BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

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B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES
LAND RESOURCES SUBGROUP

PHYSICAL HABITAT AND RANGE VEGETATION REPORT

VOLUME I

PREPARED BY:

THE TERA ENVIRONMENTAL RESOURCE ANALYST LIMITED

AND

CANADIAN BIO RESOURCES CONSULTANTS LTD.

JUNE 1978

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2.0 INTRODUCTION

In July 1976, B.C. Hydro and Power Authority awarded the Land Resources Subgroup of the Detailed Environmental Studies of the Hat Creek Project to The TERA Environmental Resource Analyst Limited. The Land Resources Subgroup was divided into five appendices. Each appendix is the responsibility of individual consulting firms under the administration of The TERA Environmental Resource Analyst Limited.

For Appendix A1, Physical Habitat and Range Vegetation, two firms conducted the study: The TERA Environmental Resource Analyst Limited (responsible for landform, geology, forest soils and native vegetation) and Canadian Bio Resources Consultants Ltd. (responsible for agricultural soils and range vegetation). A biophysical analysis of the area of influence established the relationship of the biological systems to the physical habitat.

The detailed environmental studies are to assess the impact of a 2000 MW thermal plant and associated mine in the upper Hat Creek Valley, Nicola - Thompson Region, B.C.

2.1 PHYSICAL HABITAT

(a) Terms of Reference

As per the terms of reference of the Detailed Environmental Studies dated March 1977, the Physical Habitat portion of the study is required to:

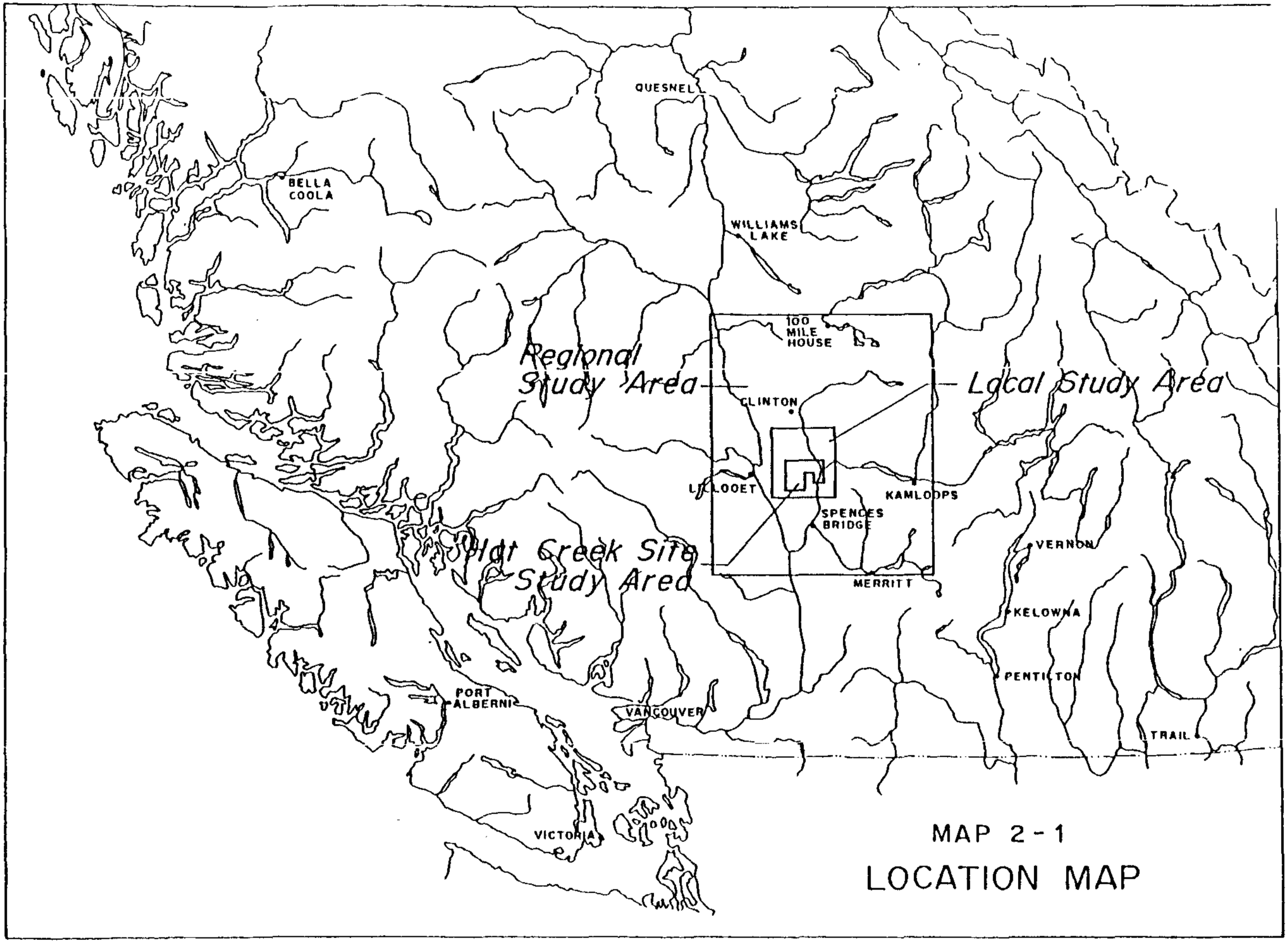
"1. *Inventory soils and landforms*

2. *Describe climate by precipitation, temperature, humidity and growing season, in co-operation with the measurement programme of the Air Quality Impact Study.*"

(b) Scope and Purpose

The physical habitat section of this report describes and maps geology, landform and soils. As in the remainder of the study, the scope of this undertaking is tailored to deal with the regional inventory at a scale of 1:250,000, the local study area at 1:50,000, and finally, the detailed study area to 1:24,000. The regional study area (see Map 2-1) is defined by a western boundary approximately 20 km (12.5 mi.) west of Lytton, a northern boundary approximately 20 km (12.5 mi.) north of 100 Mile House, an eastern boundary approximately 25 km (15 mi.) east of Kamloops, and a southern boundary approximately 10 km (12.5 mi.) south of Merritt. The total area for the regional study is 31,500 km^2 (12,304 sq. mi.).

For the local study area mapped at 1:50,000 scale, the study boundaries were defined 8 km (5 mi.) east of Lillooet, 5 km (3 mi.) south of Oregon Jack Creek, 3 km (2 mi.) east of Ashcroft, and 10 km (.6 mi.) north of Carquile. The detailed study area at 1:24,000 was defined to include an area extending 6 km (4 mi.) west of Hat Creek, 3 km (2 mi.) south of Blue Earth Creek, 5 km (3 mi.) east of Hat Creek, and 1 km (.6 mi.) north of the junction of Highway 12 and the Upper Hat Creek Road. The Harry Lake vicinity is indicated on the 1:24,000 map including the Harry Lake plant site and immediate corridors



MAP 2 - 1
LOCATION MAP

from Ashcroft to Harry Lake, up Cornwall Creek and a corridor due east to the Thompson River for the water intake pipe.

The description and mapping of all above-mentioned features permits the assessment of the environmental impact of both the mine in the valley and the thermal generating plant at Harry Lake, including all of its linkages. The progression from regional inventory, to local inventory, to detailed site inventory allows an increasing focus on environmental features and examination of physical impacts identified. The physical habitat impact assessment permits a detailed description of mitigation and compensation options for those facilities with adverse environmental consequence. These physical mitigation recommendations will be included in guidelines for the construction and operation of all facilities.

Climate was derived from three sources and compiled in this and the agricultural report. Information from Environmental Research & Technology, Inc.[01] was specially condensed to form a narrative for this text. However, climatic information from the provincial data[2, 3] needed analysis for climate capability for agriculture.

(c) Acknowledgements

The primary data base for the physical habitat of the regional and site-specific Hat Creek study areas was derived from the B.C. Ministry of the Environment, Resource Analysis Branch. We would like to extend special thanks to Gavin Young for his help in making the preliminary landform and soils maps available, as well as his untiring support in discussing his preliminary findings prior to publication of his work.

The climate capability for agriculture was supplied as well by the B.C. Ministry of the Environment, Resource Analysis Branch.

2.2 VEGETATION

(a) Terms of Reference

As per the terms of reference of the detailed environmental studies dated August 1977, the vegetation portion of the study is required to:

"1. Map and quantify present and climax plant communities, indicating increaser and decreaser species;

2. Provide a plant species check list showing the relationship and importance to wildlife, livestock, man, or other organisms. Also, identify rare or endangered plant species or communities;

3. Prior to development, establish permanent vegetation plots to monitor the effects of the operation from the standpoint of gaseous, particulate and heat emissions."

The following items listed in the terms of reference have been re-assigned to the Agriculture Report.

"1. Assess forage productivity, present and potential carrying capacity and present conditions of range areas (include land capability for grazing);

2. Study relative utilization of range by livestock and wildlife and relate to productivity;

3. Identify sensitivity of range components to construction and operation activities. Where possible, include quantitative impacts. Note maximum exposure limits, regulatory requirements and sensitive species (liaison required with air programme to identify sensitive areas);

4. Identify potentially irrigable lands which could serve as possible compensation measures and establish their feasibility, productivity, and costs. Identify specifications for water quality for irrigation water with view to using plant waste water."

(b) Scope and Purpose

The study of the vegetation for the Hat Creek development was initiated to fulfill the term of reference stated in Section 2.2(a), and provide a basis for assessing the effects a thermal generating station may have on the surrounding vegetation communities and their use.

In order to study the vegetation, three levels of mapping and description were defined (Map 2-1). A regional investigation at a scale of 1:250,000 which delineated the biogeoclimatic zones within an area bounded approximately by 100 Mile House, Kamloops, Merritt and Seton Lake; a scale of 1:50,000 (local study area) permitted investigation of the vegetation associations within the Hat Creek watershed and Thompson - Bonaparte River valleys eight kilometres (five miles) east of Ashcroft; and a scale of 1:24,000 (Hat Creek site) was used for areas affected by the mine, plant site and off-site facilities. These studies took place in the time interval from August 1, 1976 to May 31, 1977.

(c) Acknowledgements

The author wishes to thank the following individuals and government agencies for their assistance in the development and interpretations of the vegetation of the Hat Creek area:

Dr. A. Maclean, Canada Department of Agriculture, Kamloops;

Dr. V.C. Brink, Department of Plant Science, University of British Columbia;

Mr. J. White, Range Division, B.C. Forest Service, Kamloops;

Mr. Gavin Young, B.C. Ministry of Agriculture, Kelowna; and

Mr. G. Parks, local resident, Hat Creek Valley.

3.0 RESOURCE INVENTORY METHODOLOGY

3.1 PHYSICAL HABITAT

(a) Study Personnel

Project management for the Physical Habitat and Range Vegetation Report was provided by Helmut J. Urhahn. The tasks were shared by personnel of The TERA Environmental Resource Analyst Limited and Canadian Bio Resources Consultants Ltd. For analysis of climate, Helmut Urhahn and Ross Husdon shared the tasks and emphasized their respective areas, such as the biophysical description by The TERA Environmental Resource Analyst Limited and the agricultural climate capability by Canadian Bio Resources Consultants Ltd.

The inventory of the physical habitat consisted of landform, geology and soils. The landform, topography and geology were conducted on the basis of published literature and a brief field reconnaissance by Helmut Urhahn. Soils, for both the regional and site-specific study aspects were conducted by Stephan Houseknecht and Jock Forster, with the latter emphasizing agricultural and improvable soils. Grazing capability and range conditions were inventoried by Jock Forster and Ross Husdon.

(b) Climate

Environmental Research and Technology, Inc. (ERT) has provided a detailed analysis of the climate in the regional study area[01]. This report is not intended to duplicate that effort nor to simply reiterate information presented by ERT. Rather, the present climate discussion contained in the inventory section is a brief synopsis, designed to enhance the investigation of the physical habitat and vegetation within the Hat Creek region.

The climate inventory in this report was prepared by ERT at the request of The TERA Environmental Resource Analyst Limited. This provided an accurate and reliable climate description. The description discusses the climate in a regional sense with special emphasis on the Hat Creek area. The relationship of this information to the physical and biological resources has been completed using the biogeoclimatic approach. With respect to the climatic influence on agriculture, this will be handled by Canadian Bio Resource Consultants Ltd. in the Agriculture Report.

(c) Landforms

This section was primarily based on published reports of the area[04, 05, 06, 07, 08, 09, 10, 11, 12, 13]. The soils mapping of the B.C. Ministry of the Environment, Resource Analysis Branch, was used in conjunction with airphoto interpretation to determine physiographic regions and specific landform categories. A brief air and ground reconnaissance of one day each was conducted to check the physiography and to relate other physical and biological parameters to landform.

(d) Terrain

The terrain inventory emphasized bedrock and surficial geology. This was based on published information[04, 05, 06, 07, 08, 11, 12, 13, 14] and subsequent airphoto interpretation. Broad geological provinces were mapped at a scale of 1:250,000. More specific information as regards bedrock and surficial geology was incorporated into the biophysical analysis from the above data base. Bedrock and surficial geology were incorporated in the 1:50,000 biophysical maps and their important limitations and potential relationships to physical disturbance and plant air emissions discussed. Important characteristics of the terrain in the regional and local sense have been included in the land system analysis (1:250,000) and the biophysical analysis (1:50,000). A terrain analysis (1:24,000) will be provided by the geotechnical consultant and a site-specific description of the bedrock geology and surficial geology is discussed by Dr. P.T. McCullough of B.C. Hydro and Power Authority[13].

(e) Soils

The soils inventory can be compiled at various levels of mapping detail depending upon the degree of interpretation or analysis required. The inventory for the local study area was compiled from three sources:

1) Soil Association Mapping[15] available for the entire local study area

2) Soil Series Mapping[16] - available for a relatively small area within the site specific study area of the Thompson and Bonaparte River valleys

3) Modified Soil Series Mapping - mapped by Canadian Bio Resources Consultants Ltd. that covers the lower elevation lands of the Hat Creek Valley and those uplands where detailed soil analysis was required.

Regionally, the soils were mapped and briefly described at the order level of the Canadian Soil Classification System[17]. The mapping was completed using existing information at the soil association level provided by the Resource Analysis Branch and Canada Department of Agriculture[15]. This information appears on the Land System Map (Map 4-2) at a scale of 1:250,000.

The soil association level of mapping was available in only provisional form at the beginning of this study. This provisional mapping[15] was based primarily on air photo interpretation of 1:95,040 scale air photos and a minimum of field investigation. This provisional information was modified during the study through refinements conducted by the Resource Analysis Branch* using more detailed 1:63,360 scale air photographs.

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* Resource Analysis Branch, British Columbia Ministry of the Environment

The physiographic units identified at this soil association level of mapping reflect major changes in landform, parent material, vegetation, soil development, topography and drainage. Most units identified contain two or more independent soil developments defined by the System of Soil Classification for Canada[17] at the soil subgroup level of interpretation. While this level of mapping provides valuable information about the physical properties of the parent materials on which the soil developed and the biophysical environment in which they exist, it provides little or no information pertaining to the physical or chemical alterations that exist near the soil surface or within the zone of soil development apart from the generic name. Any chemical interpretations associated with this level of mapping reflect modal soil conditions and are of restricted value in relating to a specific unit identified by the soil association mapping. It is, therefore, not possible to use the information from a soils association level of mapping to determine agricultural parameters such as: productivity, irrigation requirements and fertility.

The soils series mapping is the most detailed form of soil mapping used in taxonomic soil assessments for Canada[17]. For this level of mapping, detailed interpretations are made from 1:15,840 scale air photos based on extensive field investigations. The physiographic units identified reflect major changes in landform, parent materials, vegetation, soil development, depth of topsoil, textures, topography, and drainage. At this level of mapping, detailed information is provided on physical and chemical properties within the zone of soil development and a full taxonomic description based both on field investigation and a subsequent sampling and laboratory analysis is provided for each soil series. From this data, interpretations relating to the suitability of the soil series for agricultural use, susceptibility to erosion, water requirement or water holding capacity and general soil fertility are available.

For the modified soil series mapping, initial air photo interpretation was conducted from 1:15,840 scale air photos within the major physiographic units identified and mapped. Field checking was then initiated using this information as a guide to determine the general number and placement of soil inspection locations which, in turn, were used to classify the soils and identify any further refinements and alterations required to the identified physiographic units.

Field inspection included two or three random profile inspections per map unit depending on size and soil variability noted within the unit. These inspections generally included identification of the soil development from visual identification and soil colour chart verification, soil texture as analyzed through hand texturing techniques, drainage characteristics as noted in visual inspection, slopes as recorded with a suunto clinometer, free carbonates as evident from visual inspection, salinity as evident from presence of salt crystals, and stoniness as noted from field inspection. For those parameters such as calcareous nature and soil alkalinity, soil tests were made of characteristic soil profiles, using field acid tests and pH test kit analysis which gave relative values for these items.

Maps at the soil association level are compiled for the local study area at a scale of 1:50,000. For lands at the lower elevations in the Hat Creek valley and for other areas where detailed soils information is required, maps are compiled using either the soil series or modified soil series information at a scale of 1:24,000.

(f) Land System Mapping

A land system mapping approach has been applied to the regional study area, mapped at a scale of 1:250,000. Its level of generalization is based and designed to facilitate a quick overview of physical and biological systems present within the regional study area. Specific physical and biological aspects included in the mapping are geology, slope and landform, soils and biogeoclimatic zones of the regional vegetation. The basis for using this mapping approach is that it summarizes all the physical aspects into one map rather than many, as well as exhibiting the relationship between the various physical and biological resources. Only this map will be referred to when describing the physical resources of the regional study area.

3.2 VEGETATION

(a) Study Personnel

Stephan Houseknecht of The TERA Environmental Resource Analyst Limited conducted the vegetation inventory. George Otto, a lichenologist, compiled a literature survey of plants sensitive to air emissions. James Pojar aided in the identification of grasses, mosses and lichen species. Dr. V.C. Runeckles, Department of Plant Science, University of British Columbia and Dr. H. Bunce of Reid, Collins and Associates Limited completed the assessment of air emission effects on the vegetation.

(b) Concept

The concept utilized in this study to classify the vegetation of the Hat Creek area was developed by Krajina[01, 02, 03] and is a hierarchal one using several levels of integration, each one yielding additional information on vegetation, soils, and other environmental parameters. In this sense, Krajina's approach is ecosystematic because both vegetation and environmental parameters are used to classify a particular "association".

Three levels of integration were used to describe the vegetation of the Hat Creek area; namely the biogeoclimatic zones, the association, and the forest type. A biogeoclimatic zone is a geographic area that is predominantly controlled by the same macro-climate and characterized by the same zonal soils and the same zonal (climatic climax) vegetation[01]. A biogeoclimatic zone, therefore, can be considered a regional ecosystem containing many smaller ecosystems. Topography is one of the major tools used in the mapping of the biogeoclimatic zones, since it integrates many parameters of climate as well as vegetation and soils.

The association concept within the structure of each biogeoclimatic zone classifies the vegetation in a more detailed manner. An association has a definite uniform vegetation composition and physiogomy, and is associated with a certain set of environmental and physical factors. Each vegetation association is named using the dominant overstory and understory species in the climatic climax state. It should be emphasized that, because of abundant fires, insect infestations and logging throughout the area, most associations exist in a seral condition. When fire or logging removes the existing climax vegetation and invader species mix with the climax type, the vegetation associations are not easily determined from the forest tree layer. Although the overstory may be completely removed or altered in seral state, the understory species usually persist and are very important indicators of the association types. Because of the seral nature of most of the forests of the study area, the forest types were grouped and mapped within each vegetation association. A forest type is defined by its overstory composition. In order to be listed within a forest type, a tree species must make up at least 10 percent of the canopy coverage. Generally, the first species listed is the dominant one, while any further species vary in their contribution to the overall canopy coverage.

(c) Sampling Scheme

(i) Regional Survey

The biogeoclimatic zones were mapped within the regional study area from the Biogeoclimatic Zones of British Columbia Map compiled by the Ecological Reserves Committee[04] and from field observations mainly within the Hat Creek watershed. The observations of Brayshaw[05], Arlidge[06], McLean[07], and Beil[08], who studied the interior of British Columbia, were also consulted.

(ii) Detailed Survey

The field programme consisted of a reconnaissance and sampling phase. The reconnaissance phase is used to familiarize the observer with the area and its vegetation patterns. The better the reconnaissance phase, the easier and more efficiently the sampling phase can be carried out. In the sampling phase, the observer subjectively chooses a "homogeneous" stand that represents a visible vegetation segment and continues until all the vegetation segments have been sampled. The number of replicates used largely depends on the complexity of the vegetation and degree of stratification desired within the time constraints. This type of subjective sampling has been used by many phyto-sociologists in the Pacific Northwest. It has been found to be accurate and flexible, and eliminates much repeated sampling common in objective approaches that use random or systematic sampling schemes[09].

After a sample stand had been chosen, a 10 x 10 m plot was laid out. Physical data were collected as indicated on the physical data form (Appendix A). Slope, elevation and aspect were determined using the appropriate hand held instruments. The remaining parameters were determined visually or from already existing information (soils data). Vegetation data were stratified by layer (i.e. tree, shrub, herb and moss). Criteria for this stratification is contained in Appendix C. Visual cover estimates were made on all species within each layer, as well as the total layer coverage. In addition, one increment core from each tree species present was taken and its diameter and height were recorded. The presence of any diseases was also noted. Replicate plots for each vegetation association were compared and synthesized to yield a final set of vegetation associations as well as descriptions. These were mapped at a scale of 1:50,000.

A total of 78 plots were located throughout the local study area. The locations of the vegetation plots are found on the 1:50,000 vegetation association map (Map 4-6). Most of this work was completed between September 20 and October 31, 1976 (66 plots). Because of the late date that field work began, additional work was carried out in the spring of 1977 (May 20 to May 26, 1977). This work entailed the establishment of 12 additional plots and field-checking of already established plots to include spring flowering plant species which were missed during the fall survey.

(d) Data Analysis - Detailed Survey

The analysis was carried out using the phyto-sociological techniques of the Zurich-Montpellier School as adapted by Krajina[10]. The similarity of vegetation and environmental factors were progressively stratified visually in a tabular format, and presence and mean species cover used as the major criteria for describing and differentiating the associations. A technique developed by Klinka[11] was used to stratify the vegetation and environmental factors into associations. The plant species were grouped on each table according to the following criteria:

- vegetation strata,
- highest presence, and
- highest mean cover.

This is essentially a progressive, synthesizing procedure where environment - vegetation relationships are compared for similarities of differences and the plots grouped and regrouped until the maximum degree of consistency is achieved between the vegetation and environmental components.

The final environment - vegetation tables derived from this process are presented in Appendix C along with description of the parameters used and how they were determined.

(e) Biophysical Analysis

The biophysical analysis was originated in Canada by Lacate[12] to serve as the basis to differentiate and classify ecologically significant segments of the land surface. The biophysical method allows the mapping and interpretation of the physical and biological features of the landscapes to take place in a holocoenotic approach that integrates climate, geology, landform, soils and vegetation in homogeneous units. Therefore, instead of identifying each component of the environment as an individual entity, biophysical approach treats them as integrated bodies.

Two levels of integration were used, the biophysical unit and the biophysical subunit. These units can be defined as follows:

Biophysical Unit:

A complex of biophysical subunits that possess the same landform, soil great group and occur in the same biogeoclimatic zone. This unit is used for the descriptive phase and is not mapped (refer to Map 4-7a, 7b and Appendix D).

Biophyscial Subunit:

A detailed unit utilizing landform, soil great group, and vegetation associations. Soil great groups that exhibit limitations, such as erosion, high alkalinity, and flooding were also delineated. This is a mapping unit and is described within the context of each biophysical unit (refer to Map 4-7a, 7b, and Appendix D).

The aggregation of the biophysical subunits into biophysical units for descriptive purposes eliminated much of the descriptive repetition inherent in the subunits because of differences in vegetation associations that can be accurately grouped by biogeoclimatic zone.

In the mapping phase, the biophysical subunits were arrived at by an *a posteriori* integration of maps completed during the inventory phase and already existing maps. This technique produced relatively homogeneous units in terms of climate, landform, soils, and vegetation. The biophysical subunits were then grouped into the same biogeoclimatic zone to form a biophysical unit that was then classified in terms of its physical and biological characteristics. Limitations and its resource capabilities were also attached. This information was recorded in a tabular format and presented in the inventory section.

The value of this system lies in its applicability in defining areas that have environmental limitations. For example, since a biophysical subunit is an integration of climate, soil, landform, and vegetation, one subunit may possess steep slopes, a highly erodable soil, and a sensitive vegetation association.

All of these factors can be limitations to development. Therefore, rather than having a number of maps or descriptions, one subunit can handle all interpretations and is sensitive to synergistic effects between the associated environmental parameters. In addition, the subunits are also site-specific and the observer can note where the most environmentally sensitive and least sensitive areas exist.

Following one tabular listing of the physical and biological characteristics of each unit, an assessment of its resource capability was prepared by each consultant responsible for his respective discipline.

The agricultural and grazing evaluation was prepared by Canadian Bio Resources Consultants Limited; the forestry evaluation was done by Reid, Collins and Associates Limited; and the wildlife assessment was completed jointly by The TERA Environmental Resource Analyst Limited and L.R. Erickson and Associates Ltd. The methodology for assigning each resource capability is discussed below by discipline.

Agriculture and Grazing

The relative value to agriculture of the lands within the local study area was based on agricultural capability information presented in the Agriculture Report of the Hat Creek Detailed Environmental Studies. For lands within the site-specific study area, a more detailed approach was used, based on the assessment of potential agricultural use presented in the Agriculture Report of the Hat Creek Detailed Environmental Studies. Both methods provide comparable values with the information on the site-specific study area being more detailed and accurate.

Information on the lands in the local study area but outside the boundaries of the site-specific study area was subdivided into units according to five classes of agricultural capability and five classes of grazing capability. This land classification had been based on provincial reports[13, 14] and mappings[15, 16, 17, 18] pertaining to agricultural capability.

For the purpose of the biophysical assessment, land units with Canada Land Inventory (CLI) agricultural capability class 1 or 2 (land with no or minor limitations for the production of a wide range of crops) were rated as land with high agricultural value; land units with CLI agricultural capability class of 3 or 4 (land with moderate restrictions of soil and climate which limit the range of agricultural crops) were rated as land with medium - high agricultural value; land units with CLI agricultural capability class 5 (land which is limited to the production of perennial forage crops only) were rated as land with the medium agricultural value; and land units with grazing capability classes were rated according to their numerical grazing class, i.e., 1, 2, 3, 4, or 5. Grazing class 1 indicates the best grazing land and class 5, the worst. Land with grazing class 4 or 5 would be considered of relatively low value to agriculture. For lands within the site-specific study area, the land was subdivided into units according to its potential use for the production of key crop types. The potential uses had been assigned based on series level soils information (see Section 4.1 (d)) and provincial mappings pertaining to soils and climate.

Within the site-specific study area (1:24,000), a more detailed investigation was available as a result of the agricultural studies completed by Canadian Bio Resources Consultants Ltd. This information was used for land units occurring within the site-specific study area and is defined below.

For the purpose of the biophysical assessment, land units with the potential for the production of tomatoes and corn were rated as land with high agricultural value; land units with the potential for the production of cabbage and hay were rated as land with medium high agricultural value; and land units with the potential for improved pasture use were rated as land with medium agricultural value. The biophysical assessment of grazing lands of the site-specific study area was the same as that prepared for the local study area.

Forestry

Forestry was rated as good, moderate, poor, or non-productive based upon the forest productivity rating found on the forest site map prepared by Reid, Collins and Associates Limited. The biophysical map was overlain onto the forestry site map and the units compared. A dot tally was done to compare the degree of similarity between the biophysical subunits and forest site mapping. The systems of mapping were found to be highly related. Some of the relationships were found to be borderline between medium and poor site, and were given a "poor to medium" resource capability. In others, a site class range from good to non-productive was found because of small micro-topographical differences that were not mappable. However, these types of differences were very seldom encountered.

Wildlife

The wildlife component was handled by assigning a ranked score to the biophysical subunits corresponding to their value to wildlife. Eight categories (waterfowl, big game, gamebirds, non-game birds, rare and endangered species, furbearers, small mammals, and reptiles and amphibians) were considered for each biophysical subunit. Each wildlife category and biophysical unit combination was assigned an importance value ranging between 1 (minimal) and 4 (maximal) indicating the relative value of the biophysical unit to the wildlife resource in question. Occasionally, a value of 0 was used to indicate an absolute lack of resource value. The vegetation association component of the biophysical classification was related to the wildlife sampling programme and was used as the primary determinant of wildlife resource importance value (Table 3-1).

A weighting factor was derived by ranking the eight wildlife categories, also on a scale of 1 to 4, according to the economic or ecological value of the local resource in comparison with regional and provincial resources. A value of 4 is assigned to waterfowl, a value of 3 is assigned to gamebirds and to non-game birds, a value of 2 is assigned to furbearers and to small mammals, and a value of 1 is assigned to rare and endangered species and to reptiles and amphibians.

