Terrestrial Ecosystem Mapping (TEM) with Wildlife Habitat Interpretations of the Besa-Prophet Area

Part 1: TEM Report

Prepared for:

BC Environment, Lands and Parks
Oil and Gas Division
#400, 10003-110th Avenue
Fort St. John, BC
V1J 6M7
Contact: Lisa Wilkinson
Tel: (250) 787-3332
Fax: (250) 787-3219

Prepared by:

578569BC d.b.a.
R.A. Sims and Associates
201-1600 W 6th Ave.
Vancouver, BC
V6J 1R3
Contact: Richard Sims
Tel: (604) 733-5220
Fax: (604) 738-5204

April 23, 1999

ACKNOWLEDGEMENTS

R.A. Sims and Associates would like to acknowledge the following individuals from the Ministry of Environment, Lands and Parks (MELP) in Fort St. John, BC, for their contributions and support throughout the project: Lisa Wilkinson (Wildlife/Habitat Inventory Specialist and the Contract Manager), Scott Fraser (Land and Habitat Protection Officer, Oil and Gas Division,), Jules Paquette (Regional GIS Coordinator) and Bryan Webster (Wildlife Biologist).

In addition, the following individuals provided helpful comments and advice throughout the project: Bob Maxwell (Bioterrain Specialist, MELP, Victoria), who correlated the bioterrain mapping and the digital database, Carmen Cadrin (Vegetation Ecologist, MELP, Victoria) and Craig Delong (Regional Ecologist, Ministry of Forests (MoF), Prince George Forest Region) who jointly correlated the ecosystem units and mapping, and Andy Stewart (Wildlife Specialist, MELP, Victoria) who correlated the wildlife habitat interpretations component.

The summer field crew stayed at Muskwa Safaris Ltd. and their host was Gary Vince. Transportation for both the summer and winter field exercises was ably suported by Andrew Moore (summer) and Doug Parish (winter) of Bailey Helicopters Ltd.

We are pleased to acknowledge the following R. A. Sims & Associates staff for their contributions towards the completion of the photo-typing, GIS database and support, fieldwork, final maps, wildlife report and the preparation of the Final Report:

- Richard Sims (Project Manager) coordinated and supervised the project. Bioterrain phototyping and ecosystem mapping was coordinated and completed by John Grods and Tim Janes.

- Christine Curry coordinated the GIS portion of the project. Andrew Dyk acquired and produced the merged satellite imagery and scanned and orthorectified the linework. Karen Warrendorf, York Law and Cari Kobialko provided GIS support for final edits, map legends, and final maps. Several R. A. Sims & Associates staff conducted the data input phases of the project, including York Law, Jeff Matheson, Libor Michalak, John Grods, Karen Warrendorf, Amy Tsang and Rachelle Robitaille.

- Summer field work was completed by two 3-person crews. Each crew consisted of a vegetation ecologist, soil scientist and wildlife ecologist. Vegetation ecologists were John Grods and Chris Zoladeski, soil specialists were Joe Fitzpatrick and Clayton Code, and wildlife ecologists were Jeff Matheson and Tim Janes. Winter field surveys was conducted by Jeff Matheson, Tim Janes, Rachelle Robitaille and John Grods.

- Jeff Matheson coordinated the preparation of wildlife habitat interpretations for the project. Habitat models were developed by Jeff Matheson, with the assistance of Tim Janes, Libor Michalak and Rachelle Robitaille. Christine Curry prepared and applied the GIS-based wildlife habitat algorithms. The final wildlife report was edited by Jeff Matheson, with input from Richard Sims and Tim Janes.

- Rachelle Robitaille facilitated the assembly of progress reports and the Final Report. John Grods edited the ecosystem unit description factsheets and the expanded ecosystem legend. Karen Warrendorf created the Study Area map. Richard Sims supervised and edited all reports.

EXECUTIVE SUMMARY

This project was conducted by R.A. Sims and Associates (578569BC Ltd.) on behalf of the BC Ministry of Environment, Lands and Parks' Oil and Gas Division. Phase 1 (1997-1998) of the two-year project was funded by Forest Renewal BC, and Phase II (1998-1999) was funded by the Muskwa-Kechika Fund.

This Final Report (composed of two separately bound documents, Part 1 – TEM and Part 2 – Wildlife) describes the Terrestrial Ecosystem Mapping (TEM) outputs, and related wildlife interpretations for the Besa/Prophet Area.

