine meadow on E side of Dash plateau NW of cirque; elev. 2265 m; very gentle slope (4°); NE aspect; rocky; convex; submesic

(153) Alpine fellfield on E side of Dash plateau NW of cirque; elev. 2275 m; gentle slope (6°); N aspect; very rocky; concave; xeric

(154) Alpine fellfield on E end of Dash plateau below the knoll; elev. 2310 m; very gentle slope (5°); NNW aspect; very rocky; convex; xeric

Aug. 11 (155) Willow-birch wetland on Relay Valley floor just E of Two Lakes basin; elev. 1860 m; flat; hygric; Salix growth to 1 m

(156) Subalpine meadow on S-facing hillside of Relay Valley just E of Two Lakes basin; elev. 1865 m; steep slope (39°); S aspect; rocky; convex; submesic

(157) Subalpine meadow at foot of S-facing slope just E of Two Lakes basin; elev. 1860 m; level; mesic

(158) Willow-birch shrubland on Relay Valley floor 2.5 km E of Two Lakes basin; elev. 1850 m; very gentle slope (5°); slightly concave; mesic; growth to 1 m

(159) Willow-birch shrub wetland in Relay Valley 3.2 km E of Two Lakes basin; elev. 1845 m; gentle slope (5°) with ENE aspect; convex; subhygric

(160) Subalpine meadow in Relay Valley 3.2 km E of Two Lakes basin; elev. 1835 m; on valley bottom; submesic

(161) Well drained subalpine meadow on S-facing slope of Relay Valley 3.2 km E of Two Lakes basin; elev. 1890 m; steep slope (32°); SSW aspect; convex; subxeric

(162) Willow-birch shrubland 4 km W of Relay Cabin in Relay Valley; elev. 1835 m; on valley bottom; hygric

Aug. 12 (163) Subalpine meadow in Relay Basin south of the rock slide 4 km from Relay Cabin; elev. 1820 m; valley bottom; rocky; submesic

(164) Arctostaphylos meadow on the rocky hills just beyond the talus slope in Relay Basin 4 km from cabin; elev. 1825 m; moderate slope (18°); ESE aspect; convex; subxeric

(165) Sedge wetland meadow in Relay Basin just beyond talus slope 4 km SW of Relay Cabin; elev. 1820 m; valley bottom; hygric; Carex aquatilis is dominant

(166) Willow-birch shrubland on east side of creek in Relay Basin 4.8 km; SW of Relay Cabin; elev. 1830 m; mesic; growth to 1 m

(167) Well drained subalpine grass-forb meadow on E-facing slope of Relay Basin 4.8 km SW of Relay Cabin; elev. 1870 m; moderate slope (21°); SE aspect

(168) Willow-birch shrub wetland in Relay Basin 4.8 km SW of cabin; elev. 1870 m; gentle slope (8°); E-facing; slightly concave; hygric

(169) Low willow shrubland on alluvial outwash on valley floor in Relay Basin 4.8 km SW of cabin; elev. 1850 m; rocky; submesic

Aug. 13 (170) Alpine meadow at end of Little Paradise basin; elev. 2090 m; moderate slope (16°); N aspect; hummocky; slightly concave; mesic

(171) Alpine grass meadow on E-facing slopes of Paradise Valley just over the pass from Little Paradise; elev. 2170 m; gentle slope (13°); S aspect; concave; submesic

(172) Alpine grass meadow on E-facing slopes of Paradise Valley just over the pass from Little Paradise; elev. 2145 m; moderate slope (21°); S facing; concave; submesic

(173-175) Alpine meadow on ENE facing slope in Paradise Valley just over pass from Little Paradise; elev. 2065 m; steep slope (32°); overgrazed; concave; xeric; dominants are Cirsium hookerianum & Geum triflorum

(176) Low willow shrub at end of Little Paradise Valley just W of pass to Paradise Valley; elev. 2240 m; moderate slope (15°); SW aspect; convex; mesic; growth to .3 m

Aug. 15 (177) Poplar scrub on SE facing slope in basin just SE of Two Lakes Basin off of Relay Valley; elev. 1910 m; steep slope (32°); convex; rocky; xeric; growth to 1.3 m; a lot of bare ground

(178) Poplar scrub on S-facing slope in basin just E of Two Lakes on S side of Relay Valley; elev. 1940 m; steep slope (31°); convex; rocky; xeric

(179) Subalpine meadow in spruce-lodgepole pine forest in basin just E of Two Lakes Basin on S side of Relay Valley; elev. 1955 m; moderate slope (17°); ESE aspect; slightly concave; submesic

(180) Arctostaphylos meadow N of pond to SE of Two Lakes Basin; elev. 2050 m; moderately steep slope (26°); SW aspect; concave; submesic