TABLE 3-1

WILDLIFE RESOURCE CAPABILITY RANKING BY VEGETATION ASSOCIATION (BIOPHYSICAL)

VEGETATION ASSOCIATIONS	Waterfowl*	Upland Gamebirds*	Non-Game Birds*	Furbearers*	Small Mammals*	Reptiles and Amphibians*	Rare and Endangered*	Deer*	Moose*			EVALUATED SPECIES: Waterfowl	Deer	Moose	Other	TOTAL WILDLIFE IMPORTANCE VALUE
Mountain Avens - Sedge Assoc.	0/0	1/3	2/6	1/2	2/4	0/0	2/2	2/8	1/3			Nil	Medium	Low	Low	(28) Low
Engelmann Spruce-Grouseberry Assoc.	0/0	2/6	1/3	3/6	1/2	1/1	1/1	2/8	2/6			Nil	Medium	Medium	Low	(33) Medium
Engelmann Spruce-Grouseberry -Pinegrass Assoc.	0/0	2/6	1/3	3/6	1/2	1/1	1/1	2/8	2/6			Nil	Medium	Medium	Low	(33) Medium
Engelmann Spruce-Grouseberry -White Rhododendron Assoc.	0/0	2/6	1/3	3/6	1/2	1/1	1/1	2/8	2/6			Nil	Medium	Medium	Low	(33) Medium
Engelmann Spruce-Willow-Red Heather Parkland Assoc.	0/0	2/6	1/3	3/6	1/2	1/1	1/1	2/8	3/9			Nil	Medium	Med-High	Low	(36) Medium
Engelmann Spruce-Grouseberry -Lupines Assoc.	0/0	3/9	1/3	3/6	1/2	1/1	1/1	2/8	2/6			Nil	Medium	Medium	Medium	(36) Medium
Douglas-fir-Pinegrass Assoc.	0/0	2/6	2/6	2/4	1/2	1/1	1/1	2/8	1/3			Nil	Medium	Low	Low	(31) Low
Douglas-fir-Bunchgrass Assoc.	0/0	3/9	3/9	2/4	2/4	1/1	1/1	2/8	1/3			Nil	Medium	Low	Medium	(39) Medium-High
Douglas-fir-Spiraea-Bearberry Assoc.	0/0	2/6	2/6	2/4	1/2	1/1	1/1	3/12	1/3			Nil	Med-High	Low	Low	(35) Medium
Douglas-fir-Bunchgrass-Pinegrass Assoc.	0/0	2/6	2/6	2/4	1/2	1/1	1/1	2/8	1/3			Nil	Medium	Low	Low	(31) Low
Ponderosa Pine-Bunchgrass Assoc.	0/0	2/6	3/9	2/4	2/4	1/1	2/2	2/8	1/3			Nil	Medium	Low	Medium	(37) Medium
Riparian Assoc.	2/8	4/12	4/12	4/8	4/8	3/3	2/2	3/12	4/12			Medium	Med-High	High	High	(77) High
Engelmann Spruce-Horse-tail Assoc.	0/0	2/6	2/6	2/4	1/2	1/1	1/1	1/4	1/3			Nil	Low	Low	Low	(27) Low
Willow-Sedge-Bog Assoc.	1/4	2/6	2/6	2/4	2/4	2/2	1/1	2/8	4/12			Low	Medium	High	Medium	(47) Medium-High
Highland Grassland Assoc.	0/0	1/3	2/6	1/2	3/6	1/1	2/2	2/8	1/3			Nil	Medium	Low	Low	(31) Low

*Importance Value / Ranked Score

TABLE 3-1 (Continued)

VEGETATION ASSOCIATIONS	Waterfowl*	Upland Gamebirds*	Non-Game Birds*	Furbearers*	Small Mammals*	Reptiles and Amphibians*	Rare and Endangered*	Deer*	Moose*			EVALUATED SPECIES: Waterfowl	Deer	Moose	Other	TOTAL WILDLIFE IMPORTANCE VALUE
Kentucky Bluegrass Assoc.	0/0	1/3	2/6	1/2	3/6	1/1	1/1	2/8	1/3			Nil	Medium	Low	Low	(30) Low
Bunchgrass-Kentucky Bluegrass Assoc.	0/0	1/3	2/6	1/2	3/6	1/1	1/1	3/12	1/3			Nil	Med-High	Low	Low	(34) Medium
Sagebrush-Bluebunch Wheatgrass Assoc.	0/0	1/3	2/6	1/2	3/6	1/1	1/1	4/16	0/0			Nil	High	Nil	Low	(35) Medium
Saline Depression Assoc.	4/16	1/3	4/12	1/2	2/4	2/2	4/4	1/4	0/0			High	Low	Nil	Medium	(47) Medium-High
Big Sagebrush-Bunchgrass Assoc.	0/0	2/6	2/6	1/2	3/6	1/1	2/2	3/12	0/0			Nil	Med-High	Nil	Medium	(35) Medium
Cultivated Fields	1/4	2/6	2/6	1/2	3/6	1/1	1/1	3/12	1/3			Low	Med-High	Low	Medium	(41) Medium-High
Bunchgrass-Kentucky Bluegrass/Saline Depression Complex	3/12	1/3	3/9	1/2	3/6	1/1	3/3	3/12	1/3			High	Med-High	Low	Medium	(51) High
Douglas-fir-Spirea-Bearberry/Douglas-fir-Bunchgrass Complex	0/0	2/6	3/9	2/4	1/2	1/1	1/1	2/8	1/3			Nil	Medium	Low	Low	(34) Medium
Kentucky Bluegrass/Riparian Complex	1/4	2/6	3/9	2/4	3/6	2/2	2/2	2/8	2/6			Low	Medium	Medium	Medium	(47) Medium-High
Bunchgrass-Kentucky Bluegrass/Riparian Complex	1/4	2/6	3/9	2/4	3/6	2/2	2/2	3/12	2/6			Low	Med-High	Medium	Medium	(51) High
Sagebrush-Bluebunch-Wheatgrass/Riparian Complex	1/4	2/6	3/9	2/4	3/6	2/2	2/2	4/16	1/3			Low	High	Low	Medium	(52) High
Mountain Avens-Sedge/Highland Grassland Complex	0/0	1/3	2/6	1/2	3/6	0/0	2/2	2/8	1/3			Nil	Medium	Low	Low	(30) Low
Douglas-fir-Pinegrass/Douglas-fir-Bunchgrass-Pinegrass Complex	0/0	2/6	2/6	2/4	1/2	1/1	1/1	2/8	1/3			Nil	Medium	Low	Medium	(31) Low
Douglas-fir-Spirea-Bearberry/Douglas-fir-Bunchgrass Complex	0/0	2/6	2/6	2/4	1/2	1/1	1/1	2/8	1/3			Nil	Medium	Low	Medium	(31) Low
Weighting Factor	4	3	3	2	2	1	1	4	3							

*Importance Value / Ranked Score

Rare and endangered species are assigned a minimal value because most of those species present in the regional study area would not occur in the local study area. Those rare or endangered species which can occasionnally be found in the Hat Creek Valley are mostly birds associated with wetlands. Deer and moose were given values of 4 and 3, respectively, because of their importance to local wildlife resource users. A total wildlife rank score for the vegetation association component of each biophysical unit was obtained by summing the products of the weighting factor and the rank score for each wildlife category (Table 3-1). This established a total wildlife value or capability for each biophysical unit.

Assigning a rank score to the biophysical units corresponding to their value to waterfowl is straightforward. Most of the biophysical units occur in upland areas which have essentially no value to waterfowl. Lakes and saline depressional areas have a high value to breeding, nesting, and feeding waterfowl. Biophysical subunits containing Bunchgrass - Kentucky Bluegrass/Saline Depression vegetation complexes were also rated as having a high waterfowl value despite saline depressions accounting for less than five percent of the land area of these complexes because some of the best waterfowl habitat in the regional study area occur in these biophysical units.

Other wetlands have a lesser significance to waterfowl. Biophysical units containing Riparian and Willow - Sedge Bog vegetation are considered to have a moderate value to waterfowl, as these units provide cover and feed to waterfowl and can be important to both nesting and migrating birds. Riparian/open range complexes and cultivated fields are regarded as having the potential for low value to waterfowl.

In addition, limitations to construction, operation, and decommissioning were attached to each unit based on its physical and biological characteristics, and associated resource capabilities. These will be used extensively in the assessment phase of the study in order to locate environmentally sensitive areas and suggest mitigation and compensation procedures.

4.0 RESOURCE INVENTORY

4.1 PHYSICAL HABITAT

(a) Climate

(i) Terrain Effects

The climate of the regional study area reflects the pronounced influence of major mountain systems to the west (Coast Range) and to the east (Rocky Mountains). In addition, weather at any specific location within this intermontare area will reflect local topographical features. Despite the characterization implied by its name, the Thompson Plateau itself exhibits significant terrain variations due primarily to erosion by large rivers such as the Fraser and Thompson, and smaller ones like Hat Creek. The irregular terrain is of primary importance in terms of regional patterns of temperature, precipitation, and wind flow.

The presence of the Coast Range, rising to elevations of 3050 m (10,000 ft.) restricts the region of mild and humid maritime climate to a narrow band along the Pacific Ocean. The cooling experienced by this moist air as it is forced by the prevailing westerlies up the mountain slopes results in considerable precipitation. The Coast Range is, therefore, responsible for the dramatic difference between the damp coastal climate and the relatively dry conditions prevalent in the southern interior of British Columbia. The continental air flow in the interior is similarly lifted over the western slopes of the Rocky Mountains, resulting again in relatively high annual precipitation rates. The wide difference of temperature patterns within the study region is also directly related to variations in terrain.

Orographic channeling and local circulations set up by rugged terrain are at least as important as large-scale pressure systems in determining the strength and directional sense of the winds at many locations within this region. Wind roses developed from observations in mountain valleys invariably reflect prevailing flows parallel to valley walls. Wind speeds are greatest when synoptic scale winds reinforce terrain-induced circulations.

(ii) Seasonal Influence

Upper-level winds (e.g., those at 500 mb at or about 1645 m (5400 ft.) above sea level) are generally from west to east, but are modulated by meridional currents that arise from differential heating between the equator and pole. The amplitude of the north-south waves appearing in the streamlines aloft determines the potential for storm activity near the ground. These perturbations are particularly strong at certain times of the year, and this is reflected in the mean seasonal paths of synoptic scale pressure systems. At the latitude of the Hat Creek Project area, the passage of upper-air waves in the spring and fall tends to increase the frequency of such systems during these seasons. In winter the "storm track" is generally south of the study region; during the summer, cyclones typically pass to the north. Such seasonal shifts result primarily from the migrations and relative positions of three major pressure systems: the semi-permanent high pressure region over the northern Pacific Ocean, the low-pressure centre over the Aleutians, and the continental ridge of high pressure that builds over Alaska during winter. The following sections provide basic information regarding the geographical and seasonal distribution of specific climatological variables within the regional study area.

(iii) Precipitation

The effectiveness of the Coast Range in blocking the intrusion of maritime air into the southern interior of the Province is evidenced by the generally low total precipitation recorded at weather observation stations on the lee side of these mountains. Annual precipitation in the Coast Range at the headwaters of the Stein River is about 2000 mm (79 in.). Corresponding values of from 240 mm (9 in.) at Ashcroft to 400 mm (16 in.) at Williams Lake are recorded further east. The Ashcroft area is one of the driest in British

Columbia. In general, stations at higher elevations record the highest precipitation. Total precipitation in the Clear and Marble Ranges to the west of the Hat Creek project area is estimated at about 750 mm (30 in.), with up to 1000 mm (39 in.) expected in the Adams Lake Plateau northeast of Kamloops. Only limited measurements are available for the Harry Lake site. However, its elevation and position with respect to surrounding terrain are similar to Dog Creek and Williams Lake. On the basis of records for these climate stations and data taken in the Hat Creek Valley (Lehman Ranch), total precipitation near Harry Lake is expected to be in the range from 350 mm (14 in.) to 400 mm (16 in.) per annum. Hat Creek Climate Station data are representative of the proposed mine site. Annual average precipitation there is about 310 mm (12 in.).

Annual snowfalls of 10 m (33 ft.) or more are found at Coast Range locations and in the western slopes of the Rocky Mountains. Snow depth measurements were taken at three locations within the local study area: Pavilion Mountain, Harry Lake and Cornwall Hill. The Harry Lake Climate Station is the closest to the proposed plant and mine site. Average snow depths at Harry Lake during a period from January 1977 to December 1977 did not exceed 28 cm (11 in.); however, in March of 1978 snow depths reached 69 cm (27 in.), indicating that the 1976-1977 season was particularly light. Maximum average snow depths were recorded at Pavilion in February 1978 with 64 cm (25 in.) and at Cornwall in May 1978 with 149 cm (59 in.). From the limited sampling period, Cornwall Hill appears to receive the most snowfall. On the basis of elevation and relative location, an average seasonal snowfall of 170 cm (67 in.) to 180 cm (71 in.) may be expected at the proposed power plant site. The Hat Creek Climate Station in upper Hat Creek Valley annually records an average of 133 cm (52 in.). The minimum snowfall region within the study area is Ashcroft where the annual average is only about 50 cm (20 in.).

(iv) Humidity

The highest mean relative humidity recorded at climate stations within the regional study area occurs during the winter season. Fall also exhibits relatively high humidity. Spring and summer are the driest seasons in terms of relative humidity. These results apply to stations located over a wide range of elevations. At Ashcroft and Dog Creek, dewpoints are typically lower than at other measurement locations, although relative humidities are about the same. These areas appear to be somewhat cooler and drier than Kamloops, Kelowna, Lytton, or Penticton.

Eight mechanical weather stations have been installed and operated by B.C. Hydro and Power Authority in the Hat Creek region since late 1974. Data derived from these measurements indicate that the diurnal range of relative humidity is extremely large in the lower Hat Creek Valley (approximately 40 percent during spring and summer). Relative humidity at the Harry Lake site is slightly higher than that at Kamloops during the day and about the same during the night, except during winter when average nocturnal values are somewhat higher. For reference, seasonal relative humidities at Kamloops are: winter (79 percent), spring (58 percent), summer (54 percent), and fall (72 percent).

(v) Temperature

A high degree of seasonal temperature variability is observed within the regional study area. This is characteristic of regions dominated by continental climate. Mean seasonal temperatures of Atmospheric Environment Service Stations range from about -7° to -3° C (19° to 27°F) in winter and between 15° and 20° (59° and 68°F) in summer. Absolute maximum and minimum temperatures reflect a much greater variation. The maximum and minimum values recorded at Lytton over a period of 40 years are 44.4°C (112°F) and -31.7°C (-25°F), respectively. Corresponding values for Ashcroft are about 39°C (102°F) and -37°C (-35°F). The Hat Creek Climate Station in the upper Hat Creek Valley has experienced an absolute maximum of 35.6°C (96°F) and a minimum of -42.8°C (-45°F).

It is useful in the context of this study to examine mean daily temperatures for January and July. Within the study area mean daily July averages range from more than 20°C (68°F) at Kamloops, Savona, and Lytton to less than

12^{o}C (54^{o}F) at Nicola Plateau. A July mean of about 15^{o}C (59^{o}F) is found at the Hat Creek Climate Station. Mean daily temperatures during the month of January are within the range of -3^{o}C (27^{o}F) at the lower elevations (e.g., Lytton and Ashcroft) to about -12^{o}C (10^{o}F) at higher locations (e.g., Dog Creek, Williams Lake, and Hat Creek). The January mean daily temperature at the Hat Creek Climate Station is -11.0^{o}C (12^{o}F).

Locations with a mean total of 200 or more frost-free days are found at the lower elevations within the study region (e.g., Ashcroft, Kamloops, Kelowna, Lytton, and Penticton). Stations located in higher terrain, such as Dog Creek and Williams Lake record about 170 frost-free days. An annual mean of 134 frost-free days is reported for the Hat Creek Climate Station. In regions above 1200 m (3950 ft.) MSL, 50 to 100 frost-free days are recorded. At very high elevations in the Nicola Plateau and the Coast Range, less than 50 frost-free days occur per annum.

(vi) Wind Conditions

The frictional drag of the earth's surface tends to produce wind speeds at the ground which are much lighter than those measured aloft. In addition, the directional sense of surface winds at any point within the study area reflects the influence of topographic features. This is especially true in regions characterized by deep river valleys, where the prevalent wind directions are nearly always along-valley. Differential heating of mountain slopes produces small (meso-scale) wind circulations which are quite distinct from the large-scale, well-defined pressure systems. Such local effects may be the major determinants of the strength and direction of the wind. Aerodynamic downwash in the lee of steep bluffs and ridges can also produce local circulation patterns during moderate to strong synoptic wind conditions.

Inspection of wind data compiled from observations taken at the B.C. Hydro and Power Authority mechanical weather stations in the Hat Creek Valley reflect the importance of the valley circulation. During the night and early morning hours there is a pronounced tendency for flow with a southerly component (down-valley). By midday, an up-valley (northerly) component of the wind is usually prevalent. This observation cannot be explained in terms of synoptic-scale wind patterns alone. Significant channeling along the valley floor is apparent when wind roses from the stations in the valley are compared with those at the Harry Lake Station some 500 m (1640 ft.) higher in elevation, and those at Cornwall Mountain and Pavilion Mountain both located about 1300 m (4250 ft.) above the valley. The maximum hourly wind speed recorded at the Harry Lake site during a period of nearly two years was 78 km/hr. (48 mph), but the average is near 10 km/hr. (6 mph). Average and peak values in the Hat Creek Valley are substantially lower, with essentially calm conditions occurring during 30 - 50 percent of the nighttime hours.

(vii) Sunlight and Visibility

No record of solar insolation intensity in the vicinity of the proposed Hat Creek project is presently available. Annual average hours of bright sunshine recorded at Lytton and Kamloops (1990 and 2032 hours, respectively) are assumed to be fairly representative of conditions near Hat Creek. Summer and spring are the seasons corresponding to the highest number of sunshine hours. Obscuration due to clouds and fogging reduces the number of winter hours with direct sunlight to less than 200.

Visibility is generally good in the regional study area. At Kamloops, observations of a visibility range less than 8 km (5 mi.) were recorded only about three percent of the annual hours. The corresponding value for Lytton is four percent. For each station, nearly all cases of restricted visibility occurred during the winter months, December through February.

(b) Landforms

(i) Physiography

The regional study area is located in the Inter-Montane Belt sandwiched between the Crystalline Belt of the Coast Range and the Omineca Belt of the metamorphic

Omineca Belt. The Coast Mountains, in the western portion of the study area, are divided into the Pacific Ranges and the Chilcotin Range[09]. The Inter Montane Belt consists of the Interior Plateau which divides into the Fraser Plateau and Thompson Plateau within the study area. Only a small portion of the Omineca Belt, termed the Shuswap Highlands, occurs at the eastern margins of the regional study area.

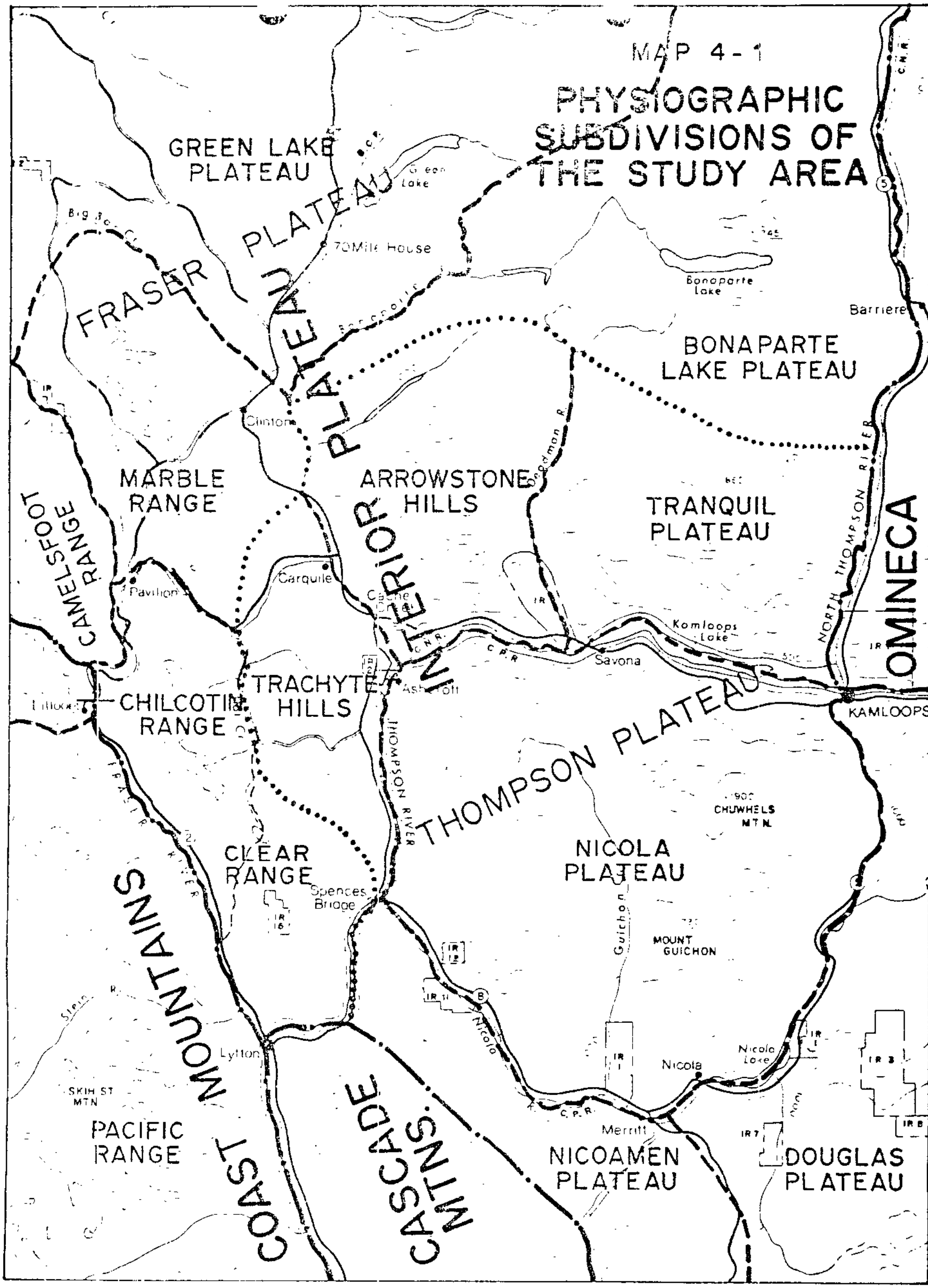
An example of the physiographic subdivisions of that outlined by Holland[09] occurs below:

Primary	Secondary	Tertiary
Coast Mountains	Pacific	(Lillooet
		(Chilcotin
Interior Plateau	Thompson Plateau	(Nicola Plateau
		(Tranquil Plateau
		(Douglas Plateau
		(Nicoamen Plateau
	Fraser	(Clear Range
		(Marble Range

The Physiographic Subdivision Map (Map 4-1) shows all specific physiographic primary, secondary, and tertiary subdivisions. Discussions of specific physiographic aspects will be dealt with on a tertiary physiographic subdivision level. The regional physiography will be discussed on the basis of the primary physiographic subdivisions.

Coast Mountains

The Coast Mountains extend into the study area at the western part of the regional mapsheet. Two physiographic tertiary units are found and these are the Lillooet Ranges and the Chilcotin Range in the southwestern section of the study area. The Pacific Range consists primarily of steeplands with deeply glaciated and incised drainages. It reaches elevations of up to 2850 m (9350 ft).


MAP 4-1
PHYSIOGRAPHIC SUBDIVISIONS OF THE STUDY AREA
GREEN LAKE PLATEAU
Green Lake
70Mile House
FRASER PLATEAU
INTERIOR PLATEAU
Bonaparte Lake
Barriere
BONAPARTE LAKE PLATEAU
Clinton
MARBLE RANGE
ARROWSTONE HILLS
TRANQUIL PLATEAU
CAMELSFOOT RANGE
NORTH THOMPSON RIVER
OMINECA
Carquile
Pavilion
Cache Creek
Kamloops Lake
C.N.R.
C.P.R.
Savona
TRACHYTE HILLS
Ashcroft
Lillooet
CHILCOTIN RANGE
KAMLOOPS
THOMPSON PLATEAU
THOMPSON RIVER
FRASER RIVER
CHUWHELS MTN.
NICOLA PLATEAU
CLEAR RANGE
Spences Bridge
MOUNT GUICHON
Guichon
Nicola
COAST MOUNTAINS
Lytton
Nicola Lake
SKIHIST MTN
PACIFIC RANGE
CASCADE MTNS.
Merritt
NICOAMEN PLATEAU
DOUGLAS PLATEAU

The Chilcotin Range of the Coast Mountains is found in the western central portion of the study area. In contrast to the Pacific Range, bedrock consists of a non-intrusive metamorphic sequence. The relief is more subdued and the elevation within the study area does not exceed 1800 m (5900 ft).

Cascade Mountains

Within the central, southern portion of the study area, a small protrusion of the Cascade Mountains occurs. These mountains are composed of plutonic, sedimentary, metamorphic and volcanic rocks. Most of the relief within the study area is subdued and elevations do not exceed 2235 m (7750 ft). Because of the presence of a Tertiary erosion surface the relief is less pronounced and prominent high elevation plateaus are evident.

Omineca Belt

Only a small portion of the Omineca Crystalline Belt is evident at the north-eastern portion of the study area. This is the Adams Plateau, which consists of crystalline, metamorphic rocks. The relief is subdued and steeplands occur only adjacent to the Thompson River.

Interior Plateau

The dominent physiographic primary subdivision is the Interior Plateau. It is divided into the Thompson and Fraser plateaus, whose major boundary sub-divides the Hat Creek drainage into two equal parts. This places the Clear Range, Marble Range and Camelsfoot Range into the Fraser Plateau, while the Trachyte Hills and Arrowstone Hills belong to the Thompson Plateau. The Thompson Plateau shows a higher relief and is of smaller size than the Fraser Plateau[99]. It consists of the Tranquil, Douglas, Nicola and Nicoamen plateaus. These latter plateaus are formed on an igneous bedrock terrain with a rolling upland portion. The highest elevation recorded is that of South Forge Mountain at 1925 m (6300 ft). The Trachyte Hills and Arrowstone Hills show more varied bedrock with differential resistance to weathering and erosion. This has resulted in a complex landform. The highest hill in the Trachyte Hills is Cornwall Peak at 2000 m (6560 ft).

Valley steeplands are associated with the Thompson and Nicola rivers. These are the result of glacial ice and post-glacial water erosion. The major valleys exhibit extensive glacial benchlands and deeply incised alluvial floodways.

The Fraser Plateau consists of the Bonaparte Lake and Green Lake plateaus which are gently rolling plains with numerous lakes. The relief is more subdued than the Thompson Plateau and in the study area does not exceed 1380 m (4525 ft). However, the Clear, Marble and Camelsfoot ranges form a higher portion of the Fraser Plateau which rises as a foothill-type landform adjacent to the Coast Mountains. These ranges show varied bedrock with a complex tectonic and geologic history. The highest peak occurs in the Clear Range at Cairn Mountain, which is almost 2350 m (7650 ft). It exhibits the only cirque development within the Fraser Plateau.

Between the Marble, Camelsfoot and Clear ranges, the Fraser River has deeply cleft the lands. The deeply incised Fraser River Valley, with its eroding steeplands, exhibits a rugged landscape.

The Hat Creek drainage is divided between the Thompson and Fraser plateaus. The Trachyte Hills of the Thompson Plateau and the Marble and Clear ranges of the Fraser Plateau intersect at the mouth of the upper Hat Creek Valley. As will be explained in subsequent sections, each physiographic subdivision has its own characteristic landform.

(ii) Slope and Relief

Slope and relief were plotted in a working map format on the regional 1:250,000 map. Slope categories for the region were steepland (30 percent +) and bottomlands and uplands (less than 30 percent). Corresponding more detailed slope categories were used on the 1:50,000 map and will be discussed later in context with the biophysical analysis.

The physiographic regions describe the relief and slope of the natural land units. The high elevation steeplands are confined to the Pacific Ranges of the Coast Mountains. The only portions with relatively flat slopes are confined to river bottomlands, such as the Stein River Valley. As with the Pacific Ranges, the Chilcotin Range consists entirely of steepland, but these are not as oversteepened as the Pacific Range. The reason for this rests in the metamorphic rock which is less resistant to weathering and erosion. No flatlands occur in the Chilcotin Range within the study area.

Within the Fraser Plateau, two major units are evident. The steepland and high relief areas are confined to the Marble, Camelsfoot and Clear ranges. The Clear Range shows extensive steeplands at its western and southern margin, dropping into the Fraser and Thompson river valleys. The only flat portions are in Botanie, Skoonka, Fontaine and Cinquefoil creeks. As the Clear Range reaches higher elevations at Cairn's Peak, Blustry Mountain and Murray Peak of up to 2300 m (7550 ft) above sea level, much of the mountain slopes reach 60 percent. Moderate slopes of less than 30 percent are located on the eastern flank of the Clear Range descending into the upper Hat Creek Valley. In addition, some portions of gently rolling upland are found above Pavilion Lake.

The Camelsfoot Range shows predominantly steepland with some small upland bowls which have developed on the higher Fraser River benchlands. In general, the slopes in the Camelsfoot Range are moderate (approaching 30 percent) and the relief does not exceed 2000 m (6550 ft).

The Marble Range shows an unusual steepland/flatland configuration. The sinkhole-karst landscape shows sudden charges from flat uplands to shear cliffs and steeplands at the angle of repose of talus (60 percent). The Marble Range reaches its highest peak at Mount Bowman, which is 2220 m (7280 ft) above sea level.

The remaining physiographic units within the Fraser Plateau are Green Lake and Bonaparte Lake plateaus. They are both very similar in their slope and relief configuration. Most of the rolling till plains are flat with the only steeplands in some of the deeply incised drainage channels, such as the Bonaparte River, Bridge Creek, Dog Creek and Big Bar Creek. The average height of the Green Lake Plateau is 1000 m (3200 ft) above sea level and the average height of the Bonoparte Lake Plateau is 1200 m (4000 ft) above sea level.

Within the Thompson Plateau, steeplands are again confined to physiographic units closest to the Coast Mountains, such as the Trachyte and Arrowstone hills. The complex geology and glaciation have resulted in steeplands associated with incised river and creek valleys, basalt flows, incised fluvial benches, various recessional moraine features, and eroded fault lines. The Trachyte Hills show steeplands associated with Oregon Jack Creek, Cornwall Hills, Hat Creek and fault features adjacent to the Thompson River. In contrast, the flatlands occur within the Hat Creek Valley and gradually extend up Medicine Creek towards, but not reaching, Cornwall Hills. The largest uplands within the Trachyte Hills are located north of Hat Creek and south of Maiden Creek, where gently rolling uplands at approximately 1000 m (3200 ft) above sea level are dominant. Another large, moderate to flat area is the Cattle Valley including Maclean Lake. Many of these uplands are associated with open range. The highest hill of the Trachyte Hills is Cornwall Peak which is almost 2040 m (6680 ft) above sea level.

The Arrowstone Hills typify the volcanic landscape of the Interior Plateau. The rolling upland plain of the Arrowstone Hills is primarily formed by plateau basalt which results in a large upland plain at 1200 to 1300 m (4000 ft to 4200 ft) above sea level. This upland drops steeply towards the surrounding drainages including the Bonaparte River, Deadman Creek and Thompson River.

The remaining units within the Thompson Plateau are the Tranquil, Nicola, Douglas and Nicoamen plateaus. The steepest and highest of these plateaus is the Nicoamen Plateau adjacent to the Cascade Mountains, being predominantly steepland in excess of 30 percent slope on the margins of the gently sloping plateau. Some upland plains are present and occur at approximately 1200 m (4000 ft) above sea level.

The Nicola Plateau is the largest physiographic unit in the Thompson Plateau and consists predominantly of rolling uplands. Again, the only steeplands are associated with the incised drainage of the Thompson River, Nicola River, Guichon Creek and Stump Creek. Since the bedrock is resistant to erosion, the landform is relatively simple. Maximum elevations in the Nicola Plateau range from 2000 m (6500 ft) at South Forge Mountain to 1700 m (5580 ft) at Guichon Mountain.

The Douglas Plateau is located in the southeast corner of the study area and is a rolling upland plain with the lowest relief in the study area. The mean elevation ranges from 750 m (2450 ft) above sea level to 1200 m (4000 ft) above sea level. Steeplands are confined to the Nicola River Valley.