A range of baseline terrain, ecosystem and wildlife information was gathered and synthesized by this project. Principal goals were to:

1) Confirm (and as necessary adjust/refine) BCG zonal / subzonal / variant boundaries within the Study Area;
2) Refine Site Series classification units (ecosystem or map units) and their descriptions in particular within the SWB, Parkland and Alpine Zones;
3) Integrate the use of Landsat and SPOT TM into 1:50 000 TEM mapping methodologies; and,
4) Produce habitat suitability interpretations for a total of eleven wildlife species.

Part 1 of the Final Report provides, at the outset, an overview of the Study Area, including location, physical description, climate, vegetation, biogeoclimatic zones, disturbances and wildlife of the Study Area. It then summarizes the methodology followed in the field sampling, photo-interpretation, and GIS processing components of the project. Part 1 also includes definitions of the symbology and mapping conventions used in the bioterrain and ecosystem maps, and summarizes the digital databases that accompany the Final Report.

The BEC field guides for the Prince George Region (Delong *et al.* 1990, 1994, MacKinnon *et al.* 1990) provide basic descriptions only of mature and undisturbed ecosystems within the general geographic region. In these, information on non-forest and/or disturbed forest ecosystems is also lacking. Within Part 1 of the Final Report, considerably more detail is provided on the range of ecosystems that occur within the Study Area. The expanded legend and ecosystem descriptions provided here, include a range of information that is organized and presented in summary tables as well as a "factsheet" format. The ecosystem descriptions in Part 1 are complementary to the information provided within the TEM 1:50,000 map products. Also included is summarized data on disturbed and non-forest ecosystems that were field visited and sampled within the Study Area. It should be noted that information provided in the ecosystem "factsheets" is provisional, and can be further augmented, in future, should additional ecological data be gathered within or adjacent to the Study Area.

Part 2 of the Final Report deals with the TEM-related wildlife habitat interpretations undertaken for the Study Area. The primary purpose of the wildlife habitat interpretations is to provide habitat suitability mapping for eleven species (American marten, grizzly bear, black bear, mule deer, white-tailed deer, moose, elk, woodland caribou, bison, stone sheep, and mountain goat). In addition to habitat suitability mapping, this project provides a synthesis of known wildlife values for the Study Area, including the results of aerial surveys, wildlife habitat assessments and incidental observations.

Wildlife habitat suitability ratings define the relative importance of mapped ecological units to wildlife populations. For this project, we have developed species-habitat models that relate each species' life requisites to the attributes of the ecosystem units present in the Study Area. Each model is based on the scientific literature, previous studies in the region, our own field data collection and expert opinion. Ratings tables were generated using a linear model that contains the key attributes of an ecosystem unit. An automated approach using a relational database was used to assign ratings to each possible ecosystem unit in the Study Area. Polygon ratings were generated by "looking-up" the ecosystem unit in the ratings table. A GIS algorithm was then constructed to apply spatial adjustments to the polygon ratings.

Wildlife habitat mapping provides a basis to evaluate the effects of development on wildlife habitat. It identifies areas that provide regionally and/or provincially significant habitat and places the loss or modification of habitat into a local and regional context. When combined with current known animal distributions, interpretations can also be made on potential avenues or opportunities for range expansion.

The following additional products accompany this Final Report (Parts 1 and 2):

- A folio of *TEM Manuscript Maps* (1:50,000 hard copy and mylar copy, and digital databases) with accompanying legend, and Ecosystem unit symbols for the entire Study Area;

- A *Plot Location Map* (1:250,000 scale, hard copy and digital database) showing locations of field sampling plots overlain on an imagery base of the Study Area; and,

- *Wildlife Habitat Interpretation Suitability Maps* for all rated seasons and uses for all 11 species in ArcView 3.0a that can be viewed on-demand.

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

This document (Part 1 – TEM) is a Final Report on Terrestrial Ecosystem Mapping (TEM) outputs and interpretations that were completed for an area in northeastern British Columbia. Fundamental terrain, ecosystem and wildlife information gathered by this TEM project will assist with operational planning activities of the Ministry of Environment, Lands, and Parks' (MELP) Oil and Gas Division, in the Fort St. John District, Omineca-Peace Region, and provides baseline ecological inventory data for the Study Area.

The project was initiated by staff of Geomatics International Inc., but subsequently completed by staff of R.A. Sims and Associates (578569BC Ltd.). Several interim reports were prepared which detailed progress and findings (Geomatics International Inc., 1998a,b,c). The project was completed in just over 15 months; work on the overall project started in early December, 1997 and finished in mid-March, 1999.