(181) Willow-birch shrubland SW of pond above Two Lakes Basin; slightly convex; submesic; level ground

(182) Sedge wetland on valley floor in basin SE of Two Lakes Basin and S of Relay Valley; slightly concave; hydric; elev. 1940 m; dominated by Carex rostrata

(183) Dry willow shrub in basin SE of Two Lakes Basin; elev. 1980 m; gentle slope (8°); N. aspect; convex; submesic

Aug. 16 (184-185) Big meadow (subalpine) on alluvial fan in Relay Basin; elev. 1925 m; gentle slope (7°); NW aspect; convex; mesic

(186) Salix wetland at S end of Relay Basin; elev. 1965 m; gentle slope (9°); W-facing; slightly concave; hygric; growth to 1.2 m

(187) Subalpine meadow in parkland at S end of Relay Basin; elev. 2020 m; gentle slope (8°); W-facing; convex; mesic to subhygric

(188) Alpine meadow on NW-facing slope at S end of Relay Basin; elev. 2080 m; gentle slope (13°); convex; submesic

(189) Salix wetland at S end of Relay Basin; elev. 2035 m; moderate slope (15°); WNW aspect; concave; hygric

Aug. 17 (190) Carex nigricans late snow depression area on E-facing ridge of Little Paradise Valley; elev. 2070 m; concave; subhygric to mesic; local

(191) Subalpine shrubland on S ridge of Little Paradise Valley; elev. 2080 m; moderate slope (16°); N aspect; undulating terrain; submesic

(192) Heath community on E-facing slope at end of Little Paradise Valley; elev. 2100 m; moderate slope (21°); mesic; late snow depression areas

(193) Seepage shrub meadow in Little Paradise; elev. 2110 m; gentle slope (14°); NW aspect; concave depression area; hygric; mosses common along stream

(194) Salix wetland at end of Little Paradise Basin; elev. 2035 m; gentle slope (11°); N aspect; concave; hygric

(195) Salix-grass meadow in N arm of Little Paradise Valley; elev. 2020 m; moderate slope (22°); SSW aspect; hummocky; submesic

(196) Poplar scrub on rocky SW-facing slope at mouth of Little Paradise Valley; elev. 2020 m; steep slope (34°); unstable; convex; xeric

Aug. 18 (197) Alpine meadow on southern, lower portion of W Dash Plateau; elev. 2170 m; slightly concave; gently rolling; submesic

(198) Birch shrubland on SW end of Dash Plateau; elev. 2170 m; gentle slope (7°); W aspect; convex; mesic

(199) Gravel bed on SW end of Dash Plateau; elev. 2170 m; gentle slope (4°); W aspect; concave; xeric

(200) Alpine meadow on Dash Plateau on the W side near Dash Creek; elev. 2030 m; gentle slope (4°); W aspect; slightly concave; subxeric

(201) Seepage meadow along Dash Creek drainage; elev. 2120 m; concave; hygric; hummocky from cattle trampling

(202) Birch-willow shrubland in central part of Dash Plateau; elev. 2135 m; gentle slope (9°); WSW aspect; convex; submesic; growth to .3 m

(203) Arctostaphylos dwarf shrub fellfield on W part of Dash Plateau; elev. 2115 m; gentle slope (6°); SE aspect; gravelly; convex; xeric; sparse vegetation

(204) Alpine meadow on SW end of Dash Plateau; elev. 2110 m; moderate slope (15°); NNE aspect; slightly hummocky; convex; submesic

(205) Alpine meadow on SW end of Dash Plateau; elev. 2135 m; moderate slope (14°); NNE aspect; convex; xeric

Aug. 19 (206) Spruce forest on knoll S of cabin across Relay Creek; elev. 1820 m; moderate slope (17°); W-facing; convex; mesic; no shrub layer

(207) Birch-willow shrubland on N-facing slope S of Relay Cabin; elev. 2090 m; moderate slope (14°); very rocky; convex; submesic

(208) Subalpine parkland on N. facing slope to S. of cabin; elev. 2075 m; moderate slope (15°); rocky; slightly concave; xeric

(209) Old lodgepole pine forest on N facing slope on S side of Relay Creek above cabin; elev. 1830 m; steep slope (27°); NW aspect; convex; mesic; successional to subalpine fir

Aug. 21 (210) Aspen scrub-Shepherdia on rocky, south-facing slope below the Red Cliffs 3 km E of cabin; elev. 1720 m; steep slope (39°); SSW aspect; convex; xeric

(211) Aspen scrub below Red Cliffs 3 km E of cabin; elev. 1750 m; steep slope (38°); SSW aspect; very rocky; convex; xeric; growth to .8 m

(212) Well drained meadow just W of Red Cliffs 3 km E of cabin; elev. 1840 m; steep slope (36°); S-facing; rocky; convex; xeric