The bottomlands confined to the North Thompson, South Thompson, Thompson, Bonaparte and Nicola rivers make up a complex linear system. The flat, glacial benchlands and alluvial fans are deeply incised by the drainages. These benchlands and moderately sloping valley flanks within the larger river valleys have formed the staging areas for settlement and transportation.

More detailed slope categories for the 1:50,000 local study area have been broken down to zero to nine percent, 10 to 29 percent, and 30 percent plus. These have been mapped in the context of the biophysical unit map for the Hat Creek drainage and surrounding Marble and Clear ranges and Trachyte Hills. They are described in the biophysical writeup. The slope character and elevation have then been related to the other physical and biological aspects and are discussed in that context.

(iii) Bedrock Geology

The regional study area is located within three geological provinces. These are the Coast Crystalline Belt confined to the Coast Mountains, the Inter Montane Belt confined to the Interior Plateau, as well as the Omineca Belt confined to the Shuswap Hills and Adams Plateau. The dominant geological province in the regional study area is the Inter Montane Belt. Roughly speaking, the physiographic boundaries between the Coast Mountains/Interior Plateau and the physiographic boundaries between the Adams Plateau/Interior Plateau define the Inter Montane Belt.

The oldest rocks within the study area occur within the Adams Plateau and are a crystalline metamorphic series 300 million years or older. These rocks consist of gneiss, schists and re-crystallized limestone. Successively younger rocks are found within the Interior Plateau area at the eastern edge within the Bonaparte Lake and Tranquil, Nicola and Douglas plateaus. These rocks consist of metamorphic rock and intrusive rocks of Triassic and Jurassic ages, approximately 200 to 250 million years old. This same chronology is repeated at the western edge of the Interior Plateau where the Marble, Camelsfoot and Clear ranges, and Trachyte and Nicoamen plateaus exhibit rock of the same age. Both the eastern and western portions of the Interior Plateau have shown some form of uplifting in relation to the two major orogenic belts which belong to the Coast Range and Rocky Mountains. In a sense, then, the eastern and western boundaries of the Interior Plateau form a transition zone between the two major mountain chains within the Cordillera. They have structurally faulted and been disturbed which resulted in uplift. Subsequent erosion exposed the old metamorphic and intrusive rocks. In contrast, the centre of the Interior Plateau is blanketed by either plateau basalt or intrusive stockworks of ages ranging from 60 to 150 million years of age. Clearly then the central portion extending from Green Lake, southeast via Kamloops Lake into the Guichon Creek-Nicola Lake area has shown less disturbance and uplift[07].

The geological history is displayed through tectonic or crustal changes in the regional study area. The most dramatic faulting has occurred along the Fraser River, forming the division between the Coast Mountains and the Interior Plateau. Secondary and sympathetic faults have been established within the Marble Range, Clear Range, Trachyte Hills and the southern Cascade Mountains. A similar pattern, although less dominant, can be recognized in the faults between the Interior Plateau and the Adams Lake Plateau, where fault patterns attest to the uplift and down-faulting at the North Thompson River Valley.

The regional geology has been considered within the land system analysis as part of the foundation for the soil development and landform control. Reference to the Land System Map (Map 4-2) shows a simple breakdown between metamorphic rocks, limestone, intrusive rocks and volcanics. The resistance to weathering and erosion, as well as the associated fault and fracture patterns, have created the controls for some of the landforms which have subsequently been exposed to glacial and post-glacial forces.

The local geology of the Hat Creek area (mapped at a scale of 1:50,000) has been described by Dr. T. McCullough[13] and is quoted below:

> *"The bedrock consists of a wide variety of rock units. Paleozoic limestone and metavolcanic rocks of the Cache Creek group form the subcrop in the centre of the area. These rocks generally strike north-northwesterly; although dips are variable, they cluster around 60 degrees southwest. The Paleozoic rocks are locally intruded by peridotite and gabbro. Near Ashcroft Jurassic sedimentary rocks lie unconformably on these older rocks. The limestone near Marble Canyon has been intruded by the Mount Martley stock, a biotite hornblende granodiorite, of Cretaceous age. A nonconformity separates the stock from the overlying Spences Bridge volcanic rocks which consist principally of andesite and dacite. Additional volcanic episodes occurred in the Cenozoic with resulting pyroclastic and flow rocks covering much of the area. The oldest volcanic rocks of these episides are of Eocene age; they are composed of basalt, dacite and rhyolite of the Kamloops group. The distribution of this unit is very erratic in the Upper Hat Creek Valley. It is exposed on the hills and on the western and eastern flanks of the valley. Sporadic occurrences were also noted in the area south of the Upper Hat Creek Valley. The attitude of bedding is variable throughout this unit. The contact between these*

lower Kamloops volcanic rocks and the overlying Coldwater beds is faulted wherever it has been found. The clastic sequence of the Kamloops group in the Hat Creek Valley has been divided into the Coldwater beds, the Hat Creek Coal formation, the Medicine Creek formation and the Finney Lake Beds. The Coldwater beds consist of sandstone, siltstone, claystone, conglomerate and minor coal which are moderately consolidated to almost unconsolidated. This unit is as much as 1,370 metres (4,500 feet) thick east of the Upper Hat Creek Valley. The Coldwater beds are overlain conformably by the Hat Creek Coal formation which ranges to 490 metres (1,600 feet) thick. The Hat Creek Coal formation consists mainly of coal with locally thick sections of siltstone, claystone, sandstone and conglomerate; partings of siltstone and claystone are common to the coal. It is not certain if there is a paraconformity, a hiatus or if the Medicine Creek formation lies conformably on the Hat Creek Coal formation. The Medicine Creek formation consists of poorly consolidated bentonitic, lacustrine claystone and siltstone. The Medicine Creek formation is overlain by the Finney Lake beds. This unit consists of sandstone and conglomerate at the base and volcanic rocks higher in the sequence. The sandstones for the most part are well sorted except for scattered, rounded boulders of vesicular volcanic rocks similar to those in the lower part of the Kamloops group. The clastic sequence is overlain by lahar (volcanic mudstone) which is composed of angular to subrounded Kamloops volcanic rocks, lithified primarily by compaction of the sandy claystone matrix. These beds are Upper Eocene or later in age and lie unconformably over the coal and claystone sequence; due to the presence of this unconformity it is not known if the beds are definitely part of the Kamloops group or if they are associated with Miocene volcanism. Locally there are small exposures of olivine basalt dykes and flows: these are probably related to extrusions of Miocene plateau basalts to the north."

(iv) Surficial Geology

The landforms of the Interior Plateau, Coast Range, and Adams Plateau have been sculptured by the various glacial and post-glacial processes. The best descriptions of glacial processes within the Interior Plateau and specifically the Hat Creek Valley are by Tipper[12] and Aylsworth[04]. The majority of the surficial deposits within the regional study area are a result of the Fraser glaciation and deglaciation. The Interior Plateau was covered by an ice sheet which may have reached heights of up to 2500 m (8675 ft). This continental glaciation planed the Tertiary erosion surface of the Interior Plateau which is the dominant land feature within the study area. The lateral confines of the southerly-moving ice sheet were the Coast Mountains, and the Columbia Mountains forced the ice sheet to move either south or north. However, lateral flow from the Pacific Ranges resulted in an easterly ice movement at the western portion of the study area. This easterly-southeasterly flow of continental ice is evident in the Hat Creek area. The best summary written for the Fraser Glaciation is by Janet Aylsworth, at the University of British Columbia[04]:

> *"In contrast, during the Fraser Glaciation, large volumes of ice entered the Interior Plateau from the surrounding mountains and coalesced into large sheets which met and diverged northward and southward. It is not known whether any ice dome stage was reached. However, lineations in Hat Creek Basin and the surrounding uplands suggest that the main movement of the ice over the study area was easterly from the Coast Mountains. This evidence may be interpreted as support for Tipper's theory or may simply represent ice flow during a relatively late post ice dome phase of glaciation. As the end of the ice age approached, the ice began to withdraw and with the shrinking ice sheet, the local ice flow began to change. Some parts including Upper Hat Creek, became ice free for a period. During the late phase of ice movement, a lobe re-entered Upper Hat Creek Valley from the northeast. Glacial lineations which represent this last movement occur at elevations below 1280 metres."*

The significance of the last statement within the aforementioned quotation indicates that a local ice sheet was shrinking and wasting within the upper Hat Creek Valley. This resulted in numerous deglaciation phenomena such as meltwater channels, eskers, fluvial gravels and silts, and small moraines. These coarser deposits were deposited on top of the rolling till plain which is, in turn, overlaying the Coldwater Beds and the volcanic flows within the Hat Creek Basin.

The regional study area exhibits three main types of surficial deposits. These are the rolling till plain of the plateau regions, and thin till veneer over rock and colluvium in the mountain ranges, and the various fluvial-glaciofluvial deposits within the bottomlands. The surficial deposits within the bottomlands have been mapped. The surficial deposits have been mapped within the context of the Land System composite map at 1:250,000 (Map 4-2). The spatial distribution of these deposits conforms closely to the physiographic regions outlined previously. The only complexities occur in physiographic border areas, such as the Thompson Plateau, Arrowstone and Trachyte Hills, and within the Fraser Plateau and Marble, Camelsfoot and Clear Ranges. The higher peaks show weathered bedrock outcroppings which turn into colluvium in the lower steep portions. The lower flanks of the ranges and hills have a till veneer and grade into till uplands within the flat portions.

Some large meltwater channels from the last glaciation are present in the Bonaparte Lake and Green Lake plateaus. These coarse-textured, glaciofluvial deposits have in some cases been re-sorted by present creeks and rivers. Thus, these glacial and alluvial complexes have formed diverse surficial conditions.

Within the Green Lake and Bonaparte Lake plateaus of the Fraser Plateau, impeded drainage conditions have caused large pockets of silt and organic deposits on the rolling till plain. Subsequent weathering has modified these deposits further into magnesium sulphate potholes and high salt content lakes and bogs.

Wind-blown lacustrine and fluvial deposits occur on the benchlands of the Thompson River. They overlie tills and glaciofluvial surficial deposits, and have developed into some of the richest agricultural soils in the area.

The local surficial geology has been mapped at a 1:50,000 scale on both the soil and biophysical maps. Categories considered are colluvium, glacial till, fluvial, glaciofluvial, aeolian, bedrock, organics, lacustrine and ablation tills. In addition, the regional surficial geology has been mapped at 1:250,000 and 1:126,720 by various geologists[10, 11, 13]. It is redundant to plagiarize all of these published documents; Dr. T. McCullough's report[13] should suffice:

> *"The Upper Hat Creek Valley ... ranges from 825 to 1,250 metres (2,700 to 4,100 feet) in elevation. The valley is flanked by the Clear Range on the west which rises steeply to over 2,300 metres (7,600 feet) and by the Trachyte and Cornwall Hills in the east. Surficial deposits in the valley consist of hummocky ground moraine, forming a thick blanket of till, but reduced to a thin veneer on hill tops and steep slopes. Locally bedrock is exposed through the veneer. There are fluvial and glacio-fluvial sands and gravels on the east side of the valley, north of Medicine Creek and in the valleys of the larger tributory creeks. Some of these deposits are overlain by glacial till. Alluvial fans extend into the valley from the surrounding mountains. Fluvial deposits comprise terraces adjacent to Hat Creek and underlie the creek. The glacial history of the Upper Hat Creek Valley is complex. This complexity is particularly evident in exposures on the lower reaches of Harry Creek which drains from Harry Lake. In this area an alternation of coarse and fine till, each 2.4 metres (8 feet) or more thick, overlies a thick sequence of glaciofluvial deposits consisting of sand and gravel. Loess more than 3 metres (10 feet) thick covers the bench on the east side of the Upper Hat Creek Valley south of Ambusten Creek.*
>
> *Throughout the Cenozoic history of the Upper Hat Creek Valley processes of mass wasting have been important. These can be divided into pre-glacial and post-glacial features.*

Preglacial lahars or volcanic mudflows at one time covered much of the Upper Hat Creek Valley. These deposits were eroded by glaciers leaving only a few remants; some are exposed as hoodoos or pinnacles whereas others are covered by the till blanket. A preglacial landslide consisting of granitic, clastic material from boulder to sand size and derived from Mount Martley covers part of the Upper Hat Creek Valley west of the No. 1 deposit. West of Bedard Lake there is a slide of volcanic debris over 60 metres (200 feet) thick. These slides are currently stable and are not expected to cause severe problems in slope stability. Potential slip planes of clay or micaceous material in these slides tend to be discontinuous.

There are numerous additional postglacial slides and earthflows in the Upper Hat Creek Valley; all but one of these appears to be currently stable. West of the No. 1 Openpit deposit there are inactive slides covering an extensive area between Finney Lake and Houth Meadows. Part of this slide area is still active. The number of slide planes in the active slide has not been determined, but there is at least one at 27 metres (90 feet) which is associated with bentonitic claystone. The headwall of this slide is characterized by numerous ponds which could be drained and may help to stabilize the slide. The instability of the slide is an important factor in planning the mine. South of the No. 1 deposit there are numerous "sand boils" resembling quicksand as further evidence of the unstable nature of many of the surficial materials. An extensive flow slide 76 metres (250 feet) thick, involving overburden and possibly some bedrock descended White Rock Creek and curved down the Hat Creek Valley.

There are numerous outcrops on the sides of the valley, however there are few outcrops near the bottom. A talus slope has formed below volcanic outcrops east of the No. 1 deposit. In the southeast there are bluffs of limestone; limestone outcrops are also numerous along the northern limit of the Upper Hat Creek Valley. On the western margin of the valley outcrops of granitic and volcanic rocks are common."

The surficial materials in and around the Hat Creek Valley are very susceptible to gulleying. If the surface layer becomes broken, they also tend to form a fine dust which resists the rooting of plants in the dry climate."

(c) Terrain Analysis

The terrain analysis is an assessment of all aspects of physiography, landform, bedrock geology and surficial geology at a scale of 1:50,000 or better. For the purpose of this report, it is being treated at two levels. For the regional level, a land system composite has overlayed the landform, bedrock geology and surficial geology, and for the biological consideration soils and vegetation, to relate broad land system complexes at 1:250,000. For the local study area at 1:50,000 the biophysical analysis has incorporated landform, slope, elevation, geology and surficial material in more detail to determine physical aspects and processes important in understanding the terrain in relation to physical limitations to disturbance of construction and operation of man-made facilities.

(d) Soil Classification

(i) Regional

The soils of the regional study area are presented by the order level as defined by the Canadian Soil Classification System[17] on the Land System Map (Map 4-2). Basically, seven soil orders occur within the regional study area. These are Brunisols, Luvisols, Chernozems, Podzols, Gleysols, Regosols, and Organics. Table 4-1 summarizes some of the general soil characteristics of the soil orders found within the regional study area. In terms of extent, the Luvisols and Brunisols are the most common, while the Gleysols and Organics only occur sporadically, occupying a minor land area. Chernozemic soils are confined to the major valleys. The Podzols are located mainly in the Coast Range where acidic parent materials are dominant. Regosolic soils are found along most major streamcourses where recent flooding and deposition of alluvium has occurred.

TABLE 4-1

GENERAL SOIL CHARACTERISTICS OF THE ORDERS FOUND WITHIN THE REGIONAL STUDY AREA

Soil Order	General Soil Characteristics	Parent Material	Topography	Dominant Vegetation Zone
Chernozemic Order	- well developed dark surface horizon - high base saturation of lower horizons - fine-textured - medanization and calcification are dominant soil processes	variable - glacial till, glacial-fluvial, alluvium, or colluvial materials	bottomlands and steep side slopes of the Thompson, Bonaparte, Nicola, and Fraser Rivers are the major concentrations of this order	- Ponderosa Pine - Bunchgrass and Interior Douglas-fir Zones - grassland vegetation type
Luvisolic Order	- an eluvial Ae-horizon is present, overlying a textural B-horizon - medium-textured - neutral to alkaline in reaction	deep glacial till	rolling plateau areas	- Engelmann Spruce - Subalpine Fir and Interior Douglas-fir Zones - forested vegetation type
Brunisolic Order	- shallow organic surface horizon overlying a rust brown coloured Bm-horizon - podzolization very weakly expressed - 100 percent base saturation in lower horizons	- colluvium or glacial fluvial materials - generally coarse-textured materials	steep to moderately steep topography	- Interior Douglas-fir and Ponderosa Pine - Bunchgrass - green forests or forest-grassland transitions
Podzolic Order	- a leached Ae-horizon underlain by an illuvial B-horizon - main accumulation products in the B-horizon are organic matter, iron, and aluminium - acidic - coarse-textured	colluvium and till derived from acid bedrock	variable, steeplands to plateaus	- Engelmann Spruce - Subalpine Fir; Coastal Western Hemlock; Subalpine Mountain Hemlock; and Interior Western Hemlock Zones - densely forested vegetation type

TABLE 4-1 (Continued)

Soil Order	General Soil Characteristics	Parent Material	Topography	Dominant Vegetation Zone
Regosolic Order	- horizons of these soils are too poorly developed to be differentiated - very young soils - fine to coarse textured - well to imperfectly drained	alluvium	bottomlands along streams	- all biogeoclimati[c] zones - riparian vegetati[on]
Gleysolic Order	- the soils are saturated with water and are under reducing conditions for an extended period of the year - mottling is present in the lower horizons - organic surface horizons up to 40 cm may be present	variable, generally glacial till and alluvium	- bottomlands - along streams or in poorly drained depressions	- all biogeoclimati[c] zones - riparian or bog vegetation
Organic Orders	- water saturated for most of the year - contains at least 30 percent organic matter	organic deposits	poorly drained depressions	- all biogeoclimati[c] zones - bog-type vegetati[on]

(ii) Local Study Area

In general, the soil materials are variable in texture, alkaline, and vary in depth from 1 m (3 ft.) to less than 15 cm (6 in.). Soil texture and alkalinity relate to the type of parent materials that are found in the local study area, which are primarily limestone, siltstone, and volcanic bedrock deposits. In areas composed of granitic deposits, the soil tends to be coarser and acidic. The majority of the upland soils are derived from glacial till and colluvial parent materials and reflect finer-textured, strongly-alkaline soil conditions. Within the valleys, several parent materials, including glaciofluvial, alluvial, and glacial till give rise to a number of heterogeneous soils.

As stated in the soil methodology, soil associations defined by the Resource Analysis Branch were used for the mapping and descriptions of the soils in the local study area (Map 4-3). Table 4-2 groups the soil associations found within the study area by parent material and soil order (after Resource Analysis Branch). The modal soil development is listed on the table, but it should be expressed that inclusions of other soils occur. A legend documenting all the soils included in the soil association mapping can be found in Appendix B. In addition, Appendix E contains preliminary soil analysis data compiled by the B.C. Ministry of Agriculture - Soils Division. These data were not completed for all the soil associations found in the local study area; consequently only a partial list exists. However, this partial list generally covers the more common soil associations found in the local study area.

TABLE 4-2

SOIL ASSOCIATIONS OF THE LOCAL STUDY AREA

Soil	Modal Soil Formation (Soil Subgroup)	Elevation Range (metres)	Texture	Drainage	Vegetation Biogeoclimatic Zone
Soils on Glacial Till (Moraine)					
Chernozemic Order:					
Tranquille Association	Orthic Brown Chernozems	180-760 (600-2500')	medium (SIL-SICL)	well-drained	Ponderosa Pine - Bunchgrass Zone
Trapp Lake Association	Orthic Dark Brown Chernozems	600-900 (2000-3000')	medium (SIL-SICL)	well-drained	Interior Douglas-fir Zone
Tullee Association	Orthic Black Chernozems	790-1280 (2600-4200')	medium (SIL-SICL)	well-drained	Interior Douglas-fir Zone
McKnight Association	Orthic Brown Chernozems	300-600 (1000-2000')	medium (SIL-SICL)	well-drained	Ponderosa Pine - Bunchgrass Zone
McQueen Association	Orthic Dark Brown Chernozems	460-900 (1500-3000')	medium (SIL-SICL)	well-drained	Ponderosa Pine - Bunchgrass and Interior Douglas-fir Zones
Massey Association	Orthic Black Chernozems	760-1220 (2500-4000')	medium (SIL-SICL)	well-drained	Interior Douglas-fir Zone
Medicine Association	Calcareous Black Chernozems	460-1060 (1500-3500')	medium (SIL-SICL)	well-drained	Interior Douglas-fir Zone

TABLE 4-2 (Continued)

Soil	Modal Soil Formation (Soil Subgroup)	Elevation Range (metres)	Texture	Drainage	Vegetation Biogeoclimatic Zones
Luvisolic Order:					
Tunkwa Association	Orthic Gray Luvisol	1060-1675 (3500-5500')	medium (SIL-SICL)	well-drained	Interior Douglas-fir Zone
Truda Mountain Association	Brunisolic Gray Luvisol	1675-2130 (5500-7000')	medium (SIL-SICL)	well-drained	Engelmann spruce - Subalpine fir Zone
McLaren Association	Orthic Gray Luvisol	1060-1675 (3500-5500')	medium (SIL-SICL)	well-drained	Engelmann spruce - Subalpine fir and Interior Douglas-fir Zones
Bowman Association	Orthic Gray Luvisol	1675-2130 (5500-7000')	medium (SIL-SICL)	well-drained	Engelmann spruce - Subalpine fir Zone
Minnie Association	Orthic Gray Luvisol	1220-1525 (4000-5000')	medium (SL-L)	well-drained	Engelmann spruce - Subalpine fir and Interior Douglas-fir Zones
Mellin Association	Brunisolic Gray Luvisol	1525-1980 (5000-6500')	medium (SL-L)	well-drained	Engelmann spruce - Subalpine fir Zone
Brunisolic Order:					
Maiden Association	Degraded Eutric Brunisol	460-1060 (1500-3500')	medium (SIL-SICL)	well-drained	Interior Douglas-fir Zone
Timber Association	Degraded Eutric Brunisol	300-1060 (1000-3500')	medium (SIL-SICL)	well-drained	Ponderosa Pine - Bunchgrass and Interior Douglas-fir Zones

TABLE 4-2 (Continued)

Soil	Modal Soil Formation (Soil Subgroup)	Elevation Range (metres)	Texture	Drainage	Vegetation Biogeoclimatic Zone
Brunisolic Order (Cont'd.)					
Carson Association	Degraded Eutric Brunisol	1060-1675 (3500-5500')	medium (SL-L)	well to rapidly drained	Engelmann spruce - Subalpine fir and Interior Douglas-fir Zones
Clemes Association	Orthic Eutric Brunisol	1675-2130 (5500-7000')	medium (SL-L)	well to rapidly drained	Engelmann spruce - Subalpine fir Zone
Conant Association	Degraded Eutric Brunisol	300-900 (1000-3000')	coarse (SL-LS)	rapidly drained	Ponderosa Pine - Bunchgrass and Interior Douglas-fir Zones
Clapperton Association	Orthic Dytric Brunisol	900-1675 (3000-5500')	coarse (SL-LS)	rapidly drained	Interior Douglas-fir and Engelmann spruce - Subalpine fir Zones
Blustry Association	Aline Dystric Brunisol	1980+ (6500'+)	coarse (SL-LS)	rapidly drained	Engelmann spruce - Subalpine fir and Alpine Tundra Zones
Kerr Association	Sombric Eutric Brunisol	1980-2200 (6500-7250')	medium (SL-L)	well drained	Engelmann spruce - Subalpine fir and Alpine Tundra Zones
Soils on Glacial Fluvial Deposits					
Chernozemic Order:					
Godey Association	Orthic Brown Chernozems	180-760 (600-2500')	medium-coarse (SiL-SL)	well to rapidly drained	Ponderosa Pine - Bunchgrass Zone

TABLE 4-2 (Continued)

Soil	Modal Soil Formation (Soil Subgroup)	Elevation Range (metres)	Texture	Drainage	Vegetation Biogeoclimatic Zone
Chernozemic Order (Cont'd.)					
Glimpse Association	Orthic Dark Brown Chernozems	760-1060 (2500-3500')	medium-coarse (SiL-SL)	well to rapidly drained	Interior Douglas-fir Zone
Gwen Association	Orthic Black Chernozems	-	medium-coarse (SiL-SL)	well to rapidly drained	-
Luvisolic Order:					
NONE	-	-	-	-	-
Brunisolic Order:					
Glossey Association	Degraded Eutric Brunisol	180-460 (600-1500')	medium-coarse (SiL-SL)	well to rapidly drained	Ponderosa Pine - Bunchgrass
Gisborne Association	Degraded Eutric Brunisol	460-1675 (1500-5500')	medium-coarse (SiL-SL)	well to rapidly drained	Ponderosa Pine - Bunchgrass and Interior Douglas-fir Zones
Gorge Creek Association	Orthic Dystric Brunisol	1525-1980 (5000-6500')	coarse (S-SL)	rapidly drained	Engelmann Spruce - Subalpine fir Zone
Holden Association	Degraded Eutric Brunisol	1060-1675 (3500-5500')	medium-coarse (SiL-SL)	well to rapidly drained	Engelmann Spruce - Subalpine fir and Interior Douglas-fir Zones

TABLE 4-2 (Continued)

Soil	Modal Soil Formation (Soil Subgroup)	Elevation Range (metres)	Texture	Drainage	Vegetation Biogeoclimatic Zones
Soils on Colluvium					
Chernozemic Order:					
Courtney Association	Orthic Brown Chernozems	182-760 (600-2500')	medium (SL-L)	well to rapid-ly drained	Ponderosa Pine - Bunchgrass Zone
Commonage Association	Orthic Dark Brown Chernozems	760-1060 (2500-3500')	medium (SL-L)	well to rapid-ly drained	Interior Douglas-fir Zone
Cache Creek Association	Saline Drown Chernozems	300-766 (1000-2500')	medium (SL-L)	well to rapid-ly drained	Ponderosa Pine - Bunchgrass Zone
Carabine Association	Rego Brown Chernozems	180-760 (600-2500')	medium (SL-L)	well to rapid-ly drained	Ponderosa Pine - Bunchgrass Zone
Crown Mountain Association	Calcareous Dark Gray Chernozems	760-1220 (2500-4000')	medium (SL-L)	well to rapid-ly drained	Interior Douglas-fir Zone
Luvisolic Order:					
NONE	-	-	-	-	-
Brunisolic Order:					
Cavanaugh Association	Degraded Eutric Brunisol	240-900 (800-3000')	medium (SL-L)	rapidly drained	Ponderosa Pine - Bunchgrass and Interior Douglas-fir Zones
Chasm Association	Degraded Eutric Brunisol	900-1675 (3000-5500')	medium (SL-L)	well to rapid-ly drained	Interior Douglas-fir and Ponderosa Pine - Bunchgrass Zone
Cairn Mountain Association	Orthic Dystric Brunisol	1675-2130 (5500-7000')	medium (SL-L)	well to rapid-ly drained	Engelmann spruce - Subalpine fir Zone

TABLE 4-2 (Continued)

Soil	Modal Soil Formation (Soil Subgroup)	Elevation Range (metres)	Texture	Drainage	Vegetation Biogeoclimatic Zone
<u>Soils on Lacustrine Deposits</u>					
<u>Chernozemic Order</u>:					
Lundbom Association	Orthic Brown Chernozems	300-900 (1000-3000')	fine (SiCL-CL)	well-drained	Ponderosa Pine - Bunchgrass Zone
<u>Soils on Alluvial Deposits</u>					
<u>Regosolic Order</u>:					
Frisken Association	Saline Regosol	300-1060 (1000-3500')	medium (SL-SiL)	imperfectly to poorly drained	Ponderosa Pine - Bunchgrass and Interior Douglas-fir Zones
Frances Association	Carbonated Cumulic Regosol	300-1060 (1000-3500')	medium (SL-SiL)	imperfectly to poorly drained	Ponderosa Pine - Bunchgrass and Interior Douglas-fir Zones

(iii) Site-Specific Soils

Soils in the site-specific study area have received the most intensive level of mapping detail and interpretation. Where available, soil series mapping, as reported by the British Columbia Department of Agriculture[16], was used. Those areas not covered by this soil survey were evaluated in a modified soil series approach conducted by Canadian Bio Resources Consultants Ltd. (Map 4-4).

In the areas covered by the governmental survey, 15 individual soil series units were identified. They were primarily Chernozemic or Regosolic in development and derived from glaciofluvial, glacial till, lacustrine, fan, alluvial, and aeolian deposits. The majority of these soils had shallow topsoil conditions and a wide range in surface texture and drainage characteristics. A number of the main soil parameters investigated were summarized in Table 4-3. For more detailed information on these soils, reference should be made to the published soil survey report[16].

Those areas mapped by the modified soil series approach include 70 different soil units. Each soil unit consists of one or more separate occurrences. These soils are characteristic of Chernozemic, Brunisolic, Luvisolic, Regosolic, and Gleysolic soil developments and derived primarily from glacial till, glacicfluvial, lacustrine, fan, alluvial and aeolian deposits. The majority of soils also have shallow topsoil cappings and wide range in surface texture and drainage characteristics. In total, the area mapped by the modified soil series approach accounts for approximately 155 km^2 (40,849 acres) of land (Map 4-4). Table 4-4 summarizes a few of the major soil parameters and reference to Appendix B should be made for a more complete description of these various soil units.

TABLE 4-3

THOMPSON-BONAPARTE VALLEY SOILS - SITE-SPECIFIC STUDY AREA*

Map Name	No. of Separate Areas	Total Area	Parent Material	Ashcroft Soils Soil Development	Relative Depth of Soil Solum	Surface Texture	Drainage	Topography Slopes in %	Agricultural Significance
Anglesey	33	5.43 km^2	Glacial Fluvial	Rego Brown Chernozem	76 cm	gsl	well drained	< 5	partial grazing, partial pasture
Barnes	2	0.08 km^2	Alluvial-Colluvial Fan	Mull Regosol	28 cm	gls	excessive	5-40	partial pasture, partial grazing
Basque	8	1.13 km^2	Glacial Till	Orthic Brown Soil Chernozem	41 cm	sil	well drained	5-30	partial pasture, partial grazing
Bonaparte	8	1.60 km^2	Alluvial Fan	Rego Brown Chernozem	46-91 cm	fsl-sicl	moderate-well drained	< 5	arable
Cache Creek	2	0.33 km^2	Alluvial-Colluvial Fan	Saline Rego Brown	61 cm	sl-sil	moderately well drained	2-15	partial grazing, partial pasture
Carquille	3	0.14 km^2	River Alluvial	Gleyed Mull Regosol	30-122 cm	fsl	imperfectly drained	< 5	arable
Cheetsum	22	11.39 km^2	Glacial Till	Rego Brown Chernozem	30-46 cm	gsil-gfsl	well drained	> 15	grazing
Joeross	8	1.16 km^2	Aeolian	Rego Brown Chernozem	51 cm	s-fsl	rapidly drained	2-15	partial grazing, partial pasture
Mcabee	4	0.47 km^2	Lacustrine	Orthic Brown Chernozem	66 cm	sil	well drained	2-15	arable
Nepa	3	0.54 km^2	Alluvial River Deposits	Orthic Brown Chernozem	20-61 cm	sl	rapidly drained	2-9	arable
Savona	6	0.33 km^2	Aeolian	Mull Regosol	20 cm	s-ls	rapidly drained	5-50	grazing

* Soil Survey of the Ashcroft-Savona Area Thompson River Valley, British Columbia, B.C. Department of Agriculture, Kelowna, B.C. March, 1963.