The overall project was divided into two phases:

- *Phase 1* (December, 1997 to March, 1998) involved background information searches and reviews, air photo-typing, the production of satellite images, the completion of a "NE Burn component", and winter field surveys.

- *Phase II* (April, 1998 to March, 1999) involved the summer field sampling, data analysis, map manuscript preparation, and Quality Assurance (QA) and revisions. Also included in this phase in the final production and delivery to MELP of all TEM and wildlife outputs.

TEM uses traditional cartographic methods to stratify landscapes into map units (polygons) which are based on the relationships between ecological features such as climate, physiography, surficial material, bedrock geology, soil and vegetation (RIC, 1998). TEM maps supply information that is critical for land-use planning and wildlife habitat management.

TEM projects are governed by standards created, implemented and updated by BC's Resource Inventory Committee (e.g., see RIC 1996, 1998). There are 2 primary map outputs associated with most TEM projects: a terrain map and an ecosystem map. Other products such as wildlife habitat suitability maps can be derived and constructed, using the terrain and ecosystem database as a foundation.

Terrain maps describe present day geomorphological processes and show the distribution of surficial deposits and related landforms. For this project, bioterrain maps were created. When delimitating bioterrain polygons, the mapper took into account characteristics of the landscape that are important when used in conjunction with wildlife habitat interpretations. Some of the criteria used for polygon delimitation were aspect, soil drainage and vegetation type (RIC, 1996).

Ecosystem mapping combines aspects of BC's biogeoclimatic ecosystem classification (BEC) with aspects of ecoregion classification. Ecosystem mapping is based on a classification system delineated by: ecoregion units, biogeoclimatic units, site series, and vegetation developmental stages (structural stages and seral community types) (RIC, 1998). Ecosystems are mapped using a procedure that focuses on observable site and biological features assumed to determine the function and distribution of plant communities on the landscape (RIC, 1998).

As part of the current project, R.A. Sims and Associates also investigated the usefulness of Landsat TM and SPOT imagery as a replacement or supplement for traditional airphotos in 1:50,000 TEM mapping. Remote sensing imagery at various scales and in digital form is a potential source of very useful and up-to-date synoptic land cover information. Such imagery has particular advantages as an input database for northern resource surveys, where project areas are frequently large, air photo coverages are typically dated and/or of poor quality, ancillary databases are lacking or inaccurate, and resource use and management pressures are growing.

The maps produced in this project have been incorporated into a Geographic Information System (GIS). The use of GIS allows the storage and rapid retrieval of large amounts of polygon-based data as compared to hard copy maps. The use of GIS also facilitates the integration of the digital maps and their associated databases so that they may be combined with other spatially-based digital data and then used to construct a range of interpretations.

The Besa/Prophet Area TEM Project revolved around the production of Bioterrain, Ecosystem and Wildlife Habitat Suitability mapping at 1:50 000 scale. The principal goals of the TEM project were to:

1. Confirm and as necessary adjust/refine BCG zonal / subzonal / variant boundaries within the Study Area;
2. Refine Site Series classification units (map units) and their descriptions in particular within the SWB, Parkland and Alpine zones;
3. Integrate the use of Landsat and SPOT TM into 1:50 000 TEM mapping methodologies; and,
4. Produce habitat suitability interpretations for eleven wildlife species.

The featured wildlife species were American marten, grizzly bear, black bear, mule deer, white-tailed deer, moose, elk, woodland caribou, bison, stone sheep, and mountain goat. The goal of the wildlife component was to produce habitat suitability interpretations for each of the eleven species based on habitat models created from literature reviews and collected field data, the latter including direct field observations of wildlife made during both winter and summer field surveys. As already noted, a separately-bound document (Final Report – Part 2) describes and details the wildlife habitat interpretation (WHI) component of the Project.

2.0 DESCRIPTION OF THE STUDY AREA

2.1 Location

The Besa/Prophet TEM Study Area (Fig. 1, 2) is located northwest of Fort St. John, BC, and southwest of Fort Nelson and covers an area of approximately 203,242 ha. The areas delineated by the Redfern-Keily Protected Area, as well as a strip of lowland along the Alaska Highway from Buckinghorse River north were excluded from the Study Area. The Study Area is located within the following UTM coordinates: 492 000, 6 348 000 (SE corner); 492 000, 6 405 000 (NE corner); 415 000, 6 348 000 (SW corner); 415 000, 6 405 000 (NW corner). The study area is highly variable in terms of relief, and ranges in elevation from approximately 900m to 2600m.