(213) Old burn site with Abies lasiocarpa & Pinus albicaulis regeneration on top of ridge above Red Cliffs 3 km E of cabin; elev. 1900 m; gentle slope (10°); N aspect; concave; submesic; growth to 3 m

(214) Subalpine meadow just W of creek by Red Cliffs 3 km E of Relay Cabin; elev. 1750 m; moderate slope (19°); ESE aspect; submesic

(215) Subalpine meadow W of creek by Red Cliffs 3 km E of Relay Cabin; elev. 1740 m; steep slope (32°); S-facing; concave; mesic

Aug. 22 (216) Alpine tundra on E side of Dash Plateau below cirque lake; elev. 2185 m; gentle slope (10°); NE aspect; rocky soil; concave; mesic

(217) Birch-willow shrubland on E end of Dash Plateau; elev. 2195 m; gentle slope (4°); ENE aspect; convex; mesic; growth to .3 m

(218) Dryas-lichen fellfield on E end of Dash Plateau; elev. 2190 m; almost flat with a south-eastern exposure; rocky; convex; xeric

(219) Willow-birch shrub wetland on E side of Dash Plateau; elev. 2190 m; very gentle slope (4°); N aspect; slightly concave; hygric; growth to .6 m

(220) Alpine meadow on E side of Dash Plateau; elev. 2230 m; gentle slope (7°); N aspect; convex; subxeric

(221) Alpine fellfield E of the dry gorge on the eastern side of Dash Plateau; elev. 2250 m; gentle slope (6°); NW aspect; very rocky with some stone stripes; convex; xeric

(222) Alpine fellfield on E end of Dash Plateau; elev. 2300 m; slight slope (2°); W aspect; very rocky; slightly concave; xeric

(223) Alpine fellfield on the knoll W of the saddle on Dash Plateau (eastern end); elev. 2370 m; slight slope (2°); S aspect; slightly convex; xeric; very rocky

(224) Alpine fellfield on top of the ridge to the W of the saddle N of Relay Cabin; elev. 2345 m; essentially flat; very rocky; xeric

Aug. 23 (225) Spruce-fir forest in cool drainage area on S-facing slope above cabin; elev. 1865 m; moderate slope (19°); E aspect; beside creek; concave; subhygric

(226) Subalpine meadow on S-facing slope above cabin; elev. 1965 m; on a bench with a SE aspect; convex; mesic

(227) Subalpine forest (parkland) with Pinus albicaulis, P. contorta & Abies lasiocarpa; on S-facing slope above cabin; elev. 1985 m; gentle slope (11o); SE aspect; very rocky; xeric

(228) Subalpine seepage meadow in forest opening on S-facing slope above cabin; elev. 1885 m; gentle slope (12°); SE aspect; concave; hygric

Aug. 24 (229) Subalpine sedge meadow 2.5 km W of Relay Cabin between Relay Creek and the trail; elev. 1775 m; moderate slope (21°); SSE aspect; concave; mesic

(230) Willow-birch shrub wetland on N side of Two Lakes midway between the lakes; elev. 1955 m; gentle slope (8°); S aspect; slightly convex; hygric; growth to .6 m

(231) Willow-birch shrubland on N side of Two Lakes Basin above the Salix wetland areas; elev. 1950 m; gentle slope (8°); SSE aspect; convex; submesic; growth to .75 m

Aug. 26 (232) Alpine meadow on N-facing slopes at end of Relay Basin (W side); elev. 2150 m; steep slope (25°); ENE aspect; convex; subxeric; just above treeline

(233) Alpine meadow on N-facing slopes at W end of Relay Basin; elev. 2220 m; moderately steep slope (22°); ENE aspect; convex; xeric; rocky

(234) Alpine meadow on N-facing slopes at W end of Relay Basin; elev. 2215 m; moderate slope (20°); ENE aspect; convex; xeric

Aug. 27 (235) Subalpine meadow 1.6 km E of cabin; elev. 1740 m; moderate slope (22°); SE aspect; slightly concave; mesic

(236) Open pine forest on old burn site on S-facing slope slightly E of cabin; elev. 1820 m; steep slope (32°); S aspect; very rocky soil; convex; submesic

Aug. 28 (237) Open pine forest - shrub area at N end of Prentice Lake; elev. 1775 m; steep slope (32°); S aspect; xeric

Aug. 29 (238) Overgrazed meadow on E facing hillside at N end of Prentice Lake above sedge meadow; elev. 1670 m; steep slope (40°); E aspect; convex; xeric; a lot of bare ground

(239) Grass meadow on E-facing slope at S end of Prentice Lake; elev. 1710 m; moderate slope (20°); E aspect; convex; xeric; rocky soil