TABLE 4-3 (Continued)

Map Name	No. of Separate Areas	Total Area	Parent Material	Ashcroft Soils Soil Development	Relative Depth of Soil Solum	Surface Texture	Drainage	Topography Slopes in %	Agricultural Significance
Semlin	2	0.48 km^2	Alluvial-Colluvial Fan	Orthic Brown Chernozem	30-41 cm	gl	rapidly drained	3-15	partially arable
Taweel	38	9.53 km^2	Alluvial-Colluvial Fan	Rego Brown Chernozem	30-61 cm	fsl-gl	well drained	3-30	partial pasture, partial grazing
Thompson	5	0.58 km^2	Alluvial River Deposits	Orthic Regosol	-	g	excessive	< 5	grazing
Walhachin	2	0.14 km^2	Glacial Outwash	Orthic Brown Chernozem	25-46 cm	sl	rapidly drained	0-9	partially arable
Venables	1	0.14 km^2	Alluvial-Colluvial Fan	Calcareous Meadow Soil	50-60 cm	sil	poorly drained	5-30	arable

TABLE 4-4

SUMMARY OF THE SOILS FOUND IN THE SITE-SPECIFIC STUDY AREA

Map Symbol	No. of Separate Areas	Total Area	Parent Material	Soil Development	Relative Depth of Soil Solum	Surface Texture	Drainage	Topography Slopes in %	Agricultural Significance
1	3	0.91 km^2	Alluvial fan deposits	Carbonated Cumulic Regosol	76 cm	l-sil	excessively-poorly	0-5	arable
2	3	1.11 km^2	Alluvial stream deposits	Carbonated Humic Gleysol	102 cm	organic-sicl	poorly	< 5	arable
3	2	1.96 km^2	Alluvial stream deposits	Carbonated Gleysol	15 cm	l	poorly	< 5	partially arable
4	3	1.37 km^2	Alluvial stream deposits	Orthic Regosol	15-76 cm	l-sil	moderately-poorly	< 5	partially arable
5	2	0.14 km^2	Glacial outwash	Degraded Eutric Brunisol	61-91 cm	l-sil	excessively	5-10	arable
6_A	12	2.69 km^2	Glacial outwash	Degraded Eutric Brunisol-Orthic Dark Brown Chernozem	36-46 cm	sil-sicl	well drained	2-10	arable
6_B	3	0.86 km^2	Glacial outwash	Degraded Eutric Brunisol-Orthic Dark Brown Chernozem	< 25 cm	sil-sicl	excessive	> 20	grazing
7	1	0.54 km^2	Glacial outwash	Orthic Dark Brown Chernozem	76 cm	sil	well drained	< 5	arable
8	2	1.25 km^2	Glacial till/ Lithic contact	Calcareous Dark Grey Chernozem	< 25 cm	sl-l	excessively	15-20	grazing
9	1	0.17 km^2	Glacial till	Calcareous Dark Grey Chernozem	< 38 cm	l-sil	moderately	5-15	grazing
10	2	2.34 km^2	Glacial till	Degraded Eutric Brunisol	46 cm	l-sil	moderately-imperfectly	< 5	pasture
11	1	1.62 km^2	Glacil till/ Lithic contact	Lithic Black Chernozem-Degraded Eutric Brunisol	20-51 cm	l-sl	excessive	2-12	grazing
12	2	1.74 km^2	Glacial till	Degraded Eutric Brunisol	20-30 cm	l-sl	excessive	3-9	pasture

TABLE 4-4 (Continued)

Map Symbol	No. of Separate Areas	Total Area	Parent Material	Soil Development	Relative Depth of Soil Solum	Surface Texture	Drainage	Topography Slopes in %	Agricultural Significance
13	5	5.25 km^2	Glacial till	Calcareous Black Chernozem	61-76 cm	l	well drained	5-10	arable
14	10	8.22 km^2	Glacial till	Orthic Dark Brown Chernozem	20-46 cm	l-sl	excessive-imperfectly	5-15	partially pasture
15	11	4.22 km^2	Glacial till	Orthic Dark Brown Chernozem	46 cm	l-sil	excessive	5-10	partially grazing
16	12	0.48 km^2	Glacial till	Carbonated Black Chernozem	46-64 cm	l-sl	imperfectly	< 5	partially arable
17	1	3.23 km^2	Glacial till	Orthic Dark Brown Chernozem-Degraded Eutric Brunisol	0-46 cm	sil-sicl	excessive-poorly	5-10	pasture
18	2	2.26 km^2	Glacial till	Degraded Eutric Brunisol	15-20 cm	l-sl	moderately well	2-5	arable
19	9	5.24 km^2	Glacial till	Degraded Eutric Brunisol-Orthic Dark Brown Chernozem	30 cm	sil	excessive	7-15	partial grazing, partial pasture
20_A	1	0.18 km^2	Glacial lacustrine	Regosolic	-	c	well	5-9	nil
20_B	1	0.07 km^2	Glacial lacustrine	Regosolic	-	c	imperfectly	< 5	nil
20_C	1	0.18 km^2	Glacial lacustrine	Orthic Eutric Brunisol	36-46 cm	sicl-cl	excessive	< 15	grazing
20_D	1	1.30 km^2	Glacial lacustrine	Orthic Eutric Brunisol	10-30 cm	sil	well	7-10	grazing
20_E	1	0.21 km^2	Glacial lacustrine	Regosolic-Orthic Eutric Brunisol	20-41 cm	sil	well	7-10	grazing
21	1	0.58 km^2	Glacial till	Orthic Dark Brown Chernozem	25 cm	sil	moderately well	5-9	pasture
22	1	0.95 km^2	Glacial till	Degraded Eutric Brunisol	30 cm	sil	moderately well	5-15	grazing
23	1	0.19 km^2	Glacial till	Orthic Dark Brown Chernozem	38 cm	l-sil	moderately well	5-9	pasture
24	10	1.52 km^2	Glacial till	Rego Brown Chernozem	10 cm	gl-gsl	well-excessive	15-30	grazing
25	8	7.10 km^2	Glacial till	Orthic Brown Chernozem-Rego Brown Chernozem	15-46 cm	fsl-sil	excessive	5-20	partial grazing, partial pasture

TABLE 4-4 (Continued)

Map Symbol	No. of Separate Areas	Total Area	Parent Material	Soil Development	Relative Depth of Soil Solum	Surface Texture	Drainage	Topography Slopes in %	Agricultural Significance
26	3	1.22 km^2	Glacial till	Orthic Brown Chernozem	25 cm	fsl-sil	excessive	5-10	partial arable, partial grazing
27	3	1.15 km^2	Glacial till	Carbonate Black Chernozem	40-58 cm	l-sil	imperfectly	-	arable
28	9	0.91 km^2	Alluvial fan	Rego Brown Chernozem	20-25 cm	l-gsl	excessive	5-20	partial arable
29	5	3.04 km^2	Glacial till	Rego Brown Chernozem	15 cm	l-gsil	excessive	15-30	grazing
30	2	0.22 km^2	Alluvial fan	Saline Gleysol	15-30 cm	organic or sil-sicl	poor	< 2	arable
31	8	1.68 km^2	Glacial till	Degraded Eutric Brunisol-Rego Brown Chernozem	10 cm	l-sil	excessive	30-50	grazing
32	10	1.11 km^2	Lithic contact	Lithic Brown Chernozem	8-10 cm	fsl-sil	excessive	25-40	grazing
33	1	0.61 km^2	Colluvial over Glacial till	Orthic Grey Luvisol	45-50 cm	l-sil	excessive	>30	grazing
34	15	7.15 km^2	Colluvial over Lithic Contact	Lithic Eutric Brunisol	10-15 cm	gsl-gl	-	10-40	grazing
35	4	2.85 km^2	Glacial till	Degraded Eutric Brunisol	15-20 cm	fsl-sil	moderately well	5-20	grazing
36	9	4.97 km^2	Glacial till	Rego Dark Grey Chernozem	5-20 cm	gsil-sil	well	5-10	grazing
37	6	15.90 km^2	Glacial till	Orthic Grey Luvisol-Degraded Eutric Brunisol	15-46 cm	fsl-sil	well-imperfectly	15-30	grazing
38	18	19.05 km^2	Glacial till	Orthic Grey Luvisol	23-35 cm	sil-gsil	moderately well	5-20	grazing
39	1	0.27 km^2	Glacial outwash	Degraded Eutric Brunisol	30-36 cm	sil-gsil	well	-	grazing
40	1	0.33 km^2	Glacial till	Orthic Grey Luvisol	46-61 cm	gl-gsil	moderately well	> 5	grazing

TABLE 4-4 (Continued)

Map Symbol	No. of Separate Areas	Total Area	Parent Material	Soil Development	Relative Depth of Soil Solum	Surface Texture	Drainage	Topography Slopes in %	Agricultural Significance
41	3	3.30 km^2	Glacial till	Orthic Grey Luvisol	46-51 cm	gsil	excessive	20-40	grazing
42	6	1.82 km^2	Glacial till	Orthic Grey Luvisol -Orthic Regosol	15-25 cm	sil-gsl	excessive	>40	nil
43	2	1.04 km^2	Glacial till	Degraded Eutric Brunisol	15-46 cm	gsil-gl	moderately well	15-40	grazing
44	2	0.65 km^2	Glacial till	Degraded Eutric Brunisol	15-46 cm	gsil-gl	moderately well	15-40	grazing
45	3	0.73 km^2	Glacial fluvial	Degraded Eutric Brunisol	13-20 cm	sil	excessive	0-20	grazing
46	1	0.70 km^2	Glacial fluvial	Degraded Eutric Brunisol	13-20 cm	sil	excessive	0-20	grazing
47	6	3.33 km^2	Glacial till	Gleyed Orthic Grey Luvisol	15 cm	sil-sicl	imperfectly	>30	grazing
48	1	0.43 km^2	Glacial till	Gleyed Orthic Grey Luvisol	15 cm	sil-sicl	imperfectly	>30	grazing
49	3	0.91 km^2	Glacial till	Orthic Dark Grey Chernozem-Orthic Grey Luvisol	5-25 cm	sil-sicl	moderately well	15-20	grazing
50	8	6.87 km^2	Glacial till over Lithic Contact	Lithic Grey Luvisol	15-30 cm	sil-gsil	-	20-30	grazing
51	19	4.67 km^2	Glacial till-Glacial outwash	Calcareous Black Chernozem	5-10 cm	l-sil	well	5-20	grazing
52	3	4.46 km^2	Glacial till	Orthic Grey Luvisol -Gleyed Grey Luvisol	25-30 cm	sil-sicl	moderate-poorly	-	grazing
53	12	0.70 km^2	Alluvial fan	Calcareous Black Chernozem	45 cm	sil-l	moderately-imperfectly	2-25	grazing
54	5	7.09 km^2	Glacial till over Lithic contact	Orthic Grey Luvisol-Lithic Grey Luvisol	8-25 cm	sil-gcl	-	>15	grazing
55	9	0.59 km^2	Alluvial fan and stream deposits	Carbonated Black Chernozem	25-30 cm	l-sil	poorly	<5	grazing

TABLE 4-4 (Continued)

Map Symbol	No. of Separate Areas	Total Area	Parent Material	Soil Development	Relative Depth of Soil Solum	Surface Texture	Drainage	Topography Slopes in %	Agricultural Significance
56	4	0.95 km^2	Glacial fluvial	Orthic Dark Brown-Calcareous Black Chernozem	25 cm	l-sil	well	5-20	grazing
57	6	5.44 km^2	Colluvial fan	Orthic Dark Brown Chernozem-Degraded Eutric Brunisol	15-20 cm	sil-gsil	well	5-20	grazing
58	3	2.46 km^2	Glacial till over Lithic contact	Lithic Dark Grey Chernozem	3-5 cm	sil-sicl	-	5-15	grazing
59	3	0.51 km^2	Glacial till	Calcareous Black Chernozem	10-15 cm	l-gl	moderately well	5-15	grazing
60	5	0.65 km^2	Glacial till	Gleyed Orthic Grey Luvisol	25 cm	sil-gcl	poorly	-	grazing
61	1	0.05 km^2	Glacial fluvial	Orthic Dark Brown Chernozem-Degraded Eutric Brunisol	10-15 cm	l-gsil	well	10-15	grazing
62	1	0.96 km^2	Glacial till	Orthic Grey Luvisol-Degraded Eutric Brunisol	15-30 cm	sil	well-imperfectly	5-15	grazing
63	1	0.93 km^2	Glacial till	Orthic Brown Chernozem-Degraded Eutric Brunisol	45 cm	sicl	well-imperfectly	5-15	grazing
64	2	1.10 km^2	Colluvial over Glacial till	Degraded Eutric Brunisol	30-38 cm	sil-sicl	moderately well	5-12	grazing

4.2 VEGETATION

(a) Biogeoclimatic Zones

Seven biogeoclimatic zones have been defined and mapped on Map 4-5. These are as follows:

(i) Ponderosa Pine - Bunchgrass Zone
(ii) Interior Douglas-fir Zone
(iii) Engelmann Spruce - Subalpine Fir Zone
(iv) Alpine Tundra Zone
(v) Cariboo Aspen - Lodgepole Pine - Douglas-fir Zone
(vi) Coastal Western Hemlock Zone
(vii) Mountain Hemlock Zone
(viii) Interior Western Hemlock Zone.

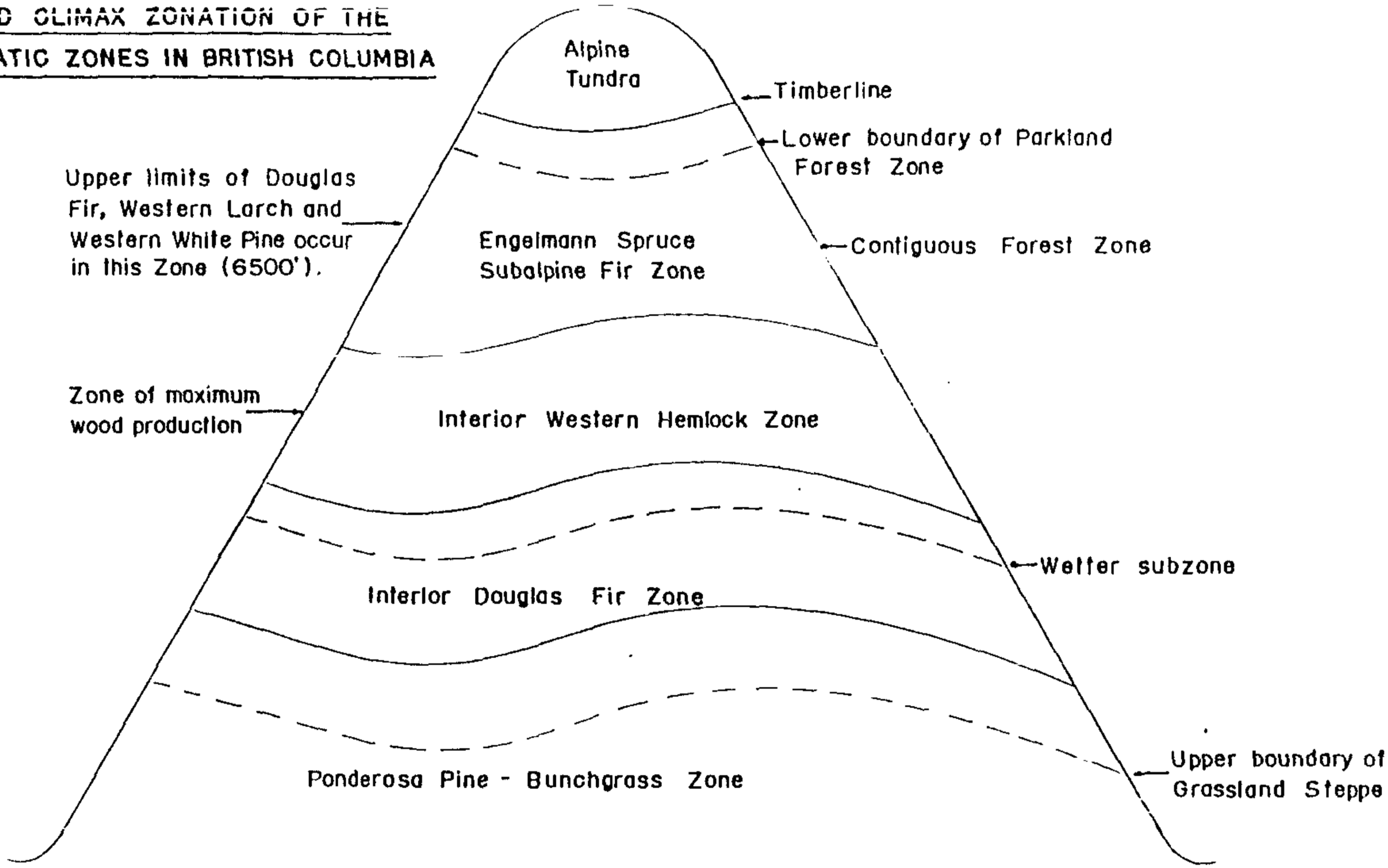
It should be emphasized that the boundaries between zones are not always well defined but, in most cases, are broad transitional belts (ecotones). This is especially true in the steep,mountainous terrain where orography and exposure play an important role in zonal distributions. Therefore, because not all the zones within the regional study area could be investigated, many local variations could not be delineated. These factors are brought out so the reader is not mislead into believing the boundary locations are exact. A generalized biogeoclimatic zonation is contained in Figure 4-1.

(i) Ponderosa Pine - Bunchgrass Biogeoclimatic Zone

The climate of the Ponderosa Pine - Bunchgrass Biogeoclimatic Zone is a semi-arid type. It is the driest and, in the summer, the warmest in British Columbia. Rainfall is very limiting to forest tree growth in the zone. Consequently, the forest consists of open savanna-like stands. This zone lies between 275 and 915 m (900 and 3000 ft.) in elevation and is the lowest forested zone in British Columbia. Within the regional study area,

FIGURE 4-1

GENERALIZED CLIMAX ZONATION OF THE BIOGEOCLIMATIC ZONES IN BRITISH COLUMBIA



it occupies the lower elevations in the Fraser, Thompson and Nicola river valleys. The climate characterized by Krajina[03] is summarized in Table 4-5.

Most of the soils are derived from glacial till with alluvial deposits being prominent in the valley bottoms. Because of the predominance of grass species, the dominant soil order is Chernozemic.

In this biogeoclimatic zone, ponderosa pine *(Pinus ponderosa)*, called yellow pine by forestry, regenerates in savanna-like stands on sandy loam soils. On finer-textured soils, ponderosa pine is usually missing, and big sagebrush *(Artemisia tridentata)* and a large number of grass species become dominant. Interior Douglas-fir *(Pseudotsuga menziesii var. glauca)* may occur here but it requires shade and a north slope where water is more efficiently conserved.

The structure of this biogeoclimatic zone and the Interior Douglas-fir Biogeoclimatic Zone differ considerably from that of the other biogeoclimatic zones. The other zones are characterized by a dense tree canopy with a shrub understory. Herbaceous species are common but do not cover that much area. In the Interior Douglas-fir Biogeoclimatic Zone and especially the Ponderosa Pine - Bunchgrass Biogeoclimatic Zone, the forest stands are open savanna types. The trees are low to moderate in density. The shrub canopy is poorly developed, while the herbs, especially the grasses, form a complete cover over the ground surface.

The Ponderosa Pine - Bunchgrass Zone is the major agricultural zone in British Columbia as well as being of prime importance for cattle grazing in the spring, fall and winter. However, because of its relatively dry climate, irrigation is necessary to achieve the best results. The forest productivity of this zone is the lowest of the forested zones occurring in the regional study area. Wintering habitat for ungulates and upland game birds are important wildlife uses.

TABLE 4-5

SUMMARY OF THE CLIMATIC DATA
FOR THE PONDEROSA PINE - BUNCHGRASS ZONE

Mean Annual Temperature	6° - 10°C (42° - 50°F)	Number of Frost Free Days	100 - 200
January Mean Monthly Temperature	-8° - -3°C (17° - 27°F)	July Mean Monthly Temperature	18° - 22°C (64° - 72°F)
Number of Months Above 10°C	5 to 7	Number of Months Below 10°C	2 to 4
Annual Total Precipitation	190 - 360 mm (7.4 - 14 inches)	Annual Snowfall	500 - 1520 cm (20 - 60 inches)
Driest Month Precipitation	7.4 - 15.2 mm (.29 - .6 inches)	Wettest Month Precipitation	29 - 51 mm (1.13 - 2 inches)
Absolute Maximum Temperature	39° - 44°C (101° - 112°F)	Absolute Minimum Temperature	-41° - -21°C (-42° - -6°F)
Snowfall in Percent of Annual Total Precipitation	19 - 42 percent	Seasonal Occurrence in Percent of Total Precipitation	W/NE: 30 - 40 percent SW/NW: Summer: 30 - 35 percent Spring: 15 - 25 percent

(ii) Interior Douglas-fir Biogeoclimatic Zone

The Interior Douglas-fir Biogeoclimatic Zone is the second warmest zone in British Columbia, next to the Ponderosa Pine - Bunchgrass Biogeoclimatic Zone. The climate is cool, continental and dry and is largely created by the rain-shadow effect of the Cascade and Coast mountain ranges. The zone varies from 300 m (980 ft.) to 1525 m (5000 ft.) above sea level. It can be divided into two sub-zones based on precipitation. The drier sub-zone, which is the most common, has an annual total precipitation of 400 mm (16 in.) to 480 mm (19 in.). The wetter sub-zone occurs at higher altitudes in a rather thin transitional belt to the next higher biogeoclimatic zone. The cimate data for the zone is summarized in Table 4-6[03].

As in the Ponderosa Pine - Bunchgrass Biogeoclimatic Zone, the soils are derived mainly from glacial till and alluvial materials, However, because of increased rainfall and a higher stocking of coniferous trees, the dominant soils are Brunisols and Luvisols[C2].

In the drier sub-zone, there are only two major coniferous species; namely ponderosa pine *(Pinus ponderosa)* and interior Douglas-fir *(Pseudotsuga menziesii var. glauca)*. The following trees occur sporadically in the sub-zone: western white pine *(Pinus monticola)* and western redcedar *(Thuja plicata)*. Most of these trees do not grow well in this sub-zone because the climate is dry or too warm. The forested area is a mosaic of open-grown ponderosa pine *(Pinus ponderosa)* and interior Douglas-fir *(Pseudotsuga menziesii var. glauca)* interspersed with bunchgrass open range areas. In this sub-zone, ponderosa pine grows mainly as a pioneer tree, because its shade tolerance is quite low. Interior Douglas-fir is the climax species. In the wetter sub-zone, several other trees are present because of the increased precipitation, and include: lodgepole pine *(Pinus contorta)*, grand fir *(Abies grandis)* and Engelmann spruce *(Picea engelmanii)*. Lodgepole pine occurs mostly above 1050 m (3500 ft.) elevation where the vegetative season is shorter and snow stays on the ground longer, It takes over the successional role of ponderosa pine at these elevations. Engelmann spruce moves down the major stream courses from the Engelmann Spruce - Subalpine Fir Zone where cold air drainage and alluvial deposits are present.

Environmental features such as soil texture, aspect and topographic position, have a critical influence on the distribution of the vegetation association in this biogeoclimatic zone because of its dry climate. All these factors affect the soil moisture status, thereby favouring certain plant species. For example, Douglas-fir does best on cool, north slopes, while ponderosa pine does better on southern exposures. On finer-textured soils, grass species are common, while trees on coarse-textured soils regenerate better. This effect is due to the lower availability of soil moisture in fine-textured soils, where moisture is held hygroscopically and less easily extracted by tree roots[05]. Poor aeration of fine-textured soils could also be a factor.

The Interior Douglas-fir Zone is a multiple-use zone where both domestic livestock grazing and forestry are very important industries. This zone provides the majority of the forage for livestock during the summer months. Logging which began in the 1860's is now one of the largest and most important industries. Agriculture usually consists of improved pasture or the production of alfalfa with irrigation. Intensive agriculture is not generally practised.

(iii) Engelmann Spruce - Subalpine Fir Biogeoclimatic Zone

This biogeoclimatic zone is a much fragmented forest occupying the higher elevations to treeline in the interior of British Columbia. This zone composes the major portion of the interior forests and is the dominant biogeoclimatic zone within the study area. Altitudinally, it ranges between 1225 m (4000 ft.) above sea level to 2290 m (7500 ft.).

The climate is characterized by Krajina[03] as a continental cold, humid one and is summarized in Table 4-7.

The parent material is largely glacial till with the dominant soil order being Brunisols. However, in the Coast Mountains, where the precipitation

TABLE 4-6

SUMMARY OF THE CLIMATIC DATA FOR THE INTERIOR DOUGLAS-FIR ZONE

Mean Annual Temperature	4^o - 9^oC (40^o - 48^oF)	Number of Frost Free Days	75 - 200
January Mean Monthly Temperature	-12^o - -3^oC (10^o - 26^oF)	July Mean Monthly Temperature	17^o - 21^oC (62^o - 69^oF)
Number of Months Above 10^oC	5 to 6	Number of Months Below 10^oC	2 to 4
Annual Total Precipitation	360 - 560 mm (14 - 22 inches)	Annual Snowfall	76 - 178 cm (30 - 70 inches)
Driest Month Precipitation	13 - 28 mm. (.5 - 1.1 inches)	Wettest Month Precipitation	51 - 89 mm (2 - 3.5 inches)
Absolute Maximum Temperature	36^o - 43^oC (97^o - 110^oF)	Absolute Minimum Temperature	-46^o - -32^oC (-51^o - -25^oF)
Snowfall in Percent of Annual Total Precipitation	21 - 35 percent		

is greater and the parent material is largely of granitic origin, Podzolic soils are the most common.

The forest ground is usually frozen before the snow falls. The winters are very severe with the snow lasting approximately 7.5 months. This, together with the cool nights, results in a short growing season. Only trees which can tolerate an extended period of frozen ground and short vegetative season can survive here. The climax species are Engelmann spruce *(Picea engelmannii)* and subalpine fir *(Abies lasiocarpa)*. The successional species, lodgepole pine *(Pinus contorta)* is the most common in this biogeoclimatic zone since lightning-caused wildfires and logging activities are extensive. Forest stands in this climax state are uncommon and scattered. White-bark pine *(Pinus albicaulis)* and alpine larch *(Larix lyallii)* occur in suitable habitats around timberline. Western hemlock *(Tsuga heterophylla)*, western white pine *(Pinus monticola)*, western redcedar *(Thuja plicata)* and interior Douglas-fir *(Pseudotsuga menziesii var. glauca)* only occur sporadically because of the short vegetative season.

Along the upper altitudinal boundary, the contiguous forest gives way to an open type "parkland forest". Krummholz formation of the tree species is common. These forest colonies develop where the snow remains on the ground longer. The snow supplies additional moisture to the trees. Lightning fires might also play an important role.

Because of the higher precipitation received by the Engelmann Spruce - Subalpine Fir Zone, the forest productivity is the second highest of all of the biogeoclimatic zones occurring in the regional study area. Consequently, logging is the major commercial use of this zone. Domestic livestock grazing occurs throughout the summer months, however the amount and quality of forage are relatively low. In addition to livestock grazing, the zone is used heavily by ungulates as summer range. The high precipitation and greater snowfall makes this zone very important as a water storage area for irrigation and domestic water supplies in the lower and drier biogeoclimatic zones.

TABLE 4-7

SUMMARY OF THE CLIMATIC DATA
FOR THE ENGELMANN SPRUCE - SUBALPINE FIR ZONE

Mean Annual Temperature	1° - 4°C (38° - 39°F)	Number of Frost Free Days	50 - 100
January Mean Monthly Temperature	-18° - -7°C (-1° - 20°F)	July Mean Monthly Temperature	12° - 16°C (54° - 60°F)
Number of Months Above 10°C	2 to 4	Number of Months Below 10°C	5 to 6
Annual Total Precipitation	410 - 1830 mm (16 - 72 inches)	Annual Snowfall	175 - 1016 cm (69 - 400 inches)
Driest Month Precipitation	15 - 66 mm (.6 - 2.6 inches)	Wettest Month Precipitation	64 - 254 mm (2.5 - 10 inches)
Absolute Maximum Temperature	32° - 37°C (90° - 98°F)	Absolute Minimum Temperature	-56° - -24°C (-68° - -30°F)
Snowfall in Percent of Annual Total Precipitation	43 - 72 percent	Seasonal Occurrences in Percent of Total Precipitation	winter: 40 percent summer: 20 percent

(iv) Alpine Tundra Biogeoclimatic Zone

The Alpine Tundra Zone is represented on the highest mountain peaks above the subalpine zone. It usually occurs above 2150 m (7000 ft.), however, in the Coast Range, this altitude is reduced because of greater accumulation of ice and snow to approximately 1830 m (6000 ft.). Under the severe conditions of this altitude no trees grow very well. Only occasionally do krummholz forms of white-bark pine *(Pinus albicaulis)* and sub-alpine fir *(Abies lasiocarpa)* form in depressions where snow accumulates and supplies insulation and moisture. The climate of this zone is summarized in Table 4-8[03].

Most of the soils are derived from shallow glacial till over bedrock and are very stony. The dominant soil order is Alpine Brunisols[03]. Podzols are dominant in the Coast Range.

A variety of herb species exist on the dry, exposed mountain peaks. The most common are: mountain-avens *(Dryas octopetala)*, alpine pussytoes *(Antennaria alpina)*, catchfly *(Silene acaulis)*, beardtongue *(Pentstemon procerus)*, sandwort *(Arenaria capillaris)*, and a variety of sedge species *(Carex scirpoidea, Carex nardina, and Carex albonigra)*. Small patches of red heather *(Phyllodoce empetriformis)*, yellow heather *(Phyllodoce glanduliflora)* and white moss heather *(Cassiope mertensiana)* can occur in moist, sheltered areas. The heather species generally increase as the climate becomes more coastal, while many of the herbaceous species disappear.

The lack of trees and severity of the climate limit most activities in this zone. The high recreational values, water storage, and use in the summer by wildlife appear to be the most important uses. In some areas in the interior, domestic livestock utilize these areas in the summer months. However, due to the short vegetative season, this practice generally results in degradation of the alpine tundra if grazed too heavily.