The Study Area extends across portions of eight 1:50,000 NTS mapsheets (94F/8 and 9, and 94G/5, 6, 11, 12, and13). It also encompasses sections of the following Landscape Units: Fort Nelson Landscape Units 29 and 30 and the Fort St. John Landscape Units 29 and 4. The area contains the Besa River (Fig. 1), Richards Creek, Pocketknife Creek, Nevis Creek watersheds, and parts of the Prophet River Watershed.

Figure 1: A section of the Besa River Watershed just upstream from its confluence with the Prophet River.

The Besa/Prophet Study Area can only be accessed by air (mainly helicopter) or on ground by horseback, snow machine or all-terrain vehicle, or by traversing on foot approximately 10 km from the nearest roads. Only a few seismic lines cross into the Study Area from the east. No roads cross into the Study Area. The closest major roads to the eastern boundary are the Alaska Highway, and a few secondary (dirt topped) roads. A guide outfitters' road currently exists along the Sikanni River, just to the south of the Study Area, but there are no nearby roads to the north or west of the Study Area.

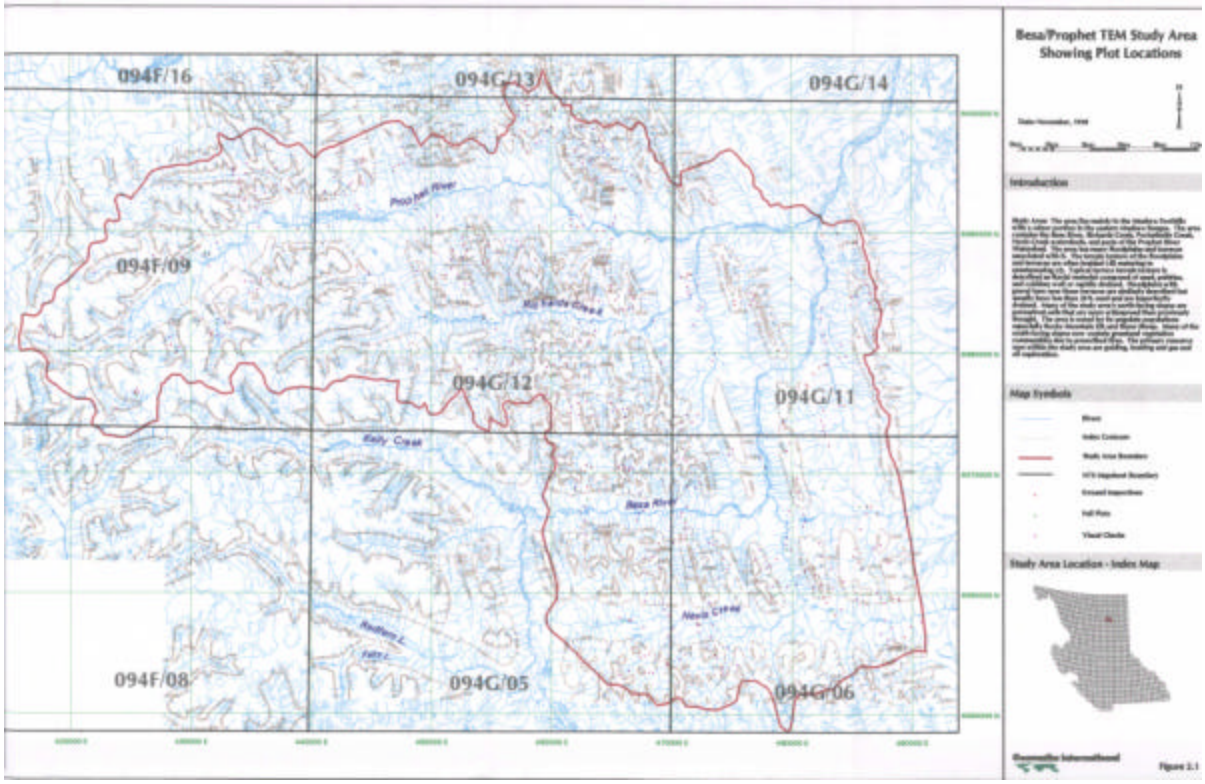

Figure 2: Locational map of the Besa/Prophet Study Area showing the project area boundary, streamlines and waterbodies, and elevational contours (100m intervals).

The Study Area is currently experiencing significant and growing pressures for development. There are prospective oil and gas reserves below-ground within the Study Area. Several energy companies are keenly interested in mounting exploratory drilling and seismic testing programs, as soon as government clearances can be given. High ungulate diversity and density attract hunters to the area, and a number of guide outfitters currently operate within the Study Area.