TABLE 4-8

SUMMARY OF THE CLIMATIC DATA
FOR THE ALPINE TUNDRA ZONE

Mean Annual Temperature	-4° - -1.5°C (25° - 29°F)	Number of Frost Free Days	< 25
January Mean Monthly Temperature	-18° - -7°C (0° - 20°F)	July Mean Monthly Temperature	7° - 11°C (44° - 52°F)
Number of Months Above 10°C	none	Number of Months Below 10°C	7 to 8
Annual Total Precipitation	700 - 2800 mm (28 - 110 inches)	Annual Snowfall	531 - 1955 cm (209 - 770 inches)
Driest Month Precipitation	23 - 122 mm (.9 - 4.8 inches)	Wettest Month Precipitation	76 - 362 mm (3.05 - 14.22 inches)
Absolute Maximum Temperature	21° - 28°C (70° - 83°F)	Absolute Minimum Temperature	-45° - -35°C (-49° - -28°F)
Snowfall in Percent of Annual Total Precipitation	72 - 74 percent		

(v) Cariboo Aspen - Lodgepole Pine - Douglas-fir Biogeoclimatic Zone

This biogeoclimatic zone is quite similar to the Interior Douglas-fir Biogeoclimatic Zone in its vegetative characteristics. However, because of its more northerly position, its climate is considerably colder and severe. The zone has a very severe winter but the snowfall is limited. This fact restricts many of the tree species common to the Interior Douglas-fir Zone. The vegetation generally consists of a mosaic of forest and grassland associations. This zone is geographically rather than altitudinally defined. The climate is characterized as micro-thermal, subhumid continental and is summarized in Table 4-9[03].

As in the previous biogeoclimatic zones, glacial till is the most common parent material. However, in this highly glaciated plateau region, glacial outwash and lacustrine deposits are common. The dominant soil order is Brunisolic on mesic habitats. Luvisols are more common on fine-textured, alkaline parent material.

The most common trees are Douglas-fir *(Pseudotsuga menziesii var. glauca)*, lodgepole pine *(Pinus contorta)* and trembling aspen *(Populus tremuloides)*. White spruce *(Picea glauca)* is frequent in cool receiving areas. Open steppe grassland associations are frequent on fine-textured soils (silty loams).

The vegetation of this zone strongly resembles that of the Interior Douglas-fir Biogeoclimatic Zone in that many of the vegetation associations and plant species are similar. The occurrence of western snowberry *(Symphoricarpos occidentalis)* and prickly rose *(Rosa acicularis)*, the general lack of many tree species and abundance of trembling aspen *(Populus tremuloides)* are important characteristics of this zone.

Domestic livestock grazing and forestry are the major uses. Agriculture is practised to a limited extent but is restricted in both the type and productivity of the crops due to the short growing season.

TABLE 4-9

SUMMARY OF THE CLIMATIC DATA
FOR THE CARIBOO ASPEN - LODGEPOLE PINE - DOUGLAS-FIR ZONE

Mean Annual Temperature	2° - 5°C (36° - 41°F)	Number of Frost Free Days	50 - 150
January Mean Monthly Temperature	-12° - -9°C (10° - 16°F)	July Mean Monthly Temperature	13° - 17°C (55° - 62°F)
Number of Months Above 10°C	3 to 5	Number of Months Below 10°C	4 to 6
Annual Total Precipitation	360 - 560 mm (14 - 22 inches)	Annual Snowfall	40 - 190 cm (16 - 75 inches)
Driest Month Precipitation	10 - 23 mm (.4 - .9 inches)	Wettest Month Precipitation	40 - 76 mm (1.6 - 3.0 inches)
Absolute Maximum Temperature	33° - 41°C (92° - 105°F)	Absolute Minimum Temperature	-52° - -38°C (-61° - -36°F)
Snowfall in Percent of Annual Total Precipitation	28 - 38 percent		

(vi) Coastal Western Hemlock Biogeoclimatic Zone

The Coastal Western Hemlock Biogeoclimatic Zone has a humid mesothermal climate[02], in which the zonal soils are strongly podzolized and western hemlock *(Tsuga heterophylla)* is the climatic climax species[03]. This zone is the wettest in British Columbia and sustains the highest production for Douglas-fir, western hemlock and western redcedar. The Coastal Western Hemlock Zone is composed of two sub-zones; the drier has an annual total precipitation of 1650 mm (65 in.) to 2800 mm (110 in.), and the wetter has an annual total precipitation of 2800 mm (110 in.) to 6650 mm (262 in.). Within the regional study area, the Coastal Western Hemlock Zone is only found in the extreme southwest portion and is confined to several drainages. Altitudinally, this zone lies between 450 m (1475 ft.) and 1050 m (3450 ft.). The climate is summarized in Table 4-10[03].

Because of the high precipitation, the soils are strongly leached, resulting in a predominance of Podzolic soils. The soils are generally coarse-textured and acidic.

The vegetation is greatly influenced by the high precipitation and a very rich shrub and herb layer exists. The moss layer generally forms a complete carpet over the ground surface.

The dominant tree species include western hemlock *(Tsuga heterophylla)*, western redcedar *(Thuja plicata)*, and Pacific silver fir *(Abies amabilis)*. Douglas-fir *(Pseudotsuga menziesii var. glauca)* occurs as a very common successional species (along with red alder *(Alnus rubra)*) after logging or fire.

The understory is composed of a dense shrub layer, primarily composed of salal *(Gaultheria shallon)* on the drier sites, with huckleberries *(Vaccinium spp.)*, devil's club *(Oplopanax horridus)*, and oregon grape *(Berberis spp.)* becoming common on moister sites. The herb layer contains a large number of species, but they tend to have low cover values except for swordfern *(Polystichum munitum)* and deerfern *(Blechnum spicant)* which are dominant understory components. Other common species include star-flower *(Trientalis latifolia)*, foamflower *(Tiarella*

TABLE 4-10

SUMMARY OF THE CLIMATIC DATA
FOR THE COASTAL WESTERN HEMLOCK ZONE

Mean Annual Temperature	5^{o} - 9^{o}C (41^{o} - 49^{o}F)	Number of Frost Free Days	120 - 250
January Mean Monthly Temperature	-4^{o} - 5^{o}C (24^{o} - 41^{o}F)	July Mean Monthly Temperature	13^{o} - 18^{o}C (55^{o} - 64^{o}F)
Number of Months Above 10^{o}C	4 to 6	Number of Months Below 10^{o}C	0 to 3
Annual Total Precipitation	1650 - 6650 mm (65 - 262 inches)	Annual Snowfall	13 - 750 cm (5 - 295 inches)
Driest Month Precipitation	30 - 165 mm (1.2 - 6.5 inches)	Wettest Month Precipitation	280 - 1170 mm (11 - 46 inches)
Absolute Maximum Temperature	26^{o} - 40^{o}C (78^{o} - 104^{o}F)	Absolute Minimum Temperature	-30^{o} - -7^{o}C (-22^{o} - 19^{o}F)
Snowfall in Percent of Annual Total Precipitation	.9 - 38 percent		

latifolia), foamflower *(Tiarella trifoliata)*, twinflower *(Linnaea borealis)* and woodfern *(Dryopteris austriaca)*.

The moss layer is very well developed and a distinct characteristic of most habitats in this zone. The dominant mosses are *Hylocomium splendens*, *Eurhynchium oreganum*, *Rhytidiadelphus loreus*, *Plagiothecium undulatum*, and *Isothecium stoloniferum*.

Because of the extremely high productivity of the forests, timber harvesting is the major resource use. The dense understory restricts recreational activities such as hiking and hunting.

(vii) Mountain Hemlock Biogeoclimatic Zone

The Mountain Hemlock Zone occurs on the upper slopes and crests of most mountains of the Coast Range. The zone occurs above 915 m (3000 ft.) as a microthermal subalpine belt with a deep snow cover over unfrozen ground. Winters are not as severe as those of its interior counterpart, the Engelmann Spruce - Subalpine Fir Zone. However, snow accumulations are much greater. Within the study area, this zone occurrence is limited to the extreme southwest portion, where its development is transitional to the interior types. The climate is summarized in Table 4-11[03]. The soils are generally derived from glacial till and colluvium deposits, developing into Humic Podzols as the zonal soils.

The most common coniferous trees are mountain hemlock *(Tsuga mertensiana)*, Pacific silver fir *(Abies amabilis)* and yellow cedar *(Chamaecyparis nootkatensis)*. These tree species are all dependent upon unfrozen ground below the snow for survival. Western hemlock *(Tsuga heterophylla)* is common at the lower elevations of this zone. Subalpine fir *(Abies lasiocarpa)*, Douglas-fir *(Pseudotsuga menziesii var. glauca)* and lodgepole pine *(Pinus contorta)* are of only limited distribution. Near timberline, subalpine fir may replace Pacific silver fir in areas exposed to a more continental climate[19]. Mountain hemlock is the dominant tree on all habitats and forms

TABLE 4-11

SUMMARY OF THE CLIMATIC DATA
FOR THE MOUNTAIN HEMLOCK ZONE

Mean Annual Temperature	3^{o} - 7^{o}C (38^{o} - 44^{o}F)	Number of Frost Free Days	40 - 120
January Mean Monthly Temperature	-9^{o} - -1^{o}C (16^{o} - 30^{o}F)	July Mean Monthly Temperature	11^{o} - 13^{o}C (51^{o} - 56^{o}F)
Number of Months Above 10^{o}C	2 to 3	Number of Months Below 10^{o}C	1 to 6
Annual Total Precipitation	1780 - 4320 mm (70 - 170 inches)	Annual Snowfall	280 - 2032 cm (110 - 800 inches)
Driest Month Precipitation	33 - 84 mm (1.3 - 3.3 inches)	Wettest Month Precipitation	305 - 410 mm (12 - 16 inches)
Absolute Maximum Temperature	24^{o} - 30^{o}C (75^{o} - 86^{o}F)	Absolute Minimum Temperature	-35^{o} - -23^{o}C (-31^{o} - -10^{o}F)
Snowfall in Percent of Annual Total Precipitation	20 - 70 percent	Seasonal Occurrence in Percent of Total Precipitation	winter: wet 30 - 40 percent spring and summer: dry 10 - 15 percent

the climatic climax species. Yellow cedar and Pacific silver fir become common on areas enriched by a flow of seepage water. Tree growth is slow because of the short vegetative season and deep snow cover.

The forests are not continuous in this zone and are mostly confined to the lower elevations. As the elevation increases, the contiguous forest gives way to a "parkland forest" where isolated krummholz tree clumps are common. This is considered the Parkland Sub-zone by Brooke[19]. Common understory constituents of the sub-zone are *Ericaceae* species, such as blueberry *(Vaccinium deliciosum)*, white rhododendron *(Rhododendron albiflorum)*, red heather *(Phyllodoce empetriformis)* and white heather *(Cassiope mertensiana)*. A very lush alpine meadow flora exists in seepage areas in the Parkland sub-zone where marsh marigold *(Caltha leptosepala)*, monkey-flower *(Mimulus Lewisii)*, mountain valerian *(Valeriana sitchensis)* and false hellebore *(Veratrum viride)* can be found.

Within the contiguous forest, the common understory species are blueberries *(Vaccinium membranaceum, Vaccinium ovalifolium, Vaccinium alaskaense)*, false azalea *(Menziesia ferruginea)*, twinflower *(Linnaea borealis)*, bunchberry *(Cornus canadensis)* and foamflower *(Tiarella unifoliata)*.

Most parts of this zone are inaccessible but, where accessible, logging has been the major land use. However, because of the beauty of the open Parkland sub-zone and heavy snowfall, recreation and watershed protection are probably the two most compatible land uses. Ungulates generally inhabit the zone in scattered numbers during the summer months.

(viii) Interior Western Hemlock Zone

This zone is the wettest and most productive of the forest zones found in the interior of British Columbia. Within the regional study area, this zone is only found in the extreme northeastern corner and covers a relatively small area. The climate of the Interior Western Hemlock Zone is comparable with the Coastal Western Hemlock Zone except that the vegetative season is shorter.

TABLE 4-12

SUMMARY OF THE CLIMATIC DATA
FOR THE INTERIOR WESTERN HEMLOCK ZONE

Mean Annual Temperature	3^o - 8^oC (37^o - 46^oF)	Number of Frost Free Days	100 - 150
January Mean Monthly Temperature	-11^o - -3^oC (12^o - 27^oF)	July Mean Monthly Temperature	15^o - 21^oC (59^o - 69^oF)
Number of Months Above 10^oC	3 to 5	Number of Months Below 10^oC	3 to 5
Annual Total Precipitation	560 - 1700 mm (22 - 67 inches)	Annual Snowfall	190 - 673 cm (75 - 265 inches)
Driest Month Precipitation	25 - 51 mm (1 - 2 inches)	Wettest Month Precipitation	81 - 254 mm (3.2 - 10 inches)
Absolute Maximum Temperature	35^o - 41^oC (95^o - 106^oF)	Absolute Minimum Temperature	-47^o - -14^oC (-52^o - 7^oF)
Snowfall in Percent of Annual Total Precipitation	29 tO 53 percent		

Altitudinally it occurs between 300 and 1350 m (1000 - 4500 ft.). The climate is characterized by Krajina[08] as a microthermal continental humid with a cool winter and a warm summer. Table 4-12 summarizes the climate for this zone.

This zone consists of two sub-zones. In both, the climatic climax tree is western hemlock *(Tsuga heterophylla)*. The drier sub-zone (annual mean total precipitation is 580 - 890 mm (22 - 35 in.)) is one of the richest areas of various coniferous trees in British Columbia. Interior Douglas-fir *(Pseudotsuga menziesii var. glauca)*, western larch *(Larix occidentalis)*, western hemlock *(Tsuga heterophylla)*, western white pine *(Pinus strobus)*, lodgepole pine *(Pinus contorta)*, western redcedar *(Thuja plicata)*, subalpine fir *(Abies lasiocarpa)*, and grand fir *(Abies grandis)* are the dominant trees. The wetter sub-zone (annual mean total precipitation 890 to 1700 mm (35 - 67 in.)) has only Interior Douglas-fir *(Pseudotsuga menziesii var. glauca)*, western hemlock *(Tsuga heterophylla)*, lodgepole pine *(Pinus contorta)*, Engelmann spruce *(Picea engelmannii)*, western redcedar *(Thuja plicata)*, and subalpine fir *(Abies lasiocarpa)* as its most common tree species. Both sub-zones contain Balsam poplar *(Populus balsamifera)*, trembling aspen *(Populus tremuloides)*, and paper birch *(Betula papyrifera)* as common deciduous trees.

The relatively high precipitation and large number of coniferous trees makes this zone one of the most important timber producing areas in the interior of British Columbia.

(b) Vegetation Associations

The vegetation within the local study area (Map 2-1) was mapped at the association level using the recent colour aerial photographs, flown in September 1976, and forest cover maps (Map 4-6). As stated earlier, the vegetation associations were named according to the climatic climax state. However, because of the abundance of burns and logging within the study area, very little of the climax overstory exists. For this reason, the forest types were mapped and designated as follows within each association:

Coniferous Types

Engelmann spruce - subalpine fir
Engelmann spruce - lodgepole pine
Engelmann spruce - Douglas-fir
Engelmann spruce - Douglas-fir - lodgepole pine
Engelmann spruce - aspen
Engelmann spruce - subalpine fir - lodgepole pine
Engelmann spruce
Douglas-fir - lodgepole pine
Douglas-fir - aspen
Douglas-fir - ponderosa pine
Douglas-fir
subalpine fir - lodgepole pine
subalpine fir
lodgepole pine - aspen
lodgepole pine
ponderosa pine

Deciduous Types

cottonwood
aspen
cottonwood - aspen

Using the plot information, information from other vegetation studies in interior British Columbia, aerial photographs and forest cover maps, 14 forest associations and six grassland associations were described and mapped within the detailed study area. Each association is common to a certain biogeoclimatic zone, with the exception of three intrazonal associations that can occur in several biogeoclimatic zones because of their definition and the result of topographic or edaphic differences between zones. The following associations have been described and mapped (Map 4-6).

Alpine Tundra Zone

mountain avens - sedge association

Engelmann Spruce - Subalpine Fir Zone

Engelmann spruce - grouseberry association
Engelmann spruce - grouseberry - pinegrass association
Engelmann spruce - grouseberry - white rhododendron association
Engelmann spruce - willow - red heather parkland association
Engelmann spruce - grouseberry - lupine association

Interior Douglas-fir Zone

Douglas-fir - pinegrass association
Douglas-fir - bunchgrass association
Douglas-fir-spirea - bearberry association
Douglas-fir - bunchgrass - pinegrass association

Ponderosa Pine - Bunchgrass Zone

ponderosa pine - bunchgrass association

Intrazonal

riparian association
Engelmann spruce - horsetail association
willow - sedge bog association

Grassland Associations

highland grassland association
Kentucky bluegrass association
bunchgrass - Kentucky bluegrass association
sagebrush - bluebunch wheatgrass association
saline depressional association
big sagebrush - bunchgrass association

Forest Associations

The 14 forest associations described in this study comprise the majority of the land within the detailed study area. Most of these associations are successional and very little climax vegetation exists. Most climax vegetation is found along streams or at high elevations on sheltered north exposures. The mosaic pattern of the forest associations is generally interrupted by grasslands interspersed throughout the forested lands.

(i) Mountain Avens - Sedge Association (Appendix C)

This association occurs above timberline on the highest windswept peaks within the study area, mainly within the Clear Range. Blustry, Cairn's, Moore and Chipuin mountains are the major distributional area of this association. The soils are generally very shallow and stony ($<$50 percent). Because of time and poor accessibility, only one plot (Plot Number 1) was located in this association.

The shrub layer is sparse and restricted to rock outcrops. The herb layer consists of a well-developed but patchy coverage of mountain avens *(Dryas octopetala)* with sedge *(Carex albo-nigrum)*, bluegrass *(Poa grayana)* and sandwort *(Arenaria capillaris)* comprising the majority of the remaining vegetation cover.

(ii) Engelmann Spruce - Grouseberry Association (Appendix C)

This association is the most abundant subalpine habitat, especially to the west and north of the Hat Creek Valley. It develops on broad ridges and gentle slopes from 1520 m (4985 ft.) to 1850 m (6068 ft.) in elevation. It occurs on all exposures, but reaches its best development on southern exposures. The soils are medium-textured, well-drained and derived from glacial till and colluvium. The major soil order is Gray Luvisol.

In the climax state, subalpine fir *(Abies lasiocarpa)* is a major component of the overstory. Engelmann spruce *(Picea engelmannii)* is also well represented.

However, within the study area, subalpine fir was found to be rare, only existing in isolated stands or as very scattered regeneration species. Engelmann spruce was the dominant species in the climatic climax forest stands. However, because of past fires, most stands are made up of mixtures of lodgepole pine *(Pinus contorta)* and Douglas-fir *(Pseudotsuga menziesii var. glauca)*, both seral species, with Engelmann spruce usually of secondary importance. Canopy coverages are dense, ranging from 60 to 100 percent.

The understory is dominated by a very low, dense cover of grouseberry *(Vaccinium scoparium)* which covers between five and 95 percent, depending on the overstory coverage. Other shrubs occurring very sporadically are buffaloberry *(Shepherdia canadensis)*, little wild rose *(Rosa gymnocarpa)* and tall huckleberry *(Vaccinium membranaceum)*.

The herb layer is greatly reduced (five to 10 percent) by the dense shrub canopy. Frequent species include twinflower *(Linnaea borealis)*, wintergreen *(Pyrola secunda)*, meadowrue *(Thalictrum occidentale)*, strawberry *(Fragaria glauca)*, arnica *(Arnica latifolia)* and lousewort *(Pedicularis bracteosa)*.

The moss layer is moderately well-developed in coverage with *Pleurozium scherberi* being the dominant species.

The lichen layer is diverse in species composition although the average cover is approximately 10 percent. *Alectoria jubata* and *Alectoria fremontii* are the dominant epiphytic lichens, while *Peltigera aphthosa* is found on the ground (terricolous) in scattered patches up to one m (3.28 ft.) in diameter.

Domestic grazing values are low because of the lack of palatable grasses. Wildlife utilize this association mainly as summer range. Forestry is by far the most common use, however the frequency of fire removes many of the higher valued tree species.

Along streams and drainage courses where moisture conditions are better, the species composition is generally better developed. Engelmann spruce dominates the tree canopy, while the shrub layer is dominated by willows *(Willow spp.)* and grouseberry *(Vaccinium scoparium)*. The herb layers contain lupines *(Lupinus lepidus)*, meadowrue *(Thalictrum occidentale)*, horsetail *(Equisetum arvense)*, mountain valerian *(Valeriana sitchensis)*, arnica *(Arnica latifolia)* and strawberry *(Fragaria glauca)*. Common mosses are *Aulacomium palustre* and *Drepanocladus uncinatus*.

(iii) Engelmann Spruce - Grouseberry - Pinegrass Association (Appendix C)

This association constitutes a dry phase of the Engelmann Spruce - Grouseberry Association. Altitudinally, it forms a well developed association between 1400 m (4600 ft.) and 1675 m (5500 ft.). It usually occupies plateau areas with deep soils of medium-texture. The Gray Luvisol is the most common soil great group. Within the study area, this association occurs most frequently to the east of the Hat Creek Valley in the area north of Cornwall Mountain and in the Arrowstone Hills.

As in the Engelmann Spruce - Grouseberry Association, Engelmann spruce *(Picea engelmannii)* forms a persistent seral constituent, while subalpine fir *(Abies lasiocarpa)* is almost lacking. However, because of the seral nature of most stands within this association, lodgepole pine *(Pinus contorta)* was found the most abundant species.

The shrub layer is characterized by a low cover of grouseberry *(Vaccinium scoparium)* and bearberry *(Arctostaphylos uva-ursi)*. A higher shrub layer exists and is composed of buffaloberry *(Shepherdia canadensis)*, *(Juniperus communis)* and mountain alder *(Alnus incana)*. Sporadic occurrences of western shadbush *(Amelanchier alnifolia)*, little wild rose *(Rosa gymnocarpa)* and spirea *(Spiraea betulifolia)* are common.

The dominant herb by far is pinegrass *(Calamagrostis rubescens)*, covering as much as 95 percent of the ground surface. On steeper slopes where the soil depth was less than 20 cm (8 in.), McLean[07] found a decrease in the amount of pinegrass. Other characteristic species are lupines *(Lupinus lepidus)*, twin-flower *(Linnaea borealis)*, wintergreen *(Pyrola secunda)* and strawberry *(Fragaria glauca)*.

The moss and lichen layers are highly variable. The moss layer is dominated by *Pleurozium schreberi*. The lichen layer, on the other hand, is composed of several dominant species. *Alectoria jubata, Alectoria fremontii, Alectoria saramentosa,* and *Letharia vulpina* are all characteristic epiphytic lichens, while *Peltigera aphthosa* is the common terricolous lichen.

(iv) Engelmann Spruce - Grouseberry - White Rhododendron Association (Appendix C)

This association occurs to the north of the Hat Creek Valley in the Pavilion Mountains on relatively flat plateau areas. The association is unique in that it is the only area where white rhododendron *(Rhododendron albiflorum)* occurs. The development of the association is not entirely understood. It appears to dominate in areas in the early stages of secondary succession due to fire or logging. As the tree canopy matures and Engelmann spruce *(Picea engelmannii)* becomes the dominant tree species, white rhododendron is drastically reduced in coverage. It is felt that this may be a successional association and only exist as a subclimax or climax on very well drained habitats. In other habitat types, the Engelmann Spruce - Grouseberry Association will probably form. For this reason, the exact nature and location of the vegetation boundaries is not known, and can only be assumed. However, it is felt that this is an important association to delineate because of the unique occurrence of white rhododendron in this area. White rhododendron is usually only found on the windward sides of the major mountain ranges. Its occurrence here, especially in successional stands, possibly indicates a higher moisture availability in the northern parts of the detailed study area where this association occurs.

The tree layer is composed of lodgepole pine *(Pinus contorta)* and scattered occurrences of Douglas-fir *(Pseudotsuga menziesii var. glauca)* and Engelmann spruce. The tree stands sampled were successional, as the abundance of lodgepole pine indicates.

The shrub layer is very well developed in both the high and low shrub layers. White rhododendron and buffaloberry *(Shepherdia canadensis)* share the dominance role in the high shrub layer with approximate coverages of 60 percent. The low shrub layer is composed of grouseberry *(Vaccinium scoparium)*.

The herb layer is fairly characteristic of that found in the Engelmann Spruce - Grouseberry Association, although not as species rich. Twinflower *(Linnaea borealis)*, meadowrue *(Thalictrum occidentale)*, arnica *(Arnica cordifolia)* and pinegrass *(Calamagrostis rubescens)* are the dominant species present.

The lichen layer is dominated by *Letharia vulpina*, which is sporadic in occurrence.

(v) Engelmann Spruce - Willow - Red Heather Parkland Association (Appendix C)

This association occurs as the climatic climax from approximately 1980 m (6494 ft.) to timberline. The trees occur in parkland type stands in a clumpy, stunted form, generally referred to as "krummholz". This is the highest forested association and is found on all exposures and slopes. The soils are shallow and stoney, with Dystric Brunisols being the common soil great group.

Engelmann spruce *(Picea engelmannii)* and subalpine fir *(Abies lasiocarpa)* share the climax status with Engelmann spruce, the more dominant of the two. White-bark pine *(Pinus albicaulis)* is also well represented. Because of the severe climate found at these elevations, tree growth and regeneration is very slow. The krummholz nature of the trees can also be attributed to the climate. Wind, snow and associated ice particles tend to shear off branches protruding above the protective snow cover, forming trees that appear flat-topped and trailing.

The shrub layer is well developed in a high shrub/low shrub habit. A heavy cover of willows *(Salix spp.)* exists, about 2.5 m (8 ft.) high and covering between 70 and 100 percent of the plot. Underneath this high shrub layer, a dense low shrub layer exists, consisting of grouseberry *(Vaccinium scoparium)* and bearberry *(Arctostaphylos uva-ursi)*. Red heather *(Phyllodoce empetriformis)* which has been found to be characteristic of this association by other observers[06,07], was found to be very sporadic in occurrence throughout the study area.

The herb layer possesses species common to both the alpine and subalpine zones. The principal herbaceous species are sedge *(Carex albo-nigrum)*, bluegrass *(Poa grayana)*, lupines *(Lupinus lepidus)*, meadowrue *(Thalictrum occidentale)* and strawberry *(Fragaria glauca)*.

In receiving areas, which are very common in this krummholz forest, a willow-bog community exists. The shrub layer is dominated by a dense canopy of willow *(Salix spp.)*, while the herb layer contains a large number of species with moderate coverage. The principal species are sedges, woodrush *(Luzula hitchcockii)*, grass-of-Parnassus *(Parnassia fimbriata)*, cowparsnip *(Heracleum lanatum)* and horsetail *(Equisetum arvense)*. The moss layer is highly developed in these wet depressions. The principal species forming an almost total carpet over the ground are *Aulacomium palustre* and *Sphagnum spp.*.

(vi) Engelmann Spruce - Grouseberry - Lupine Association (Appendix C)

This association occurs directly below the Engelmann Spruce - Willow - Red Heather Parkland Association and above the Engelmann Spruce - Grouseberry Association, on all exposures and slopes. It forms the last contiguous forest stand before the subalpine parkland is reached at approximately 1950 m (6396 ft.). The soils are derived from either colluvium or glacial till. Dystric Brunisols and Gray Luvisols are the common soil types.

The tree canopy is a dense one, composed mainly of Engelmann spruce *(Picea engelmannii)* with lodgepole pine *(Pinus contorta)* becoming dominant in seral stands. Subalpine fir *(Abies lasiocarpa)*, normally a dominant associate, was only found on one plot within this association.

The shrub layer consists of a low growth of grouseberry *(Vaccinium scoparium)* reaching a coverage of 80 percent. All other shrubs only occur sporadically, except for red heather *(Phyllodoce empetriformis)* which is very common.

The herb layer is very well developed and possesses a large number of species. The characteristic species are lupines *(Lupinus lepidus)*, lousewort *(Pedicularis bracteosa)*, globeflower *(Trollius laxus)*, wintergreen *(Pyrola secunda)* and arnica *(Arnica latifolia)*.

The lichen layer consists mainly of the epiphytic types *Alectoria jubata* and *Alectoria saramentosa*. The moss layer is poorly developed with *Drepanocladus uncinatus* and *Dicranum fusescens* being the only two found.

(vii) Douglas-fir - Pinegrass Association (Appendix C)

This association is the most widespread throughout the Interior Douglas-fir Zone. It occurs on relatively steep, cool slopes or benches on mid to upper slopes. At lower elevations, it usually occupies cool northerly aspects, shifting to southerly exposures at higher elevations. The soils are usually medium to fine-textured Brunisols and Luvisols.

The forests in the mature state are generally of an open type with Douglas-fir *(Pseudotsuga menziesii var. glauca)* dominating the overstory and an understory that is essentially shrub-free, dominated by a uniform pinegrass *(Calamagrostis rubescens)* cover. Since fire and logging are extremely important in the development of forest associations in southern British Columbia, most of the forests in this association exist in the seral condition. Seral trees include ponderosa pine *(Pinus ponderosa)* at elevations below 1050 m (3456 ft.) and lodgepole pine *(Pinus contorta)* at the upper elevations.

The shrub layer is usually poorly developed. Little wild rose *(Rosa* *gymnocarpa)*, bearberry *(Arctostaphylos uva-ursi)*, western shadbush *(Amelanchier alnifolia)* and common juniper *(Juniper communis)* are the most common shrubs. The coarser the soil, the more common bearberry becomes.

The herb layer is dominated by pinegrass. Other common associates with a high presence, but low cover value, are sedges *(Carex spp.)*, wild onion *(Allium cernuum)*, yarrow *(Achillea millefolium)*, strawberry *(Fragaria glauca)*, milk-vetch *(Astragalus miser)*, rosy pussytoes *(Antennaria roseus)* and dandelion *(Taraxacum officinale)*. Because of the density of the herb layer, the moss layer is poorly developed. The lichen layer varies considerably with the age of the forest stand, the older stands having better lichen development. *Letharia vulpina* is the most common epiphytic lichen, while *Peltigera canina* is the most common terricolous lichen species.

One important variation of this association has large portions of trembling aspen *(Populus tremuloides)*. These stands are especially prominent in the vicinity of Harry Lake. The occurrence of seepage water in the rolling topography, abundance of a limestone-derived parent material favourable to quaking aspen and, to some degree logging, probably account for the abundance. A similar association frequently occurs in swales and depressions throughout the grassland areas. The major difference exists in the dominance of quaking aspen in the overstory and an increase in the importance of Kentucky bluegrass *(Poa pratensis)*.

(viii) Douglas-fir - Bunchgrass Association (Appendix C)

This association represents the warmest found within the Douglas-fir Zone. It occurs on steep, south, southwestern and southeastern exposures on dry slopes. The soils are generally a mixture of glacial till and colluvium, with soils being Brunisols.

The Douglas-fir - Bunchgrass Association is similar structurally as well as compositionally to the lower Ponderosa Pine - Bunchgrass stands. The scattered trees and grass-dominated understory create savanna-like stands.

ponderosa pine *(Pinus ponderosa)* is the major seral species with Douglas-fir *(Pseudotsuga menziesii var. glauca)* being the climax dominant.

The shrub layer is poorly developed consisting of many scattered shrubs of western shadbush *(Amelanchier alnifolia)*, pasture sage *(Artemisia frigida)* and Rocky Mountain juniper *(Juniperus scopulorum)*.

The herb layer is well developed in coverage, but low in species composition. Bluebunch wheatgrass *(Agropyron spicatum)* is the dominant grass, while rosy pussytoes *(Antennaria roseus)*, yarrow *(Achillea millefolium)* and lemonweed *(Lithospermum ruderale)* are the common herbs.

The moss layer is generally non-existent with *Letharia vulpina* commonly occurring as an epiphytic lichen, although its coverage is low.

The forest productivity of this association is low. However, it produces good forage for domestic livestock and provides especially good winter range for wildlife.

(ix) Douglas-fir - Spirea - Bearberry Association (Appendix C)

The Douglas-fir - Spirea - Bearberry Association is found on steep talus slopes where angular rocks comprise the major growing substratum. The size of the rocks plays an important role in determining the type of vegetation. For example, on Plot Number 59 where the talus was composed of rocks 20 cm (8 in.) and greater in diameter, several characteristic species of finer talus slopes were missing, including bearberry *(Arctostaphylos uva-ursi)*, spirea *(Spiraea betulifolia)* and buffaloberry *(Shepherdia canadensis)*.

The tree layer is composed of Douglas-fir *(Pseudotsuga menziesii var. glauca)* growing in an open canopy condition. The shrub layer is more highly developed than the herb layer, which probably reflects the better rooting conditions for shrub growth. Common shrubs include Rocky Mountain juniper *(Juniperus* *scopulorum)*, common juniper *(Juniperus communis)*, quaking aspen *(Populus tremuloides)*, gooseberry *(Ribes lacustre)* and bearberry.

The herbaceous species generally have very low coverage values ($<$ five percent) Beardtongue *(Penstemon fruticosus)*, pussytoes *(Antennaria roseus)* and bluebunch wheatgrass *(Agropyron spicatum)* are the constant species.

Letharia vulpina is the only lichen found. It is found growing on the trunks and branches of the Douglas-fir trees.

(x) Douglas-fir - Bunchgrass - Pinegrass Association (Appendix C)

The Douglas-fir - Bunchgrass - Pinegrass Association represents an intermediate stage between the Douglas-fir - Bunchgrass and Douglas-fir - Pinegrass associations. If logging and grazing have taken place, the understory will usually be dominated by bluebunch wheatgrass *(Agropyron spicatum)*. As the canopy closes, the dominance of bluebunch wheatgrass decreases and the pinegrass *(Calamagrostis rubescens)* component increases. Within the scope of the mapping, it also represents a mixture of both the Douglas-fir - Bunchgrass and Douglas-fir - Pinegrass associations that are too small to map individually.

The Douglas-fir - Bunchgrass - Pinegrass Association generally occurs on southern exposures with moderate slopes. The soils are Brunisolic and derived from colluvial material. Within the study area, it can be found in the Oregon Jack Creek Valley, Medicine Creek Valley and the western side of the Thompson River Valley.

The tree layer is characterized by a moderate canopy composed of mainly Douglas-fir *(Pseudotsuga menziesii var. glauca)* with ponderosa pine *(Pinus ponderosa)* being the seral species. The shrub layer contains a large number of species with a sporadic occurrence and low cover values. The dominant shrubs are Rocky Mountain juniper *(Juniperus scopulorum)*, bearberry

(Arctostaphylos uva-ursi), snowberry *(Symphoricarpus albus)* and western shadbush *(Amelanchier alnifolia)*.

The grass layer is well developed, covering approximately 50 percent of the ground surface. Bluebunch wheatgrass and pinegrass are the dominant grasses. Bluebunch wheatgrass becomes more dominant in open forest stands, while pinegrass increases in dominance as the forest canopy closes.

The herb layer is mainly composed of weedy plants, such as balsamroot *(Balsamorhiza sagittatas)*, yarrow *(Achillea millefolium)*, strawberry *(Fragaria glauca)*, lemonweed *(Lithospermum ruderale)* and rosy pussytoes *(Antennaria roseus)*. Other common associates include onion *(Allium cernuum)*, purple avens *(Geum triflorum)* and dandelion *(Taraxacum officinale)*.

The lichen layer is composed of mainly the epiphytic type. *Letharia vulpina* is by far the most common although its coverage only reaches 10 percent. The moss layer is poorly developed and difficult to detect in the field. *Polytrichum piliferum, Drepanocladus uncinatus,* and *Tortula ruralis* are the only mosses found.

(xi) Ponderosa Pine - Bunchgrass Association (Appendix C)

This association occupies very coarse-textured parent material of glacial-fluvial or colluvial origin. The coarse-textured nature of either of these materials allows the trees to obtain soil moisture whereas, in fine-textured soils this soil moisture is bounded too tightly. The soils are either Dark Brown Chernozems or Eutric Brunisols. This is the only forested association occurring within the Ponderosa Pine - Bunchgrass Zone.

The tree layer is an open savanna-like stand, composed of ponderosa pine *(Pinus ponderosa)*. Occasionally, Douglas-fir *(Pseudotsuga menziesii var. glauca)* is found on cooler, north-facing slopes.

The shrub layer is poorly developed with rabbitbrush *(Chrysothamnus nauseosus)* being the dominant shrub with a coverage of only five percent. The herb layer is characterized by an overwhelming dominance of bluebunch wheatgrass *(Agropyron spicatum)*. Other herbs are low in cover value.

In many respects, this association closely parallels the adjacent Big Sagebrush - Bunchgrass Association. The lack of big sagebrush *(Artemisia tridentata)* and presence of ponderosa pine are the major vegetative differences. Grazing in this association is also common and the vegetation is subjected to a similar change in species composition as in the Big Sagebrush - Bunchgrass Association. McLean[20] found hawkbeard *(Crepis atrabarba)*, balsamroot *(Balsamorhiza sagittata)* and rabbitbrush to be more common in this association than in the Big Sagebrush - Bunchgrass Association.

(xii) Riparian Association (Appendix C)

This association occurs along the banks of streams and on their associated floodplains in the Interior Douglas-fir and Ponderosa Pine - Bunchgrass biogeoclimatic zones. It is a complex perpetual seral association which usually never reaches a climax condition because of periodic flooding. The structure of the stand is a multi-layered and dense one, developed due to periodic floods providing new seedbeds for colonization. This, coupled with the availability of moisture throughout the growing season, makes this association the most species-diverse and highly productive within the study area.

The soils are highly variable. They range from coarse gravels to very fine alluvium. The soil order is Regosolic and gleysolic with a moder humus formation.

The species diversity in this association is very high due to the large number of micro-habitats available. The characteristic dominant tree is black cottonwood *(Populus trichocarpa)*. Willows *(Salix spp.)*, red alder *(Alnus rubra)* and trembling aspen *(Populus tremuloides)* are very common and dominate in some cases but usually do not occupy a dominant canopy position. The black cottonwood trees may attain heights of 31 to 37 m (102 to 121 ft.)

although usually containing a large amount of heart rot and broken tops. The understory is composed mainly of woody vegetation. Herbaceous plants are not as common because of the coarse soil matrix. The understory dominants are red osier dogwood *(Cornus stolonifera)*, Nootka rose *(Rosa nutkana)*, current *(Ribes lacustre)*, snowberry *(Symphoricarpus albus)* and little wild rose *(Rosa gymnocarpa)*.

In terms of grasses and herbaceous species, a large number of species occur, but both their presence and mean cover are highly variable. This probably reflects the wide diversity of habitats available and varied distribution within the riparian association. Common associates are bentgrass *(Agrostis alba)*, bromegrass *(Bromus inermis)*, horsetail *(Equisetum arvense)*, meadowrue *(Thalictrum occidentale)*, sweet cicely *(Osmorhiza chilensis)*, yarrow *(Achillea millefolium)*, dandelion *(Taraxacum officinale)*, clover *(Trifolium repens)* and white sweet-clover *(Melilotus alba)*.

(xiii) Engelmann Spruce - Horsetail Association (Appendix C)

In deeply incised creek valleys, tree species from higher vegetation zones sometimes move down due to cold air drainage. This association is found in a narrow band along the stream or depression and is small in total area.

Engelmann spruce *(Picea engelmannii)* is the only tree in the upper tree canopy, and usually forms a dense canopy, broken occasionally by windfall activity. The shrub and herb layers are moderately well developed, affected by the dense tree canopy. The shrub layer is dominated by currant *(Ribes lacustre)* and willows *(Salix spp.)*. Sporadic species include red alder *(Alnus rubra)*, red-osier dogwood *(Cornus stolonifera)* and red raspberry *(Rubus ideaus)*.

The herb layer contains a large number of species with low cover values. Common species include horsetail *(Equisetum arvense and Equisetum scirpoides)*, twin-flower *(Linnaea borealis)*, baneberry *(Actaea rubra)*, sweet cicely

(Osmorhiza chilensis), wintergreen *(Pyrola secunda)*, bedstraw *(Galium triflorum)*, strawberry *(Fragaria glauca)* and twisted stalk *(Streptopus amplexifolius)*.

The moss layer is well developed, but usually confined to the areas close to the streambank or in wet depressions. *Hylocomium splenden, Pleurozium scherberi,* and *Aulacomium palustre* are the dominant mosses, while epiphytic lichens such as *Alectoria jubata* and *Alectoria saramentosa* are common.

(xiv) Willow - Sedge Bog Association (Appendix C)

The Willow - Sedge Bog Association is widespread throughout the study area, although the area covered is relatively small. It occurs in depressions where impeded drainage is found and standing water is present for at least part of the year. The soils are either organic or gleysolic. The bog association has been described and mapped as one unit throughout all elevations. However, local variations are inherent and plant species found in the vicinity of the bogs will contain some local species, but the dominance of both willows *(Salix spp.)* anc sedge species *(Carex spp.)* will prevail.

Normally, a dense cover of willows about 1.5 m (5 ft.) high exists with other shrub species occurring only sporadically. These include bog birch *(Betula glandulosa)* and Douglas' spirea *(Spiraea douglasii)*.

Underneath the willows, sedge species such as *Carex rostrata, Carex aquatalis* and *Carex pyrenaica* are dominant. In some cases tall sedges, such as *Carex rostrata*, grow 2 m (6.5 ft.) tall, forming a dense sedge-dominated bog. Other common species are large-leaved avens *(Geum macrophyllum)*, horsetail *(Equisetum arvense)* and strawberry *(Fragaria glauca)*.

The moss layer is sporadic in occurrence and coverage, depending on the degree of moisture present and type of vegetative coverage.

Grassland Associations

The grasslands of the local study area have an interrupted pattern of occurrence. Topographically, they occur as expected on the valley floors and lower slopes, or at higher elevations they are confined to areas of compacted glacial till. Isolated patches of grassland also occur throughout the study area on exposed southern aspects at all elevations. These are usually the result of two major factors, compacted glacial till and forest history. The isolated grasslands are most commonly the result of a compacted glacial capping of fine-textured till layer restricting the establishment of trees. The resultant grasslands are generally permanent features of the landscape. The second reason for the development of grasslands within an otherwise forested environment is the occurrence of insect infestations or spot fires which have resulted in the loss of the canopy. This allows the grass cover to expand and restrict the regeneration of trees. If this process occurs on a steep south-facing slope, the successional trend towards a forest environment proceeds very slowly, resulting in a grassland condition that exists for several decades.

The grassland areas of the Hat Creek area are of great importance because they furnish spring, fall and sometimes winter grazing for livestock. The depletion of most of these grassland areas due to extensive overgrazing has resulted in a drastic alteration of the species composition. Unlike fire, which removes the entire vegetation canopy, livestock grazing selectively removes the most palatable plants and results in an invasion by woody components of the vegetation, as well as less palatable herbaceous plants. Studies have indicated that it may take 20 to 40 years for overgrazed ranges to recover to excellent range conditions[21].

Because of these problems, the grasslands were classified by their existing vegetation rather than the climax vegetation. This type of approach will yield more data concerning the present condition of the grasslands in terms of their grazing potential and future management practices needed to restore them to better quality ranges. A brief discussion on the climax vegetation to be expected if the grasslands were protected from grazing for 20 to

40 years is given here.

The climax grassland vegetation for Interior British Columbia has been initially classified by Tisdale[22] and further described by McLean[20]. Three major divisions of grassland vegetation exist: *Agropyron - Artemisia* or Lower Grassland Zone, *Agropyron - Poa* or Middle Grassland Zone, and *Agropyron - Festuca* or Upper Grassland Zone. These are essentially a vertical elevation sequence of the vegetation in response to climate. *Agropyron spicatum* is the common species which ties the three zones together and was once a dominant constituent of all the grasslands of the Interior.

The vegetation of the Lower Grassland Zone is characterized by the presence of big sagebrush *(Artemisia tridentata)* and a well-spaced cover of bluebunch wheatgrass *(Agropyron spicatum)*. Few other plant species exist. Sandberg's bluegrass *(Poa sandbergii)*, rabbitbrush *(Chrysothamnus nauseosus)* and dwarf pussytoes *(Antennaria dimorpha)* occur occasionally. This zone is confined to the major river valleys. Within the detailed study area, it is only found in the Thompson and Bonaparte river valleys.

The Middle Grassland Zone is distinguished by the dominance of bluebunch wheatgrass *(Agropyron spicatum)* in a close-spaced pattern and lack of big sagebrush *(Artemisia tridentata)*. As in the Lower Grassland Zone, species richness is poor. Common species include junegrass *(Koeleria cristata)*, Sandberg's bluegrass *(Poa sandbergii)*, pasture sage *(Artemisia frigida)* and dwarf pussytoes *(Antennaria dimorpha)*. This zone occurs mostly on lower slopes composed of glacial till material to approximately 790 m (2590 ft.) in elevation.

The Upper Grassland Zone is the moistest of the three zones and contains the greatest number of species. This climax vegetation type is the most common within the Hat Creek Valley and at higher elevations. The vegetation is characterized by a dominance of bluebunch wheatgrass *(Agropyron spicatum)* and rough fescue *(Festuca scabrella)* in dense stands. Other common constituents are junegrass *(Koeleria cristata)*, Kentucky bluegrass *(Poa pratensis)*, Columbia needlegrass *(Stipa columbiana)* and sticky geranium *(Geranium viscosissimum)*. The lack of xerophytic shrubs is evident. This zone is the highest of the three zones and usually lies adjacent to the forest area or in openings intermingled within the forest matrix.

Present Grassland Vegetation of Hat Creek and Vicinity

(xv) Highland Grassland Association (Appendix C)

This association occurs on the high mountain peaks, generally over 1800 m (5900 ft.) in elevation with a southerly exposure. The Highland Grassland Association develops on hot, dry slopes where either the Mountain Avens-Sedge or Engelmann - Spruce - Willow - Red Heather Parkland associations cannot form due to adverse growing conditions. The Highland Grassland Association is the most common non-forested association on Cornwall, Cairn's, Chipuin and Pavilion mountains. The soils are developed from very stony till or colluvium in a fine soil matrix. Moisture is limiting in the association, resulting in a dominance of grass species.

The shrub layer consists of a low, patchy growth of bearberry *(Arctostaphylos uva-ursi)* with scattered individuals of buffaloberry *(Shepherdia canadensis)* and Rocky Mountain juniper *(Juniperus scopulorum)*.

The herb layer is dominated by grass species with broad-leaved herbs becoming more dominant in areas subjected to heavy grazing pressure, as most of these high elevation grasslands are. Pinegrass *(Calamagrostis rubescens)*, purple reedgrass *(Calamagrostis purpurascens)*, timber oatgrass *(Danthonia intermedia)* and bluegrass *(Poa grayana)* are the common grasses occurring in about 75 percent of the plots. Many of the broad-leaved herbs that were common in the other lower elevation grasslands are found in the Highland Grassland Association. These include prairie purple avens *(Geum triflorum)*, windflower *(Anemone multifida)* and yarrow *(Achillea millefolium)*. Pussytoes *(Antennaria alpina)*, chickweed *(Cerastium arvense)* and sticky purple geranium *(Geranium viscosissimum)* are common.

(xvi) Kentucky Bluegrass Association (Appendix C)

This association occurs on all large open range areas found at 1200 to 1800 m (3936 to 5900 ft.) in elevation. The grassland areas of Harry Lake, Medicine Creek and McLean Lake fall within this association. The Kentucky Bluegrass Association differs from the lower Bunchgrass - Kentucky Bluegrass Association in that a higher moisture status exists in the soils. This results in a greater abundance of Kentucky bluegrass *(Poa pratensis)*. The lack of a shrub layer is also indicative of a higher moisture status. The soils are generally medium-textured glacial till with a high alkalinity. The soils are classified as Black Chernozems. Table 4-13 illustrates decreaser, increaser and invader components of the association developed from the field investigation and McLean[20].

The shrub layer is poorly developed and, in some cases, non-existent. Little wild rose *(Rosa gymnocarpa)* is the only shrub that occurs with any frequency.

Because of the increased moisture status of the soils, the herb layer has a higher species diversity than in the Bunchgrass - Kentucky Bluegrass Association. Kentucky bluegrass generally forms a complete turf over the ground surface. Western needlegrass *(Stipa occidentalis)*, Richardson's needlegrass *(Stipa richardsonii)* and junegrass *(Koeleria cristata)* comprise the bunchgrass component. Bluebunch wheatgrass *(Agropyron spicatum)* was only found on one plot.

The broad-leaved herb component contains compound fleabane *(Erigeron compositus)*, dandelion *(Taraxacum officinale)*, yarrow *(Achillea millefolium)*, strawberry *(Fragaria glauca)*, windflower *(Anemone multifida)*, cinquefoil *(Potentilla diversifolia)* and buckwheat *(Eriogonum heracleoides)* with a presence greater than 80 percent. However, their associated cover values are quite low, generally five percent or less.

Colourful spring flowers were found on several plots. These included yellow

TABLE 4-13

DECREASER, INCREASER, AND INVADER PLANTS
OF THE KENTUCKY BLUEGRASS ASSOCIATION

Decreasers	Increasers	Invaders
Agropyron spicatum	*Achillea millefolium*	*Anemone multifida*
Festuca scabrella	*Antennaria roseus*	*Cerastium arvense*
	Eriogonum heracleoides	*Erigeron compositus*
	Fragaria glauca	*Geum triflorum*
	Koeleria cristata	*Taraxacum officinale*
	Poa pratensis	
	Stipa occidentalis	
	Stipa richardsonii	

bells *(Fritillaria pudica)*, spring beauty *(Claytonia lanceolatum)*, shooting star *(Dodocathon pauciflorum)* and death-camas *(Zigadenus venenosus)*.

(xvii) Bunchgrass - Kentucky Bluegrass Association
(Appendix C)

The Bunchgrass - Kentucky Bluegrass Association is confined mainly to the valley bottom of the Hat Creek Valley. Its occurrence is restricted to below 1200 m (3936 ft.). The association has developed due to the heavy grazing presence found in the Hat Creek Valley. This is especially true on the west side of the valley, where a mixture of the Bunchgrass - Kentucky Bluegrass and Saline Depression associations occur. Table 4-14 indicates the decreaser, increaser and invader plant species found in this association developed from the field programme and McLean[20].

The shrub layer varies in its development, but generally averages approximately five percent coverage. Pasture sage *(Artemisia frigida)*, rabbitbush *(Chrysothamus nauseosus)* and little wild rose *(Rosa gymnocarpa)* are the most frequently encountered shrubs.

The herb layer contains a large number of species with the grass species dominating, in terms of total coverage. Bluebunch wheatgrass *(Agropyron spicatum)*, foxtail barley *(Hordeum jubatum)* and western needlegrass *(Stipa occidentalis)* form the major proportion of the grass component. In areas that are heavily grazed and higher in moisture, the sod-forming grass, Kentucky bluegrass *(Poa pratensis)* forms a complete turf at the expense of the bunchgrass. Normally, Kentucky bluegrass is scattered throughout the bunchgrass stand. During the field surveys, there was a noticeable lack of several bluegrasses that Brink[23] indicated to be common to the Hat Creek area, namely *Poa ampla* and *Poa sandbergii*. Both these species generally produce their fruit early and dry up by mid-summer as well as being grazed heavily. Therefore, they were probably absent at the time of the field surveys.

Broad-leaved herbaceous species are also very common. Most have increased

TABLE 4-14

DECREASER, INCREASER, AND INVADER PLANTS
OF THE BUNCHGRASS - KENTUCKY BLUEGRASS ASSOCIATION

Decreasers	Increasers	Invaders
Agropyron spicatum	*Achillea millefolium*	*Erigeron compositus*
Festuca scabrella	*Antennaria roseus*	*Geum triflorum*
Poa sandbergii	*Artemisia frigida*	*Taraxacum officinale*
	Chrysothamnus nauseosus	
	Hordeum jubatum	
	Koeleria cristata	
	Lomatium macrocarpum	
	Poa pratensis	
	Stipa occidentalis	

or invaded this association due to grazing pressure. The common species, although their coverage is not high, are compound fleabane *(Erigeron compositus)*, pussytoes *(Antennaria roseus)*, dandelion *(Taraxacum officinale)*, purple avens *(Geum triflorum)*, desert-parsley *(Lomatium macrocarpum)* and wild onion *(Allium cernuum)*. Colourful displays of yellow bells *(Fritillaria pudica)* and death-camas *(Zigadenus venenosus)* were found in several plots within this association in the early spring.

(xviii) Sagebrush - Bluebunch Wheatgrass Association (Appendix C)

This association is localized in the northern section of the upper Hat Creek Valley at the proposed mine location. This association is not very common within the Interior Douglas-fir Zone. It is found more consistently in the Ponderosa Pine - Bunchgrass Zone. The occurrence of the Sagebrush - Bunchgrass Association is probably related to the presence of high amounts of bentonite in the soil. McLean[07] found this to be true in his work in the Similkameen Valley, B.C. The soils are very fine-textured and Black to Dark Brown Chernozems. Table 4-15 illustrates the decreasers, increasers, and invaders found in this association developed from the field investigation and McLean[20].

The tree layer is non-existent, except in a disturbed area due to a mudslide, where several Douglas-fir *(Pesudotsuga menziesii var. glauca)* and ponderosa pine *(Pinus ponderosa)* are growing.

The shrub layer is dominated by big sagebrush *(Artemisia tridentata)*, where cover values range from 35 to 85 percent with a 100 percent presence. Because of the dominance of big sagebrush, all other shrubs are reduced or eliminated. Shrubs that still remain are Rocky Mountain juniper *(Juniperus scopulorum)*, rabbitbrush *(Chrysothamnus nauseosus)* and pasture sage *(Artemisia frigida)*.

As in the shrub layer, one species dominates the herb layer, namely bluebunch wheatgrass *(Agropyron spicatum)*. Other frequent grasses and herbs are needlegrass *(Stipa richardsonii)*, lemonweed *(Lithospermum ruderale)* ,

TABLE 4-15

DECREASER, INCREASER, AND INVADER PLANTS
OF THE SAGEBRUSH - BLUEBUNCH WHEATGRASS ASSOCIATION

Decreasers	Increasers	Invaders
Agropyron spicatum	*Achillea millefolium*	*Anemone multifida*
	Antennaria roseus	*Erigeron compositus*
	Artemisia frigida	
	Artemisia tridentata	
	Lithospermum ruderale	
	Lomatium macrocarpum	

yarrow *(Achillea millefolium)*, locoweed *(Oxytropis sericea)* and pussytoes *(Antennaria roseus)*.

(xix) Saline Depressional Association (Appendix C)

This association occurs through the grasslands of the Hat Creek Valley in moist receiving areas where water is collected for at least part of the year. Because evapotranspiration is greater than precipitation, salts are drawn to the surface. This limits the vegetation on these sites to species that can tolerate high alkalinity and salinity. The Saline Depressional Association is most common in the grassland areas of the west side of upper Hat Creek Valley.

The shrub layer is very poorly developed with only an occasional specimen of rabbitbrush *(Chrysothamnus nauseosus)* and Nootka rose *(Rosa nutkana)* exhibiting poor vigor.

The herb layer contains a well developed grass layer with broad-leaved herbs very sporadic in abundance. Baltic rush *(Juncus balticus)*, redtop bentgrass *(Agrostis alba)* and saltgrass *(Distichlis stricta)* dominate in the bottom of the depression where the salinity is generally the greatest. Further from the centre of the depression in less saline areas, Kentucky bluegrass *(Poa pratensis)* and dandelion *(Taraxacum officinale)* begin to become dominant.

The association is utilized heavily by livestock because the increased moisture allows for a longer growing season and, therefore, a higher productivity.

(xx) Big Sagebrush - Bunchgrass Association (Appendix C)

This association is the driest in the study area and is confined to the lower valley slopes on glacial till and glaciofluvial deposits. The elevation range is generally between 400 and 650 m (1312 and 2132 ft.). It is developed on Brown Chernozemic soils under the influence of the semiarid climate in the Ponderosa Pine - Bunchgrass Zone. This grassland association is closely tied with the Sagebrush - Bluebunch Wheatgrass Association that occurs in the Interior Douglas-fir Zone. The major differentiating characteristic between the two is the occurrence of a greater number of species, due to the superior soil moisture conditions found in the Sagebrush - Bluebunch Wheatgrass Association of the Interior Douglas-fir Zone. Table 4-16 lists the increaser, decreaser and invader plant species for this association developed from the field investigations and McLean[20].

The shrub layer consists of big sagebrush *(Artemisia tridentata)* as the characteristic shrub. Other shrubs such as rabbitbrush *(Chrysothamnus nauseosus)* and pasture sage *(Artemisia frigida)* are infrequent or low in coverage.

The herb layer is well developed with bluebunch wheatgrass *(Agropyron spicatum)* dominating in areas not overgrazed. With overgrazing, bluebunch wheatgrass is replaced by Sandberg's bluegrass *(Poa sandbergii)*, needle-and-thread *(Stipa comata)*, sand dropseed *(Sporobolus cryptandrus)* and downy brome *(Bromus tectorum)*. The broad-leaved herbs are generally very scattered and low in mean cover (less than five percent). The most constant species are line-leaved fleabane *(Erigeron linearis)*, dwarf pussytoes *(Antennaria dimorpha)*, cactus *(Opuntia fragilis)*, whitlow-grass *(Draba verna)* lemonweed *(Lithospermum ruderale)* and Russian thistle *(Salsola kali)*.

(c) Successional Pattern

The vegetation of the detailed study area is largely in a successional state due to past forest fires, logging and grazing histories. In terms of forest fires and logging, the major alteration to the vegetation is to the overstory or tree component. Although the understory component is largely removed by fire and somewhat altered by logging, it tends to remain in small clumps or regenerate from underground rhizomes after disturbances[09, 24]. The understory component changes occur as a decrease in abundance of forest species (shade-

TABLE 4-16

DECREASER, INCREASER, AND INVADER PLANTS
OF THE BIG SAGE - BUNCHGRASS ASSOCIATION

Decreasers	Increasers	Invaders
Agropyron spicatum	*Antennaria dimorpha*	*Bromus tectorum*
Stipa comata	*Artemisia frigida*	*Descurainia sophia*
	Artemisia tridentata	*Draba verna*
	Chrysothamnus nauseosus	*Salsola kali*
	Lomatium macrocarpum	
	Poa sandbergii	
	Sporobolus cryptandrus	

loving) and the invasion of the site by species such as fireweed *(Epilobium spp.)* and willows *(Salix spp.)*. These invader species generally persist until the forest canopy closes (10 to 20 years). Unlike the short-lived understory successional species (invaders), the forest trees persist for a much longer period of time and have a much greater influence on the forest environment.

The common successional tree species of the detailed study area are lodgepole pine *(Pinus contorta)*, ponderosa pine *(Pinus ponderosa)* and Douglas-fir *(Pseudotsuga menziesii var. glauca)*. Lodgepole pine occurs above 1065 m (3500 ft.) above sea level and is the most common successional species in the higher elevation forests. Douglas-fir is found as a successional species only above 1525 m (5000 ft.) above sea level; below this level it forms part of the climax forest. At elevations below 1065 m (3500 ft.), ponderosa pine becomes the sole successional species in open parklike stands. Because of the diverse histories of the forests in terms of forest fires and logging, the forest stands now exist mainly as a mosaic of pure and mixed successional forest. Climax forest species usually are found as dominant regeneration components, lesser components of mixed successional stands, or isolated patches of pure climax forest stands.

As forest fires and logging have a profound effect on the forest composition, so does livestock grazing affect both open ranges and forest ranges. Domestic grazing use of the rangelands in the detailed study area has been extensive, especially in the Interior Douglas-fir and Ponderosa Pine - Bunchgrass zones. The effect of livestock grazing is the alteration of the species composition towards species that can withstand grazing pressure. This generally results in a decrease in the palatable grasses and herbs, an increase in the unpalatable species, and an invasion of the rangeland by species that could not compete for moisture, light and nutrient before the preferred species had been destroyed by grazing. Many of these invaders have some grazing values.

Grazing has been very heavy in the open ranges of the Hat Creek Valley, Medicine - Cornwall Creek areas, Harry Lake vicinity, Thompson River Valley, and all the alpine areas. The forest ranges have suffered less than the open ranges, with the greatest depletion occurring in the Cornwall Mountain - Bedard Lake area. Difficult access and lack of preferred grazing species has lessened the impact on the forest ranges.

(d) Quantitative Aspects

(i) Regional

The total area in both square kilometres and square miles was calculated for all the biogeoclimatic zones within the regional study area (Table 4-17).

Within the regional study area, the Engelmann Spruce - Subalpine Fir Biogeoclimatic Zone is the most widely distributed and covers the most area (40 percent). The Interior Douglas-fir Zone follows closely behind with a square kilometre area of 11,300 or 33 percent. Localized occurrences of the Coastal Western Hemlock and Subalpine Mountain Hemlock zones are found in the extreme southwest portion of the study area, where areas of 389 and 648 km^2 or 1.2 and 1.9 percent of the total area are encountered respectively.