The Study Area falls within the Muskwa-Kechika Reserve. The Muskwa-Kechika Reserve covers an area of 4.4 million hectares and is composed of 1.17 million hectares of parks and protected areas surrounded by a special management area of 3.24 million hectares. Resource development in this area is managed through a specially-designed model that sees management objectives and boundaries legislated. Management of the Reserve is funded via an established government trust fund that is controlled by a multiple-interest Advisory Board, appointed by and reporting to the Provincial Premier.

2.2 Physical Description

The Besa/Prophet Study Area lies within the Eastern System of the Canadian Cordillera and is underlain primarily by folded and faulted sedimentary rocks (Holland, 1976). The Study Area is composed of two physiographic zones, the Muskwa Ranges, and the Rocky Mountain Foothills. The Muskwa Range extends from the Peace River north to the Liard rivers and from the Rocky Mountain Trench in the west to the Rocky Mountain Foothills in the east. On their eastern side, the Muskwa Ranges are eroded largely in Devonian and Permo-Carboniferous limestones. Longitudinal valleys of great length and width are characteristic of the Muskwa Ranges. They are eroded parallel to the structural trend along lines of faulting or along belts of softer, more easily eroded rock (Holland, 1976). The Rocky Mountain Foothills is entirely underlain by sedimentary rocks that are largely of Meoszoic age. The rocks are folded northerly to northwesterly which results in prominently developed longitudinal ridges. Valleys are eroded along belts of soft rock and fault zones and are generally wide and flaring.

The Study Area contains very diverse terrain features. The most common surficial materials are morainal and colluvial, other surficial materials found were-glaciofluvial, glaciolacustrine, several types of bare bedrock, shallow veneers, outwash, and alluvial. Undifferentiated, aeolian, and anthropogenic materials have not been encountered within the Study Area. Weathered bedrock occurs, but was not found in extents large enough to formally map.

Applying the terminology of Howes and Kenk (1997), the geomorpic processes of the fluvial floodplains and terraces associated with the Besa and Prophet Rivers are often Braided (-B), maturing to anastamosing (-J). Much of the river is an intergrade between the two types of channels. The typical terrain texture of terraces is described as: spkFt –B (or –J); well or rapidly drained. Floodplains with gravel bars near these terraces are similarly but usually have < 20% sand and are described as $pkF^{A}p$ –B (or –J); imperfectly drained.

Red granite from the Canadian Shield was found at two locations on the west side of the outer foothills which signifies that Continental Ice Sheets borught rocks from the Canadian Shield into the Study Area.

2.3 Soils

Following the Canadian System of Soil Classification (Agriculture Canada Expert Committee on Soil Science 1987), the most common *Soil Order* sampled in the Study Area was Brunisolic, in particular, the *Great Groups* Melanic Brunisols, Dystric Brunisols and Eutric Brunisols. Commonly-encountered *Soil Subgroups* included Typic Fibrisols, Gleyed Humic Regosols, Orthic Regosols, Orthic Humic Gleysols, Brown Chernozems, Orthic Dystric Cryosols, and Static Cryosols.

Field work undertaken as part of this project confirmed that permafrost soils (Cryosols) are more widespread within the Study Area than had been previously acknowledged. During field sampling, Cryosols were regularly encountered on many north-facing slopes that had organic veneers.

A wide range of soil textures was encountered within the Study Area. Soils on morainal, colluvial and outwash landforms support a range of mainly coarser-textured soils, while lacustrine, alluvial and most other lower-relief surficial features are mainly associated with finer-textured soils. Clay textures are localized and infrequent within the Study Area.

Generally, soils within the Study Area range from imperfectly, to moderately-well and rapidly drained. In general, very rapidly drained and poorly drained sites were less commonly encountered during our investigations.

2.4 Climate

The Study Area is dominated by Polar Continental and Polar Pacific air and experiences long, cold winters and short, warm summers (Luckhurst, 1973). The climate is cool continental, with moderate rain and snowfall, and, on average, moderately warm summers. The area experiences the most continental climate occurring within BC, with annual summer temperatures occassionally in excess of 26º C, and temperatures that may fall below –45º C for short periods during most winters (Luckhurst, 1973)

The Rocky Mountains to the west create, within the Study Area, a mild rainshadow effect throughout the year. Snow persists well in late Spring, but most valleys are free of snow by June. Although snow may be present at higher elevations during part or all of the summer, it does not normally begin to accumulate until October. In the winter months, temperatures do not remain extremely cold and snow depths are not deep, compared to adjacent higher-elevation areas to the east and west. Winter cold spells can be occasionally broken by Chinook winds.