(ii) Local Study Area

Table 4-18 shows the areas covered by each vegetation association and vegetation complex found within the local study area (which encompasses approximately 1621 km^2). The dominant vegetation association is the Douglas-fir - Pinegrass which covered 30 percent of the total study area followed by the Big Sagebrush - Bunchgrass (12.5 percent), Engelmann Spruce - Grouseberry (12.4 percent), Engelmann Spruce - Grouseberry - Pinegrass (11.5 percent), and Douglas-fir - Pinegrass - Bunchgrass (9 percent). Other vegetation associations each cover less than five percent of the study area.

TABLE 4-17

AREA SUMMARY OF THE BIOGEOCLIMATIC ZONES
FOUND IN THE REGIONAL STUDY AREA

Biogeoclimatic Zone	Area (km^2)	Area (mi^2)
Engelmann Spruce - Subalpine Fir Zone	13,670.	5,278.
Interior Douglas-fir Zone	11,300.	4,363.
Cariboo Aspen - Lodgepole Pine - Douglas-fir Zone	3,495.	1,350.
Ponderosa Pine - Bunchgrass Zone	3,253.	1,256.
Alpine Tundra Zone	980.	378.
Subalpine Mountain Hemlock Zone	648.	250.
Coastal Western Hemlock Zone	389.	150.
Interior Western Hemlock Zone	200.	77.
TOTAL	33,935.	13,102.

TABLE 4-18 (Continued)

Vegetation Association	Area (km^2)	Area (mi^2)
Douglas-fir - Spirea - Bearberry Association	0.8	0.3
Ponderosa Pine - Bunchgrass Zone		
Ponderosa Pine - Bunchgrass Association	13.9	5.4
Intrazonal		
Riparian Association	10.1	3.9
Engelmann Spruce - Horsetail Association	6.2	2.4
Willow - Sedge Bog Association	6.5	2.5
Grassland Association		
Highland Grassland Association	9.1	3.5
Kentucky Bluegrass Association	46.6	18.0
Bunchgrass - Kentucky Bluegrass Association	25.6	9.9
Sagebrush - Bluebunch Wheatgrass Association	6.7	2.6
Saline Depression Association	0.3	0.1
Big Sagebrush - Bunchgrass Association	199.9	77.2

TABLE 4-18 (Continued)

Vegetation Association	Area (km^2)	Area (mi^2)
Complexes		
Bunchgrass - Kentucky Bluegrass/ Saline Depression Complex	21.7	8.4
Rock/Douglas-fir - Spirea - Bearberry Complex	0.5	0.2
Douglas-fir - Spirea - Bearberry/ Douglas-fir - Pinegrass - Bunchgrass Complex	14.2	5.5
Douglas-fir - Pinegrass/Douglas-fir - Spirea - Bearberry Complex	6.0	2.3
Mountain Avens - Sedge/Highland Grassland Complex	23.3	9.0
Kentucky Bluegrass/ Riparian Complex	8.3	3.2
Douglas-fir - Bunchgrass/ Douglas-fir - Spirea - Bearberry Complex	10.1	3.9
Highland Grassland/Engelmann Spruce - Willow - Red Heather Parkland Complex	0.08	0.03
Other		
Logged Areas	164.2	63.4
Cultivated Fields	30.3	11.7
Non Satisfactorily Restocked Areas	28.7	11.1
Water	7.5	2.9
Rock	7.0	2.7
TOTAL	1621.1	625.9

Logged areas within the study area comprise 164.2 km^2 or 10 percent of the total study area.

(e) Plant Species Checklist

The plant species identified during the field studies have been grouped in the following species list by vegetation strata (Table 4-19). The following manuals were used during the identification:

Hubbard[25]
Lyons[26]
Mulligan[27]
Schofield[28]
Taylor[29]
Taylor[30]
Clark[31]
Demarchi[32]
Hitchcock[33]
Hitchcock[34].

During the field studies, no rare or endangered species were encountered that are listed on the endangered species lists[35, 36, 37]. It should be noted that, within the local study area, several species of showy wildflowers that exhibit beautiful spring colours do exist. These include yellow bells *(Fritillaria pudica)*, shootingstar *(Dodocathon pauciflorum)*, spring beauty *(Claytonia lanco-lata)*, and death camas *(Zigadenus venenosus)*. In a regional perspective, two known species that occur near Hat Creek have been identified as endangered, namely swordfern *(Polystichum kruckbergii)* and locoweed *(Oxytropis podocarpa)**.

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* Pojar, James. Personal communication.

TABLE 4-19

PLANT SPECIES CHECKLIST

Trees:

Abies lasiocarpa
Alnus rubra
Picea engelmanni
Pinus albicaulis
Pinus contorta
Pinus ponderosa
Populus tremuloides
Populus trichocarpa
Pseudotsuga menziesii var. glauca
Salix spp.

Shrubs:

Acer glabrum
Actaea rubra
Alnus incana
Alnus rubra
Amelanchier alnifolia
Arctostaphylos uva-ursi
Artemisia campestris
Artemisia dracunculus
Artemisia frigida
Artemisia tridentata
Betula glandulosa
Cassiope mertensiana
Chrysothamnus nauseosus
Cornus stolonifera
Empetrum nigrum
Juniperus communis
Juniperus scopulorum
Kalmia microphylla
Lonicera involucrata
Pachystima myrsinites
Phyllodoce glandiflora
Physocarpus capitatus
Pinus albicaulis
Rhododendron albiflorum
Ribes inerme
Ribes lacustre
Ribes oxyacanthoides

TABLE 4-19 (Continued)

Rosa gymnocarpa
Rosa nutkana
Rosa woodsii
Rubus ideaus
Salix cascadensis
Salix nivalis
Salix sp.
Shepherdia canadensis
Spiraea betulifolia
Spiraea douglasii
Symphoricarpos albus
Vaccinium caespitosum
Vaccinium membranaceum
Vaccinium scoparium

Grasses:

Agropyron caninum
Agropyron cristatum
Agropyron repens
Agropyron smithii
Agropyron spicatum
Agrostis alba
Agrostis scabra
Bromus ciliatus
Bromus erectus
Bromus inermis
Bromus tectorum
Calamagrostis canadensis
Calamagrostis purpurascens
Calamagrostis rubescens
Carex albo-nigrum
Carex aquatilis
Carex petasata
Carex praticola
Carex pyrenaica
Carex rostrata
Carex sp.
Cinna latifolia
Danthonia intermedia
Distichlis stricta
Eleocharis palustris
Elymus cinereus
Eriophorum viridiarinatum
Festuca arundinacea
Festuca occidentalis

TABLE 4-19 (Continued)

Festuca ovina var. brevifolia
Festuca ovina var. rydbergii
Festuca rubra
Festuca scabrella
Hordeum jubatum
Juncus balticus
Juncus filifolius
Juncus tenuis
Koeleria cristata
Luzula glabrata
Luzula hitchcockii
Luzula piperi
Muhlenbergia sylvatica
Oryzopsis hymenoides
Phleum alpinum
Phleum pratense
Poa alpina
Poa cusickii
Poa gracillima
Poa grayana
Poa interior
Poa juncifolia
Poa nevadensis
Poa pratensis
Poa sandbergii
Poa scabrella
Spartina gracilis
Sporobolus cryptandrus
Stipa comata
Stipa occidentalis
Stipa richardsonii
Trisetum spicatum

Herbs:

Achillea millefolium
Allium cernuum
Anemone lyallii
Anemone multifida
Antennaria alpina
Antennaria anaphaloides
Antennaria dimorpha
Antennaria neglecta
Antennaria parvifolia
Antennaria roseus
Antennaria umbrinella

TABLE 4-19 (Continued)

Arabis drummondii
Arabis holboelii
Arenaria capillaris
Arnica cordifolia
Arnica latifolia
Arnica rydbergii
Aster campestris
Aster ciliolatus
Aster conspicuus
Astragalus filipes
Astragalus miser
Astragalus purshii
Astragalus sp.
Balsamorhiza sagittata
Castilleja miniata
Centaurea diffusa
Cerastium arvense
Chaenatis douglasii
Chenopodium leptophyllum
Chimphila menziesii
Claytonia lanceolata
Commandra umbellata
Cornus canadensis
Crepis atrabarba
Cystopteris fragilis
Descurainia sophia
Disporum trachycarpum
Dodocathon pauciflorum
Draba verna
Dryas octopetala var. hookeriana
Empetrum nigrum
Epilobium angustifolium
Epilobium glandulosum
Equisetum arvense
Equisetum scirpoides
Erigeron compositus
Erigeron flagellaris
Erigeron linearis
Erigeron philadelphicus
Erigeron peregrinus
Erigeron speciosus
Erigeron subtrinervis
Eriogonum heracleoides
Eriogonum pyrolifolium
Fragaria glauca
Fritillaria pudica
Gaillardia aristata

TABLE 4-19 (Continued)

Galium boreale
Galium triflorum
Gentiana amarella
Geranium viscossissium
Geum macrophyllum
Geum triflorum
Goodyera oblongifolia
Haplopappus lyallii
Hedysarum boreale
Heracleum lanatum
Heuchera cylindrica
Lathyrus nevadensis
Lathyrus ochroleucus
Lemna minor
Lewisia rediviva
Linnaea borealis
Listera caurina
Lithospermum ruderale
Lomatium macrocarpum
Lomatium sp.
Lonicera involucrata
Lupinus lepidus
Lycopodium camplanatum
Medicago lupulina
Melilotus alba
Mitella trifida
Opuntia fragilis
Osmorhiza chilensis
Oxytropis campestris
Oxytropis sericea
Parnassia fimbricata
Pedicularis bracteosa
Pedicularis racemosa
Penstemon fruticosus
Penstemon procerus
Petasites frigida var. nivalis
Phacelia sericea
Phlox longifolia
Phyllodoce empetriformis
Plantago major
Polemonium pulcherrimum
Polygonum viviparum
Potamogeton spp.
Potentilla arguta
Potentilla diversifolia
Potentilla hippiana
Pyrola chlorantha
Pyrola secunda

TABLE 4-19 (Continued)

Pyrola uniflora
Rhus radicans
Salsola kali
Saxifraga bronchialis
Saxifraga lyallii
Sedum lanceolatum
Sedum stenopetalum
Senecio deblis
Senecio megacephalus
Senecio triangularis
Silene douglasii
Silene parryi
Sisymbrium altissimum
Smilacina stellata
Solidago multiradiata
Solidago spathulata
Stellaria calycantha
Stellaria longipes
Streptopus amplexifolius
Streptopus roseus
Taraxacum officinale
Thalictrum occidentale
Tragopogon dubius
Trifolium repens
Trollius laxus
Valeriana sitchensis
Vicia americana
Viola adunca
Viola canadensis
Zigadenus venenosus

Lichens:

Alectoria americana
Alectoria fremontii
Alectoria jubata
Alectoria saramentosa
Cladonia cornuta
Cladonia gonecha
Cladonia gracilis
Cladonia phyllophora
Cladonia pyxidata
Cladonia rangiferina
Letharia vulpina
Peltigera aphthosa
Peltigera canina
Peltigera polydactyla

TABLE 4-19 (Continued)

Mosses:

Aulacomium palustre
Dicranum fusescens
Drepanocladus uncinatus
Hylocomium splendens
Leptobyrum pyriforme
Pleurozium schreberi
Pohlia nutans
Polytrichum juniperinum
Polytrichum piliferum
Sphagnum spp.
Tortula ruralis

(f) Importance of the Plant Species to Wildlife, Man, and Livestock

The plant species identified during the field studies were investigated for species that may be important to man, livestock, or wildlife. This was accomplished by reviewing the literature[38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48] for pertinent information concerning the use of the plant species found in Hat Creek for food or cover requirements. Table 4-20 lists the species that were found to be important to man, wildlife, or livestock. The table gives the resource use, its relative importance, the major season the plant species are utilized, and the relative abundance of the plant species in the Hat Creek local study area. General comments were made where applicable. It should be emphasized that the information concerning resource use, importance, and season of use were derived from the literature and does not cover all the plant species that may be used by local wildlife and livestock.

TABLE 4-20

RELATIVE IMPORTANCE AND USE OF THE PLANT SPECIES FOUND IN THE LOCAL STUDY AREA TO WILDLIFE, LIVESTOCK, AND MAN

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
TREES:					
Abies lasiocarpa	Low	Forestry	Low		Some local forestry value
		Blue Grouse	Low	All Seasons	Buds and leaves utilized
		Moose	Medium	Summer	
Alnus rubra	Low	Moose	Low	Winter/Spring	
Picea engelmannii	Medium	Forestry	Medium		
		Grouse	Low	All	Buds
Pinus albicaulis	Low	Forestry	Very Low		Very localized forest value
Pinus contorta	High	Forestry	Medium		
		Moose	Low	Winter/Spring	
		Bighorn Sheep	Low	Winter/Spring	Wildlife/Forestry conflict
		Elk	Low	Winter/Spring	
		Man	N/A	Spring	Bark
		Grouse	Low	All Seasons	Buds utilized
Pinus ponderosa	High	Forestry	Low		Some local forestry value
		Deer	Medium-High	Winter/Spring	Forage and cover. Forestry/wildlife conflict
		Livestock	Low	Spring/Fall	Abortion (potential)
Populus tremuloides	High	Elk	Medium-Low	Summer/Fall	
		Elk	Medium	Winter/Spring	
		Deer	Low	Winter/Spring	
		Deer	Low	Summer/Fall	
		Moose	Medium	Winter/Spring	
		Livestock	High	All Grazing Season	New shoots

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Populus tremuloides (continued)		Beaver	High	All Seasons	
		Ruffed Grouse	High	All Seasons	Buds and leaves forming 25% of diet
Populus trichocarpa	Medium	Moose	Medium-Low	Winter/Spring	
Pseudotsuga menziesii var. glauca	High	Forestry	High	N/A	
		Elk	Low	Summer/Fall	
		Elk	Low	Winter/Spring	Used by wildlife as forage as well as for cover. Wildlife/forestry conflict.
		Deer	Medium	Winter/Spring	
		Deer	Medium	Summer/Fall	
		Bighorn Sheep	Low	Winter/Spring	
		Gamebirds	High	All Seasons	Buds and leaves forming up to 50% of diet.
SHRUBS:					
Acer glabrum	Low	Moose	Medium	Winter/Spring	
		Elk	Medium	Winter/Spring	
Amelanchier alnifolia	Medium	Deer	Medium-High	Winter/Spring	
		Moose	Medium-High	Winter/Spring	
		Bighorn Sheep	Low	Winter/Spring	
		Elk	Medium-High	Winter/Spring	
		Livestock	Medium	Late Summer/Fall	Livestock/wildlife competition
		Man	N/A	Late Summer	Berries
		Gamebirds	Low	All Seasons	Buds
Arctostaphylos uva-ursi	High	Deer	Medium-High	Winter/Spring	
		Bighorn Sheep	Low	Winter/Spring	
		Man	N/A	Early Fall	Berries

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Artemisia dracunculus	Low	Deer	Medium-Low	Winter/Spring	
		Deer	Low	Summer/Fall	
		Bighorn Sheep	Medium	Winter/Spring	
		Elk	Medium-Low	Summer/Fall	
		Elk	Low	Winter/Spring	
Artemisia frigida	High	SEE *Artemisia dracunculus* - WILDLIFE			
		Livestock	Low	Late Summer/Fall	Important browse species on sheep winter range. Livestock/wildlife competition.
Artemisia tridentata	High	Deer	Medium	All Seasons	Important browse species in big sagebrush benchlands at mouth of upper Hat Creek
Betula glandulosa	Low	Moose	Medium-Low	Summer/Fall	Found in one bog area at Pavilon Creek
		Moose	Medium-Low	Winter/Spring	
Chrysothamnus nauseosus	High	Deer	Medium-Low	Winter/Spring	A widely distributed species in Hat Creek
		Elk	Medium-Low	Winter/Spring	
Cornus stolonifera	High	Moose	Medium	Winter/Spring	Important winter browse species
		Elk	Medium	Winter/Spring	
		Livestock	Low-Medium	Late Summer-Fall	
Empetrum nigrum	Low	Man	N/A	Late Summer	Berries
Juniperus communis	High	Deer	Medium	Winter/Spring	
		Deer	Medium-Low	Summer/Fall	
		Elk	Low	Summer/Fall	
		Man	N/A	Fall	Berries
		Gamebirds	Low	All Seasons	Berries

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Juniperus scopulorum	SEE *Juniperus communis* - WILDLIFE				
	High	Gamebirds	Low	All Seasons	Berries
Kalmia microphylla	Low	Livestock	Low	-	Poisonous
Lonicera involucrata	Medium	Gamebirds	Low	All Seasons	
Pachystima myrsinites	Low	Moose	High	Winter/Spring	One occurrence noted in the Pavilon mountains
		Elk	Low	Winter/Spring	
		Gamebirds	Low	All Seasons	
Ribes inerme	Low	Deer	Medium	Summer/Fall	
		Bighorn Sheep	Low	Winter/Spring	
		Gamebirds	Low	All Seasons	
Ribes lacustre	SEE *Ribes inerme* - WILDLIFE				
	Medium	Gamebirds	Low	All Seasons	
Ribes oxyacan-thoides	SEE *Ribes inerme* - WILDLIFE				
	Low	Gamebirds	Low	All Seasons	
Rosa gymnocarpa	High	Deer	Medium-Low	Winter/Spring	
		Deer	Medium	Summer/Fall	
		Bighorn Sheep	Low	Winter/Spring	
		Elk	Medium-Low	Summer/Fall	
		Elk	Low	Winter/Spring	
		Livestock	Medium-High	Summer/Fall	
		Gamebirds	Medium	All Seasons	
Rosa nutkana	SEE *Rosa gymnocarpa* - WILDLIFE				
	High	Man	N/A	Fall	Hips
		Gamebirds	Medium	All Seasons	

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Vaccinium scoparium	SEE *Vaccinium caespitosum* - WILDLIFE				
GRASSES:					
Gramineae (undefined grass species)	High	Deer	Medium-Low	Winter/Spring	
		Deer	Low	Summer/Fall	Extensively used by wildlife throughout the year
		Bighorn Sheep	High	Winter/Spring	
		Elk	Medium-High	Summer/Fall	
		Elk	High	Winter/Spring	
		Gamebirds	Low	All Seasons	
		Livestock	High	All Grazing Season	Very serious livestock/wildlife conflict
Agropyron caninum	Medium	Deer	Medium	Winter/Spring	
		Livestock	High	Spring/Summer	Livestock/wildlife competition
		Gamebirds	Low	All Seasons	Seeds
Agropyron cristatum	SEE *Agropyron caninum* - WILDLIFE				
	Medium	Livestock	High	Summer	Livestock/wildlife competition
Agropyron repens	SEE *Agropyron caninum* - WILDLIFE				
	Low	Livestock	Low	Spring/Summer	Livestock/wildlife competition
		Man	N/A	All Seasons	Roots
Agropyron smithii	SEE *Agropyron caninum* - WILDLIFE				
	Low	Livestock	High	Spring/Summer	Livestock/wildlife competition
Agropyron spicatum	High	Deer	Medium	Winter/Spring	One of the most important winter forage species
		Bighorn Sheep	High	Winter/Spring	
		Elk	Medium-High	Summer/Fall	
		Elk	High	Winter/Spring	
		Livestock	High	Spring/Summer	Very serious livestock/wildlife competition

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Agropyron spicatum (continued)		Gamebirds	Low	All Seasons	Seeds
Agrostis alba	Medium	Livestock	High	Spring/Summer	
		Waterfowl	Medium	N/A	
Agrostis scabra	Medium	Livestock	Medium	All Grazing Season	
Bromus ciliatus	Low	Elk	Medium	Summer/Fall	Important wildlife forage species
		Elk	Medium-High	Winter/Spring	
		Livestock	Medium	All Grazing Season	Livestock/wildlife conflict
		Chukar	Low	All Seasons	
Bromus erectus	SEE *Bromus ciliatus* - WILDLIFE				
	Low	Livestock	Medium	All Grazing Season	Livestock/wildlife conflict
Bromus inermis	SEE *Bromus ciliatus* - WILDLIFE				
	Low	Livestock	Medium	All Grazing Season	Livestock/wildlife conflict
Bromus tectorum	SEE *Bromus ciliatus* - WILDLIFE				
	High	Livestock	Low	Spring	
Calamagrostis canadensis	Medium	Elk	Medium-Low	Winter/Spring	
		Livestock	Low	Spring/Fall	
		Gamebirds	Low	All Seasons	Seeds
Calamagrostis purpurascens	Low	Elk	Medium-Low	Winter/Spring	
		Livestock	Medium	All Grazing Season	Livestock/wildlife conflict

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Calamagrostis rubescens	High	Elk	Medium-Low	Winter/Spring	
		Livestock	Medium	Late Summer	Livestock/wildlife conflict
Carex spp.	High	Deer	Low	Winter/Spring	
		Moose	Medium	Winter/Spring	
		Moose	Medium-Low	Summer/Fall	
		Bighorn Sheep	Low	Winter/Spring	
		Elk	Medium-Low	Winter/Spring	
		Livestock	Low	Fall	Livestock/wildlife conflict
		Waterfowl	Medium	N/A	Food and cover
		Blue and Spruce Grouse	Low	All Seasons	Seeds (less than 5% of diet)
Carex albo-nigrum	SEE *Carex sp.* - WILDLIFE				
	Low	Livestock	Medium	Late Summer/Fall	
		Waterfowl	Medium	N/A	Food and cover
Carex aquatilis	SEE *Carex albo-nigrum* - WILDLIFE				
	Low	Livestock	Low	Spring/Fall	
		Waterfowl	Medium	N/A	Food and cover
Carex petasata	SEE *Carex albo-nigrum* - WILDLIFE				
	Low	Livestock	Low	Fall	
		Waterfowl	Medium	N/A	Food and cover
Carex praticola	SEE *Carex albo-nigrum* - WILDLIFE				
	Low	Livestock	Low	Fall	
Carex pyrenaica	SEE *Carex albo-nigrum* - WILDLIFE				
	Low	Livestock	Low	Spring/Fall	
Carex rostrata	SEE *Carex albo-nigrum* - WILDLIFE				
	Medium	Livestock	High	Summer/Fall	

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Carex rostrata (continued)		Waterfowl	Medium	N/A	Food and cover
Danthonia inter-media	Medium	Livestock	Medium	All Grazing Season	
		Gamebirds	Low	All Seasons	
Distichlis stricta	Medium	Livestock	Low	Spring	
Eleocharis palustris	Low	Waterfowl	High	N/A	Food and cover
Elymus cinereus	Medium	Livestock	Medium	Spring	
		Waterfowl	Medium	N/A	Food and cover
Eriophorum viridi-arinatum	Low	Livestock	Low	-	
Festuca occidentalis	Low	Livestock	Medium	Spring	
		Gamebirds	Low	All Seasons	
Festuca ovina var. brevifolia	Medium	Bighorn Sheep	Medium-High	Winter/Spring	
		Gamebirds	Low	All Seasons	
Festuca ovina var. rydbergii	Medium	Livestock	Medium	Spring	
		Gamebirds	Low	All Seasons	
Festuca rubra	Low	Livestock	Medium	Spring/Fall	
Festuca scabrella	Low	Livestock	Medium	Spring	
Hordeum jubatum	High	Livestock	High	All Seasons	
		Waterfowl	High	N/A	

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Juncus balticus	Medium	Livestock	Low	Spring	
		Waterfowl	Medium	N/A	
Juncus filifolius	Low	Livestock	Low	All Grazing Season	Livestock/wildlife conflict
		Waterfowl	Medium	N/A	Food and cover
Juncus tenuis	SEE *Juncus filifolius* - WILDLIFE				
	Medium	Livestock	Low	All Grazing Season	
		Waterfowl	Medium	N/A	Food and cover
~~*Koeleria cristata*~~	~~High~~	~~Deer~~	~~Medium~~	~~Winter/Spring~~	
		Bighorn Sheep	Medium-Low	Winter/Spring	
		Livestock	Medium	Spring/Summer	Livestock/wildlife conflict
Muhlenbergia sylvatica	Low	Livestock	Medium	All Grazing Season	
Oryzopsis hymenoides	Low	Livestock	High	All Grazing Season	
		Gamebirds	Low	All Seasons	Seeds
Phleum alpinum	Medium	Livestock	Medium	All Grazing Season	
		Deer	Medium	Summer	
Phleum pratense	Medium	Livestock	High	Spring	
		Waterfowl	Medium	N/A	Food and cover
Poa alpina	Medium	Deer	Medium-High	Winter/Spring	All *Poa spp.* important wildlife forage species
		Bighorn Sheep	Medium-High	Winter/Spring	

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Poa alpina (continued)		Elk Livestock	Medium Medium-Low	All Seasons All Grazing Season	 Livestock/wildlife conflict
Poa cusickii	SEE *Poa alpina* - WILDLIFE				
Poa gracillima	SEE *Poa alpina* - WILDLIFE				
Poa grayana	SEE *Poa alpina* - WILDLIFE				
Poa interior	SEE *Poa alpina* - WILDLIFE				
	Medium	Livestock	Low	Spring	
Poa juncifolia	SEE *Poa alpina* - WILDLIFE				
	Low	Livestock	Low	Spring/Summer	
Poa nevadensis	SEE *Poa alpina* - WILDLIFE				
Poa pratensis	SEE *Poa alpina* - WILDLIFE				
	High	Livestock	Medium	All Grazing Season	
Poa sandbergii	SEE *Poa alpina* - WILDLIFE				
	Medium	Livestock	Low	Spring	
Poa scabrella	Medium	Livestock	Low	All Grazing Season	
Spartina gracilis	Low	Livestock	Low	All Grazing Season	
		Waterfowl	Medium	N/A	Food and cover

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Sporobolus cryptandrus	Medium	Livestock	Medium	Spring	
		Gamebirds	Low	All Seasons	Seeds
Stipa comata	Medium	Livestock	Medium	Spring/Summer	
		Gamebirds	Low	All Seasons	Seeds
Stipa occidentalis	Medium	Bighorn Sheep	Low	Winter/Spring	
		Livestock	Low	Spring/Summer	
		Gamebirds	Low	All Seasons	
Stipa richardsonii	Medium	Livestock	Low	Spring/Summer	
		Gamebirds	Low	All Seasons	
Trisetum spicatum	Medium	Livestock	Low	Spring/Summer	
HERBS:					
Achillea millefolium	High	Deer	Medium-Low	Winter/Spring	
		Bighorn Sheep	Low	Winter/Spring	
Allium cernum	Medium	Man	N/A	All Seasons	
Antennaria alpina	Medium	Deer	Medium-Low	Winter/Spring	
		Grouse	Low	All Seasohs	Important forage species on deer spring range. Forms less than 5% of Grouse's diet.
Antennaria anaphaloides	Low	Deer	Medium-Low	Winter/Spring	
		Grouse	Low	All Seasons	
Antennaria dimorpha	Medium	Deer	Medium-Low	Winter/Spring	
		Grouse	Low	All Seasons	
Antennaria neglecta	Low	Deer	Medium-Low	Winter/Spring	
		Grouse	Low	All Seasons	

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Antennaria parvifolia	Medium	Deer Grouse	Medium-Low Low	Winter/Spring All Seasons	Important forage species on deer spring range. Forms less than 5% of Grouse's diet.
Antennaria roseus	High	Deer Grouse	Medium-Low Low	Winter/Spring All Seasons	
Antennaria umbrinella	Low	Deer Grouse	Medium-Low Low	Winter/Spring All Seasons	
Arnica cordifolia	High	Livestock	Low	Summer	
Aster campestris	Low	Deer Elk	Medium Medium	Summer/Fall Summer/Fall	
Aster ciliolatus	Low	Deer Elk	Medium Medium	Summer/Fall Summer/Fall	
Aster conspicuus	High	Deer Elk	Medium Medium	Summer/Fall Summer/Fall	
Astragalus sp.	Medium	Livestock	Medium	Summer/Fall	
Astragalus miser	Medium	Livestock	Medium	Summer/Fall	
Astragalus purshii	Medium	Livestock	Medium	All Grazing Season	
Balsamorhiza sagittata	Medium	Deer	Medium	All Seasons	Important forage species on spring ranges
Castilleja miniata	Medium	Livestock	Low	Summer	

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Epilobium angustifolium	Low	Livestock	Low	Spring/Summer	
Equisetum arvense	Medium	Moose Moose	Medium Medium-High	Winter/Spring Summer/Fall	
Equisetum scirpoides	Medium	SEE *Equisetum arvense* - WILDLIFE			
Erigeron speciosus	Low	Livestock	Medium	Summer	
Eriogonum heracleoides	Medium	Bighorn Sheep Gamebirds	Medium-Low Low	Winter/Spring All Seasons	 Seeds
Eriogonum pyrolifolium	Low	Gamebirds	Low	All Seasons	Seeds
Fragaria glauca	High	Man Livestock	N/A Low	Summer Spring/Summer	
Fritillaria pudica	Medium	Man	N/A	Spring	Bulb
Geranium viscossissium	Low	Livestock	Low	All Grazing Season	
Lathyrus ochroleucus	Low	Livestock	High	All Grazing Season	
Lemna minor	Low	Waterfowl	Medium	N/A	Aquatic plant
Lewisia rediviva	Low	Man	N/A	Spring	Roots

TABLE 4-20 (Continued)

Plant Species	Relative Abundance	Resource Use	Relative Importance	Season of Use	Comments
Trifolium repens	Low	Livestock	High	All Grazing Season	
		Man	N/A	Summer	Roots
		Gamebirds	Low	All Seasons	
Valeriana sitchensis	Low	Livestock	Low	All Grazing Season	
MOSSES:					
Moss (General):	High	Spruce Grouse	Low	All Seasons	Less than 5% of diet.