Snowpacks within the Study Area are influenced by two main factors: 1) the amount of snow that actually falls; and, 2) an area's exposure to Chinook winds that can periodically affect the region. South-facing and southwest-facing slopes within more mountainous regions of the Study Area are generally more affected by the influences of Chinook winds and solar radiation. Southerly exposures tend to experience the least amount of snow; north-facing aspects tend to have deeper and more persistent snowpacks, while east and west experience intermediate conditions (Chilton, 1990).

The Study Area experiences a generally more moderate climate then occurs to the immediate west. This results in the provision, within the Study Area, of some particularly favourable all-year living and wintering habitat for many wildlife species, especially ungulate species such as elk, caribou and moose. Year-to-year climatic variation is also a key determinant of shifts and dynamics in wildlife movements and habitat use. For example, during warmer winters, moose have been observed at high

elevations instead of their normal lowland preferences. Similarly, during winters of deep snow, caribou have been observed shifting their usage patterns and aggregating in the Muskwa Foothills and Plateau.

2.5 Vegetation

The Study Area contains pockets of commercially-viable timber, and these are mainly restricted to lower-elevation valleys. There is a lack of road access within the Study Area, and so there are no operational forestry activities ongoing or currently contemplated, although some might be expected on the heels of oil and gas activities within the area. In general, mature forest stands within the Study Area are poorly-developed and many of them resemble a "tall shrub" structural stage (RIC 1998). White spruce is the predominant forest tree species within the Study Area. Scrub birch and *Salix* species are also very common throughout the area.

Wetlands and other non-forested conditions are scattered throughout the Study Area. Wetlands are particularly common along valley bottoms, especially along rivers such as the Besa and Prophet. A variety of alpine ecosystems occur, although alpine fir krummholz is relatively rare within the Study Area.

The vascular and non-vascular plant diversity within the Study Area is notable. Many berry-producing plants such as lingonberry and other *Vaccinium* speicies are scattered throughout the area. Flowering plants such as fireweed, tall larkspur and tall bluebell are found in the Study Area, and occur from valley bottom to mountain top. Graminoids such as Altai fescue, *Poa* spp. and *Carex* spp. are likewise encountered from low elevation valleys to alpine areas. Bryophytes and lichens are very common throughout the Study Area especially step moss, other feathermosses, and *Cladina* spp.

At the outset of this project, a "Rare Element Occurrence" report for the Besa/Prophet area was obtained from the BC Conservation Data Centre (CDC). The CDC listing included all individual, verified occurrences for rare vascular plants. The following information was received from the CDC for each rare plant located in the vicinity of the Study Area: scientific name, common name, global rank, provincial rank (a rarity rank assigned by the CDC), status on MELP's "Red or Blue List", location, directions to the location, informational notes, UTM coordinates, precision, ecosection and BEC Subzone of the occurrence, date last observed, and a code identifying the major source used to compile the information contained in the record. Table 1 summarizes the rare plant element occurrence data as provided by the CDC.

2.6 Biogeoclimatic Zones

For Terrestrial Ecosystem Mapping, ecosystem classification is conducted according to a three-level hierarchy of units. The two upper levels of classification, the "Ecoregion/Ecosection Classification" and "Biogeoclimatic Ecosystem Classification" (BEC) together provide the broad ecological context for mapping. More locally-occurring "ecosystem units" are then delineated, described and mapped at finer levels.

The Study Area falls within the Northern Boreal Mountains Ecoprovince and in the Northern Canadian Rocky Mountains Ecoregion (Demarchi 1995). The Study Area is represented within two Ecosections: Muskwa Foothills (MUF), in the east, and Eastern Muskwa Ranges (EMR), in the west.

Table 1: Vascular plants reported by BC's Conservation Data Centre as being potentially rare in the general vicinity of the Study Area.

Vascular Plant	Rank	Location	Eco Section[1]	BGC[2]	Last Observed	UTM NAD83
Cryptantha intermedia var *grandiflora*	Red listed	Nevis Creek south slope.	MUF	SWBmk	1970/07/05	10 477010 63555
Draba glabella var *glabella*	Blue listed	Fairy Lake, very common of open talus slopes below peaks.	EMR	SWBmk	1960/07/19	10 443310 63548
Draba porsildii	Blue listed	Fairy Lake, rare on steep open talus slope below mountains.	EMR	SWBmk	1960/07/19	10 443310 63548
Epilobium hornemannii ssp *bemringianum*	Blue listed	Fairy Lake, moist alpine slope.	EMR	SWBmk	1977/07/25	10 443310 63548
Epilobium leptocarpum	Blue listed	Fairy Lake, near stream in white spruce-subalpine fir forest.	EMR	SWBmk	1977/07/28	10 443210 63548
Lomatogonium rotatum	Blue listed	Fairy Lake, gravel stream edge, flat, scattered low vegetation.	EMR	SWBmk	1991/07/13	10 445810 63564
Oxytropis jordalii spp *davisii*	Blue listed	Fairy lake, very rare noted below east facing rock cliffs at 1524 m at one spot.	EMR	SWBmk	1960/07/19	10 443310 63548

[1] MUF (Muskwa Foothills Ecosection), EMR (Eastern Muskwa Ranges Ecosection).
[2] Follows Delong *et al.* (1990), Meidinger and Pojar (1991).

The MUF is an area of subdued mountains, isolated by wide valleys. It is in the rainshadow of the Muskwa Range, and is commonly influenced by cold Arctic winter air. The EMR includes some of the highest, most rugged mountains in northern BC, including some at the western edge of the Study Area. It is characterized by more snowfall than the MUF, and some areas are glaciated to the east (Demarchi 1996).

There are three BEC Zones (cf. Meidinger and Pojar 1991) that are represented within the Study Area (Table 2): the Boreal White and Black Spruce (BWBS), Spruce Willow Birch (SWB) and Alpine Tundra (AT) Zones.

The Boreal White and Black Spruce zone (BWBS) occurs as an extension of the Great Plains (Alberta Plateau) into the northeastern corner of BC. The zone occupies the lower elevations of the main valleys west of the northern Rocky Mountains. The climate of this zone is characterised by short growing seasons, long, very cold winters with frequent outbursts of arctic air masses. Annual precipitation averages between 330 and 570 mm with 35-55% of this falling as snow. The ground freezes deeply for a large part of the year and discontinuous permafrost is common in the northeastern parts of the zone. White spruce, trembling aspen, lodgepole pine, black spruce, balsam poplar, tamarack, subalpine fir and paper birch are major tree species found in the BWBS. Forest fires are frequent, maintaining most of the forests in various structural stages (Meidinger and Pojar 1991). True climax forests are largely unknown in the BWBS as few stands have escaped fire for several hundred years (Delong *et al.* 1991).

Table 2. Brief descriptions of BEC zones within the Besa/Prophet Study Area.

BEC Zone	Subzone/ Variant	Elevation (m)	Description
BWBS	mw2 – Fort Nelson moist warm	900 to 1000	Zonal climax forests are comprised of White Spruce and Aspen with a dominantly stepmoss forest floor. Seral stands containing pine and aspen are very common.
SWB	mk – moist cool	900 to 1600	Zonal climax forests consist of mixed White Spruce and Sub-alpine Fir forests, with bog birch and shrub willow present in the understory.
SWB	mks – moist cool scrub	1500 to 1800	Zonal vegetation is dominated by lush forb-alpine grass communities, in association with shrubby willow, scrub birch and krummholz vegetation (mostly Sub-alpine fir).
AT	AT	Above 1750	An upper-elevation treeless area characterized by a harsh climate and a very short growing season. Zonal vegetation is dominated at lower elevations by lush mixed forbs and alpine grasses. At higher elevations, conditions for growth are more limiting and support a less vigorous mix of sedges, dwarf shrubs, forbs and alpine grasses.

The Fort Nelson Moist Warm BWBS (BWBSmw2) occurs between 300 and 1050 m and features aspen-white spruce forest on well-drained sites and black spruce forests (with some tamarack) commonly on very wet sites (Delong *et al.* 1990). Lodgepole pine is relatively common, especially on wetter sites with black spruce or on well-drained, higher elevation sites. Balsam poplar, white spruce and often, trembling aspen and paper birch are common on the floodplains of the major watercourses. Winter snow depths for this zone are approximately 185 cm (Delong *et al.* 1990, 1991). The Spruce – Willow – Birch zone is the subalpine zone above the BWBS over most of its range and within the Besa/Prophet Study Area (Meidinger and Pojar 1991).

The Spruce – Willow – Birch zone (SWB) is the most northerly subalpine zone in BC (Pojar and Stewart 1991a). The climate is characterised by long, cold winters and brief, cool summers. Winter cold spells can be broken by Chinook winds. Mean annual precipitation is 460 to 700 mm, with 35-60% occurring as snowfall (Meidinger and Pojar 1991).