8.0 GLOSSARY

8.1 PHYSICAL HABITAT

aeolian deposit: material transported and deposited by wind and consisting mainly of silt-sized particles

A-horizon: This is a mineral horizon formed at or near the soil surface in the zone of the removal of materials.

alkaline: soils containing excess of strong bases usually sodium or calcium

alluvial fan: postglacial materials deposited by streams and rivers that occur at the mouth of a river in a fan-shaped deposit. An alluvial fan may have either a neutral or a steeply sloping topography depending on the angle of the repose of the stream course.

alluvium: postglacial materials moved and redeposited by water. It consists of sediments deposited by streams.

androcite: a volcanic rock composed of little quartz and large amounts of dark-coloured minerals

argillite: a rock derived either from siltstone, claystone or shale that has undergone a higher degree of pressure and heat ranges than the rocks they are derived from

basalt: an extrusive volcanic rock with a high quartz content commonly associated with the Interior Plateau lavas base saturation: the extent to which the absorption complex of a soil saturated with exchangeable cations other than hydrogen and aluminium

bentonite: a clay formed from the decomposition of volcanic ash and composed of clay minerals

B-horizon: this is a mineral horizon that is enriched by either silicate clay, iron, aluminium or humus, or possesses a columnar of prismatic structure

chernozemic A-horizon: an Ah-horizon that is not less than 9 cm (3.5 in.) thick; its colours have values darker than 3.5 when moist and 5.5 when dry, and chromas of less than 3.5 when moist.

chert: rock high in silica and derived through heat and pressure; flint is the most commonly known chert

coarse-texture: the texture exhibited by sands, loamy sands and sandy loams, except very fine sandy loam

colluvium: soil and rock materials transported down a mountain slope by the action of gravity

dacite: an extrusive volcanic rock with relatively high quartz content

drumlin: an elongated or oval hill of glacial till, deposited by glacier ice with its long axis parallel to the direction of ice movement

drumlinized: a stream-lined hill and swale topography in glacial drift, with the long axis parallel to the direction of flow of the former glacier esker: serpentine ridges of sand and gravel deposited in ice tunnel rivers

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

ephemeral stream: stream or portion of a stream which flows only in direct response to precipitation. Its channel is at all times above the water table

fine-texture: consisting of or containing large quantities of the fine fractions, particularly silt and clay. It includes all clay loams and clays, clay loam, sandy clay loam, silty clay loam, sandy clay, silty clay, and clay textural classes.

glacial outwash: materials swept out, sorted and deposited beyond the glacial ice front by streams of melt water. Outwash usually exists in the form of flat plains or terraces

glacial till: material which has been deposited directly by the ice with little or no transportation by water. It is generally an unstratified, unconsolidated, heterogeneous mixture of clay, silt, sand, gravel and boulders.

gneiss: a coarse-grained rock highly changed due to heat and pressure still maintaining the banding of its sedimentary origin

greenstone: altered basic plutonic rock, altered due to heat and pressure

humus: the material that develops as a result of decomposition of organic matter illuviation: the process of deposition of soil material removed from one horizon to another in the soil

kettle: depression in glacial drift made by the wasting away of a detached mass of glacial ice that had been wholly or partly buried in the glacial drift

lacustrine deposits: deposits laid down by extinct glacial lakes. These sediments are usually very fine in texture

landform: areas of land, topographic features, that are defined in terms of their slope and slope patterns, the materials that produce the relief, and wherever possible, in terms of the mode of origin

leaching: the removal of materials in solution from the soil

loam: soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. Loamy soils are usually considered medium-textured.

medium-texture: intermediate between fine and coarse textured soils. It includes the following textural classes: very fine sandy loam, loam, silt loam and silt

meltwater channel: glacial outwash deposits conforming to topography

metamorphic rock: all rocks which are formed in a solid state in response to pronounced changes in temperature, pressure and chemical environment which take place below the shell of weathering and sedimentation

moraine: drift deposited by direct glacial action and having constructional topographic surface control organic: deposits formed by organisms and plant materials undergoing decomposition

orographic: the derivation of rain from rising air currents adjacent to mountains

ortstein layer: an iron hardpan formed from the oxidation of ferrous iron to the ferric state and then deposited

parent material: unconsolidated, and more or less chemically weathered, material or organic matter from which the solum of a soil is developed by pedogenic processes

pedogenic processes: processes fundamental to development of soil

quartzite: metamorphosed silica-rich sandstone

re-crystallized limestone: metamorphosed limestone in which the calcite crystals have been reformed

rilled topography: topography transected by very small trickling streams of water. Water is usually present for only a short period of the year

ryolite: a volcanic rock high in quartz with fine-grained texture

schist: a metamorphic rock with sub-parallel orientation of minerals

soil association: a sequence of soils of about the same age, derived from similar parent material and occurring under similar climatic conditions but having different characteristics due to variations in relief and in drainage soil horizon: a layer of soil approximately parallel to the land surface that differs from the adjacent genetically related layers in properties such as colour, structure, texture, consistency, chemical, biological and mineralogical composition.

The following is a partial list of the designations of the soil horizons. Detailed definitions may be found in the System of Soil Classification for Canada, 1974.

Organic Horizons:

L - an organic layer characterized by an accumulation of organic matter in which the original structures are easily discernable

F - an organic layer characterized by the accumulation of partly decomposed organic matter

H - an organic layer characterized by an accumulation of decomposed organic matter.

Mineral Horizons:

A - a mineral horizon formed at or near the surface in the zone of removal of materials in solution

B - a mineral horizon that is enriched by either silica clay, iron, aluminium or humus, or possesses a columnar or prismatic structure

C - a mineral horizon comparatively unaffected by pedogenic processes found in the A and B-horizons.

Lower Case Suffixes:

e - a horizon characterized by removal of clay, iron, aluminium, or organic matter, alone or in combination h - a horizon enriched with organic matter

j - this is used as a modifier to denote the varier to meet the specific units of the suffix it modifies

k - indicates the presence of carbonate

m - a horizon slightly altered by hydrolysis, oxidation or both of these to give a change in colour or structure, or both

p - a horizon disturbed by man's activity

t - a horizon enriched with silica clay as indicated by a higher clay content than the overlying alluvial horizon.

soil mottling: irregularly marked with spots of different colours, mottling in soil usually indicates poor aeration and lack of good drainage; the colours result from oxidation and reduction of iron

soil order: soil profiles reflecting dominant pedogenic processes

soil texture: the relative proportion of the various soil separates in a soil material

solum: the upper horizons of a soil in which the parent material has been modified.

8.2 VEGETATION

basal area: the cross-sectional area of a tree, usually measured in square feet at diameter at breast height (DBH)

caespitose: pertains to plants growing in clumps or bunches

characteristic species: species that are indicative of a habitat due either to their high presence or high mean cover values

climax: the vegetation association that gains permanent occupancy of the habitat indefinitely unless disturbed by some type of outside force

decreaser species: these are species that decrease under prolonged, excessive grazing. Usually they are perennials that produce high quality forage and dominate the climax community.

dominant: plant species covering the most area within an association and, therefore, exerting the greatest influence on the microclimate of that association

ecotone: zone of integration between two vegetation types that reflects a gradual blending of vegetation from both types

floristic: refers to the plant species inhabiting a site

forest canopy: a more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth

habitat: place with a particular type of environment which can be inhabited by organisms suited for the type of environment hydric: indicates very wet conditions, with water standing on the surface for a significant part of the year

hygroscopic water: water which is so tightly held by the attraction of soil particles that it cannot be removed except as a gas. This water is unavailable to plants.

increaser species: these are species that increase with moderate grazing over-use; they decrease with continued heavy over-use. Increasers commonly are the shorter, less productive species in the climax plant community.

invader species: these are species that invade the plant community as the range deteriorates. They are not members of the climax plant community since they cannot withstand the competition for moisture, nutrients and light from the vegetation in the climax state.

krummholz form: the growth form of trees at high elevations caused by the layering of branches under the snow. This results in the open parkland type forest.

mean cover: a value calculated by taking the mean of all cover values

moder: a zoogeneous forest humus made up of plant remains partly disintegrated by the soil fauna, but not matted as in new humus

overstory: plant species that overtops another layer of species; usually trees

presence: the number of occurrences of a species divided by the total number of plots in a particular association

receiving:	an area that receives water; usually it is located at the bottom of a depression or slope
riparian:	related to or located on the bank of a natural water course, lake or tidewater
savanna:	trees scattered individually over a lower stratum of grasses
seepage:	the escape of water laterally through the soil usually in response to the slope gradient
sere:	a temporary community or stage that develops in the sequence of succession; the adjective seral is used for particular communities or organisms.
steppe:	grassland in regions too dry for natural forests to proliferate
succession:	progressive changing in composition of plant populations during the development of a vegetation type, which proceeds from the initial colonization of the site to the final attainment of climax
understory:	vegetation that is subordinate in terms of height to another layer of vegetation, i.e., overstory.

9.0 REFERENCES

9.1 PHYSICAL HABITAT

01 Environmental Research & Technology, Inc. 1976. Climatology of the Hat Creek Valley. Concord, Massachusetts.

02 Climate and Data Services Division, B.C. Environment and Land Use Committee Secretariat. Various dates. Climate Capability for Agriculture, map sheets: 92O/NE (9/71), 92O/SE (8/71), 92P/NW (9/71), 92P/NE (8/76), 92P/SW (8/71), 92P/SE (8/76), 92I/NE (3/76), 92I/SE (3/76).

03 Geography Department, University of British Columbia. 1965-66. B.C. Climate Maps prepared for joint ARDA/B.C. Government project.

04 Alysworth, J. 1975. *The Occurrence of Small Moraines in the Hat Creek* Valley, British Columbia. M.Sc. thesis. Department of Geography, University of British Columbia, Vancouver, British Columbia.

05 B.C. Natural Resources Conference. 1956. B.C. Atlas of Resources. Vancouver, British Columbia.

06 Campbell, R.B. and H.W. Tipper. 1971. Geology of Bonaparte Lake Map Area, B.C. Geological Survey of Canada. Ottawa, Canada.

07 Duffell, S. and K.C. McTaggart. 1947. Geology of Ashcroft, B.C. Geological Survey of Canada. Ottawa, Canada.

08 Fulton, R.J. 1975. Quarternary Geology and Geomorphology, Nicola - Vernon Area, B.C. Memoir 380. Geological Survey of Canada. Ottawa, Canada.

09 Holland, S. 1963. The Physiography of British Columbia. Bulletin 48. B.C. Department of Mines and Petroleum Resources. Victoria, British Columbia.

10 Lord, T.M. and A.J. Green. 1974. Soils of the Tulameen Area of British Columbia. Report No. 13. Research Branch, Canada Department of Agriculture. Vancouver, British Columbia.

11 Ryder, J.M. 1976. *Terrain Inventory and Quarternary Geology of* Ashcroft, British Columbia. Paper 74-49. Geological Survey of Canada. Ottawa, Canada.

12 Tipper, H.W. 1971. Glacial Geomorphology and Pleistocene History of Central British Columbia. Bulletin 196. Geological Survey of Canada. Ottawa, Canada.

13 McCullough, P.T. 1978. Hat Creek Detailed Environmental Studies, Mineral and Petroleum Report. Systems Engineering Division, Generation Planning Department, B.C. Hydro and Power Authority. Vancouver, B.C.

14 B.C. Research and Dolmage Campbell & Associates Ltd. 1975. Preliminary Environmental Impact Study of the Proposed Hat Creek Development. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

15 B.C. Department of Agriculture. 1976. Soils and landform maps, map sheets 92I/11-14.

16 Sprout, P.N. and C.C. Kelly. 1963. Soil Survey of the Ashcroft - Savona Area, Thompson River Valley, B.C. B.C. Department of Agriculture. Kelowna, B.C.

17 National Soil Survey Committee of Canada. 1974. The System of Soil Classification for Canada. Canada Department of Agriculture. Publ. 1455. Ottawa, Ontario.

18 Lacate, D.S. 1969. Guidelines for Bio-physical Land Classification: For Classification of Forest Lands and Associated Wildlands. Subcommittee on Bio-physical Land Classification, Canadian Forestry Service, Dept. of Fisheries and Forestry, Environment Canada. Publ. No. 1264. Ottawa, Ontario.

19 INTEG-EBASCO. 1977. B.C. Hydro and Power Authority, Hat Creek Project, Section 3: Power Plant Description Revision F. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

20 B.C. Hydro and Power Authority. 1977. Hat Creek Mining Project, Engineering Description for Environmental Report. Mining Department, Thermal Division, B.C. Hydro and Power Authority. Vancouver, B.C.

21 B.C. Hydro and Power Authority. 1977. B.C. Hydro and Power Authority, Hat Creek Project, Project Description, Section 5: Ofsite Facilities. Thermal Engineering Dept, Thermal Division, B.C. Hydro and Power Authority. Vancouver, B.C.

22 H.A. Simons (International) Ltd. 1977. British Columbia Hydro, Hat Creek Project, Report on Single Status Construction Camps. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

23 The TERA Environmental Resource Analyst Limited. 1977. Land Resources Subgroup, Impact Assessment, Bulk Sampling Programme, Hat Creek Project. Prepared for B.C. Hydro and Power Authority. Vancouver, B.C.

24 B.C. Hydro and Power Authority. 1977. Preliminary Report on the Bulk Sampling Programme. B.C. Hydro and Power Authority. Vancouver, B.C.

25 Environmental Research and Technology, Inc. 1977. Air Quality and Climatic Effects of the Proposed Hat Creek Project. ERT Document No. P-5074. Westlake Village, California.

26 Environmental Research and Technology, Inc. 1977. Air Quality and Climatic Effects of the Proposed Hat Creek Project. Appendix D. Assessment of Atmospheric Effects and Drift Deposition Due to Alternative Cooling Tower Designs. ERT Document No. P-5074. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

27 Webster, C.C. 1967. The Effects of Air Pollution on Plants and Soil. Agricultural Research Council. London. 53 pp.

28 Acid Rain Committee. 1977. Report of the Acid Rain Committee, July 1977. Vancouver, B.C.

29 Environmental Research and Technology, Inc. 1977. Air Quality and Climatic Effects of the Proposed Hat Creek Project. Appendix F. Trace Element Analysis. ERT Document No. P-5074. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

30 MacIntyre, W.H. 1952. Air versus soil as channels for fluorine contamination of vegetation of two Tennessee locales. In McCabe, L.C. (ed.). Air Pollution. U.S. Tech. Conf. Air Pollution. McGraw Hill. New York.

31 MacIntyre, W.H. 1957. Fate of airborne fluorides and attendant effects upon soil reaction and fertility. J. Assn. Off. Agri. Chem. Wash. 40: 958-973.

32 Hansen, E.D., H.H. Wiebe and W. Thorne. 1958. Air pollution with relation to agronomic crops. VII Fluoride uptake from soils. Agron. J. 50: 565-568.

33 Acres Consulting Services Limited. 1978. Hat Creek Detailed Environmental Study, Draft Report, Leachate and Vegetation Tests, Re-use of Plant Wastes and Review of Plant Systems. Acres Document No. P4376.00. Prepared for B.C. Hydro and Power Authority. Vancouver, B.C.

9.2 VEGETATION

01 Krajina, V.J. 1960. Ecosystem Classification of Forests. Silva Fennica 105: 107-110.

02 Krajina, V.J. 1965. Biogeoclimatic Zones and Classification of British Columbia. Ecology of Western North America 1(1): 1-17.

03 Krajina, V.J. 1969. Ecology of Forest Trees in British Columbia. Ecology of Western North America 2(2).

04 Krajina, V.J. 1973. Biogeoclimatic Zones of British Columbia (map). B.C. Ecological Reserves Committee, B.C. Department of Lands, Forests and Water Resources. Victoria, B.C.

05 Brayshaw, T.C. 1970. The Dry Forests of Southern British Columbia. Syesis 3: 17-43.

06 Arlidge, J.W.C. 1955. A Preliminary Classification and Evaluation of Engelmann Spruce - Alpine Fir Forest at Bolean Lake. B.C.M.F. Thesis. Faculty of Forestry, University of British Columbia. Vancouver, B.C.

07 McLean, A. 1969. Plant Communities of the Similkameen Valley, B.C. and Their Relationships to Soils. Ecol. Mons. 40: 403-424.

08 Beil, C.E. 1974. Forest Associations of the Southern Cariboo Zone, British Columbia. Syesis 7: 201-233.

09 Mueller-Dombois, D. 1965. Initial Stages of Secondary Succession in the Coastal Douglas-fir and Western Hemlock Zones. Ecol. of Western North America 1: 38-41.

10 Krajina, V.J., L. Orloci and R.C. Brooke. 1963. Standard Forms Used for Ecosystem Studies. 1962 Progress Report (Appendix K), National Research Council Grant No. T-92. Department of Biology and Botany, University of British Columbia. Vancouver, B.C.

11 Klinka, K. 1975. Environment-Vegetation Tables by a Computer Program. 1974 Progress Report (Appendix C), National Research Council Grant No. T-92. Department of Biology and Botany, University of British Columbia. Vancouver, B.C.

12 Lacate, D.S. 1969. Guidelines for Bio-physical Land Classification: For Classification of Forest Lands and Associated Wildlands. Publication No. 1264. Subcommittee on Bio-physical Land Classification, Canadian Forestry Service, Department of Fisheries and Forestry, Environment Canada. Ottawa, Canada.

13 B.C. Ministry of Environment. September 1976. Resource Analysis Branch. Agriculture Land Capability in British Columbia.

14 Runka, G. 1973. Methodology Land Capability for Agriculture, B.C. Land Inventory (CLI). B.C. Ministry of Agriculture.

15 Resource Analysis Branch, B.C. Ministry of Environment. Various dates and undated. Canada Land Inventory - Agricultural Capability (B.C.) map sheets: 92G/16 (provisional (p)); 92H/15 & 16 (advance prints); 92I/1 (p), 2 (p), 5 (p), 6 (p), 7 (p), 8 (p), 9 (p), 10 (p), 11 (p-Jan.'76), 12 (p), 13 (p), 14 (p-Jan.'76), 15 (p), 16 (p-Oct.'65); 92J/9 (p), & 16 (p); 920/1, 8, 9, & 16; 92P/1 (p), 2 (p), 3 (p), 4, 5, 6 (p), 7 (p), 8 (p), 9 (p), 10 (p), 11 (p), 12, 13, 14 (p), 15 (p), & 16 (p).

16 B.C. Ministry of Agriculture. September 1976. Soils and Landform Maps. Map sheets 92I/11-14.

17 B.C. Ministry of Agriculture. March 1963. Soil Survey of the Ashcroft-Savona Area Thompson River Valley, British Columbia.

18 Resource Analysis Branch. December 1, 1977. Climate Capability for Agriculture (provisional), map sheet 92I/NW at 1:100,000.

19 Brooke, R.C. 1965. The Subalpine Mountain Hemlock Zone. Part II. Ecotopes and Biogeocoenotic Units. Ecol. of Western North America 1:79-101.

20 McLean, A. and L. Marchand. 1968. Grassland Ranges in the Southern Interior of British Columbia. Canada Dept. of Agriculture. Ottawa, Canada.

21 McLean, A. and E. Tisdale. 1972. Recovery Rate of Depleted Range Sites under Protection from Grazing. Jour. of Range Mgt. 25(3): 178-184.

22 Tisdale, E.W. and A. McLean. 1959. The Douglas-fir Zone of Southern British Columbia. Ecol. Monog. 27: 247-266.

23 Brink, V.C. 1977. Personal communication.

24 Houseknecht, S.J. 1976. Tree Regeneration in the Coastal Western Hemlock Zone. M.Sc. thesis. University of British Columbia. Vancouver, British Columbia.

25 Hubbard, W.A. 1969. The Grasses of British Columbia. Handbook Number 9. British Columbia Provincial Museum. Victoria, B.C.

26 Lyons, C.P. 1952. Trees, Shrubs and Flowers to Know in British Columbia. J.M. Dent and Sons Limited. Vancouver, British Columbia.

27 Mulligan, G.A. 1976. Common Weeds of Canada. Canada Dept. of Agriculture and McClelland and Stewart Ltd. Ottawa, Canada.

28 Schofield, W.B. 1969. Some Common Mosses of British Columbia. Handbook No. 28. British Columbia Provincial Museum. Victoria, B.C.

29 Taylor, T.M.C. 1973. The Rose Family of British Columbia. Handbook No. 30. British Columbia Provincial Museum. Victoria, B.C.

30 Taylor, T.M.C. 1974. The Pea Family of British Columbia. Handbook No. 32. British Columbia Provincial Museum. Victoria, B.C.

31 Clark, L.J. 1973. Wildflowers of British Columbia. Gray's Publishing Ltd. Sidney, B.C.

32 Demarchi, D.A. 1971. A Guide to the Major Plant Families of British Columbia. Department of Recreation and Conservation, Fish and Wildlife Branch. Victoria, B.C.

33 Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press. Seattle, Washington.

34 Hitchcock, C.L., A. Cronquist, M. Ownbey and J.W. Thompson. 1969. Vascular Plants of the Pacific Northwest. Volumes 1 to 5. University of Washington Press. Seattle, Washington.

35 Anonymous. 1975. State lists of endangered and threatened species of the Continental United States - Washington. Federal Register 40(127).

36 Taylor, R.L. 1976. Flora of B.C. Botanical Garden, University of British Columbia. Vancouver, B.C.

37 Kershaw, L. and J.K. Morton. 1975. Rare and Potentially Endangered Species in the Canadian Flora - A Preliminary List of Vascular Plants. Canadian Botanical Association, University of Waterloo. Toronto, Ontario.

38 Cowan, I. McT., W.S. Hoar and J. Hatter. 1950. The Effect of Forest Succession upon the Quantity and Nutritive Values of Woody Plants used as Food by Moose. Can. J. Res. (D) 28: 249-271.

39 Edwards, R.I. and R.W. Ritcey. 1960. Foods of Caribou in Wells Gray Park, B.C. Can. Field Natl. Vol. 74 3-7.

40 Hatter, J. 1950. The Moose of Central B.C. Ph.D thesis. State Collage of Washington, Pullman. 356 pp.

41 Ritcey, R.W. 1965. Ecology of Moose Winter Range in Wells Gray Park, B.C. B.C. Fish and Wildlife Branch. Victoria.

42 Ritcey, R.W. and N.M. Verbeck. 1969. Observations of moose feeding on aquatics in Bowron Lake Park, B.C. Can. Field Natl. 83(4): 339-343.

43 Singleton, J. 1976. Food Habits of Wild Ungulates in B.C. B.C. Fish and Wildlife Branch. Victoria, B.C. 50 pp.

44 Szczawinski, A.F. and G.A. Hardy. 1972. Guide to Common Edible Plants of British Columbia. B.C. Provincial Museum. Handbook No. 20. Victoria, B.C.

45 Lodge, R.W., A. McLean and A. Johnston. 1968. Stock-poisoning Plants of Western Canada. Publication No. 1361. Agriculture Canada. Ottawa, Ontario.

46 McLean, A., E.R. Smith and W.L. Pringle. 1964. Handbook on Grazing Values of Range Plants of British Columbia. Canada Dept. of Agriculture, Research Station. Kamloops, B.C.

47 McLean, A. and H.H. Nicholson. 1958. Stock Poisoning Plants of the British Columbia Ranges. Canada Dept. of Agriculture, Research Station. Publication 1037. Kamloops, B.C.

48 Martin, A.C., H. Zim and A.L. Nelson. 1951. American Wildlife and Plants: A Guide to Wildlife Food Habits. Dover Publications, Inc. New York.

49 Reid, Collins and Associates Ltd. 1977. Forestry Report, Detailed Environmental Studies, Hat Creek Project. Prepared for B.C. Hydro and Power Authority. Vancouver, B.C.

50 Canadian Bio Resources Consultants Ltd. 1977. Agriculture Report, Detailed Environmental Studies, Hat Creek Project. Prepared for B.C. Hydro and Power Authority. Vancouver, B.C.

51 Daubenmire, R. 1968. Plant Communities. Harper and Row, Publishers. New York.

52 B.C. Hydro and Power Authority. 1977. Hat Creek Mining Project, Envineering Description for Environmental Report. Mining Department, Thermal Division of B.C. Hydro and Power Authority. Vancouver, B.C.

53 INTEG-EBASCO. 1977. B.C. Hydro and Power Authority, Hat Creek Project, Section 3: Power Plant Description. Revision F. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

54 B.C. Hydro and Power Authority. 1977. B.C. Hydro and Power Authority, Hat Creek Project, Project Description, Section 5: Offsite Facilities. Thermal Engineering Department, Thermal Division, B.C. Hydro and Power Authority. Vancouver, B.C.

55 H.A. Simons (International) Ltd. 1977. British Columbia Hydro, Hat Creek Project, Report on Single Status Construction Camps. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

56 The TERA Environmental Resource Analyst Limited. 1977. Land Resources Subgroup, Impact Assessment, Bulk Sampling Programme, Hat Creek Project. Prepared for B.C. Hydro and Power Authority. Vancouver, B.C.

57 B.C. Hydro and Power Authority. 1977. Preliminary Report on the Bulk Sampling Programme. B.C. Hydro and Power Authority. Vancouver, B.C.

58 Brandt, D.J. and R.W. Rhoades. 1973. Effects of limestone dust accumulation on lateral growth of forest trees. Environ. Pollut. 4: 207-213.

59 Darley, E.F. 1966. Studies on the effect of cement-kiln dust on vegetation. J. Air. Pollut. Control Assn. 16: 145-150.

60 Vasiloff, G.N. and D.B. Drummond. 1974. The effectiveness of road dust as a protective agent on buckwheat and pinto bean against sulfur dioxide and ozone. Phytopathology 64: 588.

61 Edmunds, G.F. 1973. Ecology of black pineleaf scale. Environ. Entomology 2(5): 765-777.

62 Bartlett, B.R. 1951. The action of certain 'inert' dust materials on parasitic *Hymenoptera*. J. Ecol. Entomol. 44: 891-896.

63 Environmental Research and Technology, Inc. 1977. Air Quality and Climatic Effects of the Proposed Hat Creek Project. ERT Document No. P-5074. Westlake Village, California.

64 Environmental Research and Technology, Inc. 1977. Air Quality and Climatic Effects of the Proposed Hat Creek Project. Appendix D. Assessment of Atmospheric Effects and Drift Deposition Due to Alternative Cooling Tower Designs. ERT Document No. P-5074. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

65 Environmental Research and Technology, Inc. 1977. Air Quality and Climatic Effects of the Proposed Hat Creek Project. Appendix C. Alternative Methods of Air Quality Control. ERT Document No. P-5074. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

66 Environmental Research and Technology, Inc. 1977. Air Quality and Climatic Effects of the Proposed Hat Creek Project. Appendix B. Model Methodology. ERT Document No. P-5074. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

67 Environmental Research and Technology, Inc. 1977. PEAK Programme, Computer Print-out of 1-hour SO_2 Concentrations, Detailed Environmental Studies, Hat Creek Project. Prepared for B.C. Hydro and Power Authority. Vancouver, B.C.

68 Petit, C., M. Trinite and P. Valentin. 1976. Study of turbulent diffussion above and within a forest - Application in the case of SO_2. Atmos. Environ. 10: 1057-1063.

69 Murphy, C.E., Jr., T.R. Sinclair and K.R. Knoerr. 1977. An assessment of the use of forests as sinks for the removal of atmospheric sulfur dioxide. J. Environ. Quality 6: 388-396.

70 Ashenden, T.W. and T.A. Mansfield. 1977. Influence of wind speed on the sensitivity of ryegrass to SO_2. J. Exp. Bot. 28: 729-735.

71 Lewis, E. and E. Brennan. 1977. A disparity in the ozone response of bean plants grown in a greenhouse, growth chamber of open-top chamber. J. Air Pollut. Control Assoc. 27: 889-891.

72 Environmental Research and Technology, Inc. 1977. Air Quality and Climatic Effects of the Proposed Hat Creek Project. Appendix F. Trace Element Analysis. ERT Document No. P-5074. Report submitted to B.C. Hydro and Power Authority. Vancouver, B.C.

73 U.S. Environmental Protection Agency. 1971. Air Quality Criteria for Nitrogen Oxides. U.S. Department of Health, Education and Welfare. Publ. No. AP-84. Washington D.C.

74 Brandt, C. and W.W. Heck. 1968. Effects of air pollutants on vegetation. In Stern, A.C. (ed.). Air Pollution, Volume 1. Academic Press. New York.

75 Tingey, D.T., R.A. Reinert, J.A. Dunning and W.W. Heck. 1971. Vegetation injury from the interaction of nitrogen dioxide and sulfur dioxide. Phytopathology 61(12): 1506-1511.

76 Hill, A.C. and J.H. Bennett. 1970. Inhibition of apparent photosynthesis by nitrogen oxides. Atmos. Environ. 4: 341.

77 Thompson, C.R., D.T. Tingey and R.A. Reinert. 1974. Acceptable Limits for Air Pollution Dosages and Vegetation Effects: Nitrogen Dioxide. Preprint, Air Pollution Control Association. Paper 74-227. Pittsburgh, Penna.

78 Tingey, D.T. 1968. Foliar Absorption of Nitrogen Dioxide. M.A. Thesis, Utah University. Salt Lake City.

79 Taylor, C.C. and D.C. MacLean. 1970. Nitrogen oxides and the peroxyacl nitrates. In Jacobson, J.S. and A.C. Hill (eds.). Recognition of Air Pollution Control Injury to Vegetation, A Pictorial Atlas. Air Pollution Control Association. Pittsburgh, Pennsylvania.

80 Campbell, D.J., et al. 1975. The effect of a subterranean leak of town gas on the growth of a wheat crop. Environ. Poll. 8: 171-178.

81 Crocker, W., P.W. Zimmerman and A.E. Hitchcock. 1932. Ethylene-induced epinasty of leaves and the relation of gravity to it. Contributions from Boyce, Thompson Institute 4(2): 177-218.

82 Acid Rain Committee. 1977. Report of the Acid Rain Committee, July 1977. Vancouver, B.C.

83 Greeley, R.P., J.T. Ouellette and S. Wilcox. 1975. Sulfates and the Environment; a Review. U.S. Dept. of Commerce. NTIS PB-248 122.

84 National Academy of Sciences. 1975. Air Quality and Stationary Source Emission Control. National Academy of Sciences, National Academy of Engineering, National Research Council. U.S. Govt. Printing Office. Washington, D.C. 909 pp.

85 Shriner, D.S. 1977. Effects of simulated rain acidified with sulfuric acid on host-parasite interactions. Water, Air, Soil Pollut. 8: 9-14.

86 McCune, D.C., D.H. Silberman, R.H. Mandl, L.H. Weinstein, P.C. Freudenthal and P.A. Giardina. 1977. Studies of the effects of saline aerosols of cooling tower origin on plants. J. Air Pollut. Control Assoc. 27: 319-324.

87 Runeckles, V.C. 1978. Assessment of Impacts of Airborne Emissions on Vegetation: Proposed Hat Creek Project, B.C. Hydro and Power Authority. Report submitted to The TERA Environmental Resource Analyst Limited. Vancouver, B.C.

88 Mansfield, T.A. and O. Majernik. 1970. Can stomata play a part in protecting plants against air pollutants? Environ. Pollut. 1: 149-154.

89 Acres Consulting Services Limited. 1978. Hat Creek Project Detailed Environmental Study, Draft Report, Leachate and Vegetation Tests, Re-use of Plant Wastes and Review of Plant Systems. Acres Document P4376.00. Prepared for B.C. Hydro and Power Authority. Vancouver, B.C.

90 Stickel, W.H. 1975. Some effects of poolutants in terrestrial ecosystems. In McIntyre, A.D. and C.F. Mills (eds.). Ecological Toxicology Research. Plenum Publ. Corp. New York.

91 Equitable Environmental Health, Inc. 1976. Environmental Impacts of the Generation of Electricity in the Pacific Northwest. Volume I and II. NTIS No. PB-257 096 and PB-257 097. 449 pp.

92 Jurdant, M., et al. 1977. L'inventoire du Capitol-Nature. Service des Etudes Ecologiques Regionales, Direction Regionale des Terrest, Pêches et Environnement Canada. Quebec.