Lower-elevation conditions of the SWB are generally forested, consisting mainly of white spruce and some subalpine fir. On mid-slopes, spruce is the dominant tree species, especially on northern and eastern exposures, while fir is more limited in distribution, mainly falling within the EMR on southerly aspects. Black spruce, lodgepole pine and trembling aspen are relatively minor species, although all can be locally abundant. At high elevations, the SWB is characterised by a scub/parkland zone dominated by scrub birch (*Betula glandulosa*) and several species of willow (*Salix spp*.) (Meidinger and Pojar 1991). Subzones of the SWB have not been well studied. The Besa-Prophet Study Area contains the Moist Cool and the Moist Cool Scrub subzones (SWBmk and SWBmks respectively).

Generally, Alpine Tundra (AT) occurs above 1800 m. The climate in this zone is cold, windy, snowy and characterised by low growing season temperatures and a very short frost-free period. Most precipitation falls as snow. By definition, the AT is treeless. Alpine vegetation is dominated by shrubs, herbs, bryophytes, and lichens (Fig. 3). Many areas in the AT are dominated by rock, snow and ice. Common shrubs in the Study Area are scrub birch and various willows (Pojar and Stewart 1991b).

Figure 3. An oblique view of the SWBmks Zone, showing ecosystem conditions that provide good-quality summer forage for ungulate species such as elk.

2.7 Disturbances

Site disturbances include a range of natural or man-made events or effects that have led to alterations / modifications of vegetation and soil characteristics. Disturbances can result from biotic and abiotic factors, ranging from natural forest, and insect damage/mortality to forest operations and oil and gas exploration and testing.

The following "broad categories" of natural site disturbances have widely affected vegetation and soil characteristics within the Study Area: extreme cold (in particular, the effects of snow compaction, and cold air drainage); wildfires and pathogens (insects, disease); natural terrain failures, such as slumps (Fig. 4); and, inundation and temporary seepage.

Slumps, observed on northern slopes, were frequently found to occur in association with permafrost soils (Fig. 4). Extensive effects of insect infestations or animal foraging/overgrazing were not observed within the Study Area during the field investigation portion of the work. The most readily noticeable disturbance within the Study Area is wildfire, which is widespread. Most fires originate from lightening strikes, although some large fires originated from intentionally-ignited "prescribed burns" that were undertaken to enhance ungulate habitat. Many recent fires within the area have burned intensely, and extensively. Wildfires in excess of >200 ha in size are common throughout the Study Area, especially on south and east facing slopes where generally drier and warmer conditions prevail (Fig 5A).

Prescribed burning was initiated in the 1950's within the Study Area. The fires have allowed the return of a herbaceous structural stage (Fig. 5B) to these areas. Generally, areas that are frequently burned will only reach an edaphic condition of shrub and herbs or to an aspen seral stage.

Figure 4. Examples of natural site disturbances that were encountered within the Besa/Prophet TEM Study Area: (a) recent slumps, (b) landslides, (c) recent fires, and (d) inundation and flooding along wide, flat valley bottoms.

Figure 5A: Aerial oblique photo showing the extent of a prescribed burn across a south-facing slope along the Prophet River (late winter, 1998).

Figure 5B: Burned-over areas, such as shown in this ground photo, help to create important foraging areas for elk (summer, 1998).

Some burned sections of the Study Area will be extremely slow and prolonged in returning to their natural status of a mature coniferous stand due to the fact that numerous and severe fires have destroyed seed beds and humus forms. If prescribing burning continues in the area, white spruce stands will be slowly eliminated from the area. The frequency of fires has already potentially affected the area in two ways. If the frequent fires have not totally destroyed the conifer seed source, conifer dominated stands will be replaced by mixed forests dominated by Aspen, Lodgepole Pine and White Spruce and if the seed source has been totally destroyed, hardwood stands will persist.

3.0 METHODOLOGY

3.1 TEM Data Sources

3.1.1 Air Photos

Good quality stereo-pair black and white photos at 1:60,000 scale were acquired for the whole of the Study Area. The area was flown and photographed in 1986.

3.1.2 Satellite imagery

Two type of satellite imagery, Landsat Thematic Mapper (TM) and SPOT, were acquired for the Study Area. The TM sensor on the Landsat satellite provides multi-spectral coverage of the earth's surface at a resolution of 30m. The SPOT satellite collects panchromatic imagery at a resolution of 10m. By combining these two types of imagery, a merged composite image is produced that retains the higher resolution of the SPOT panchromatic data, but which also incorporates the colouration provided by red, blue and green themed TM spectral bands (Fig. 6).

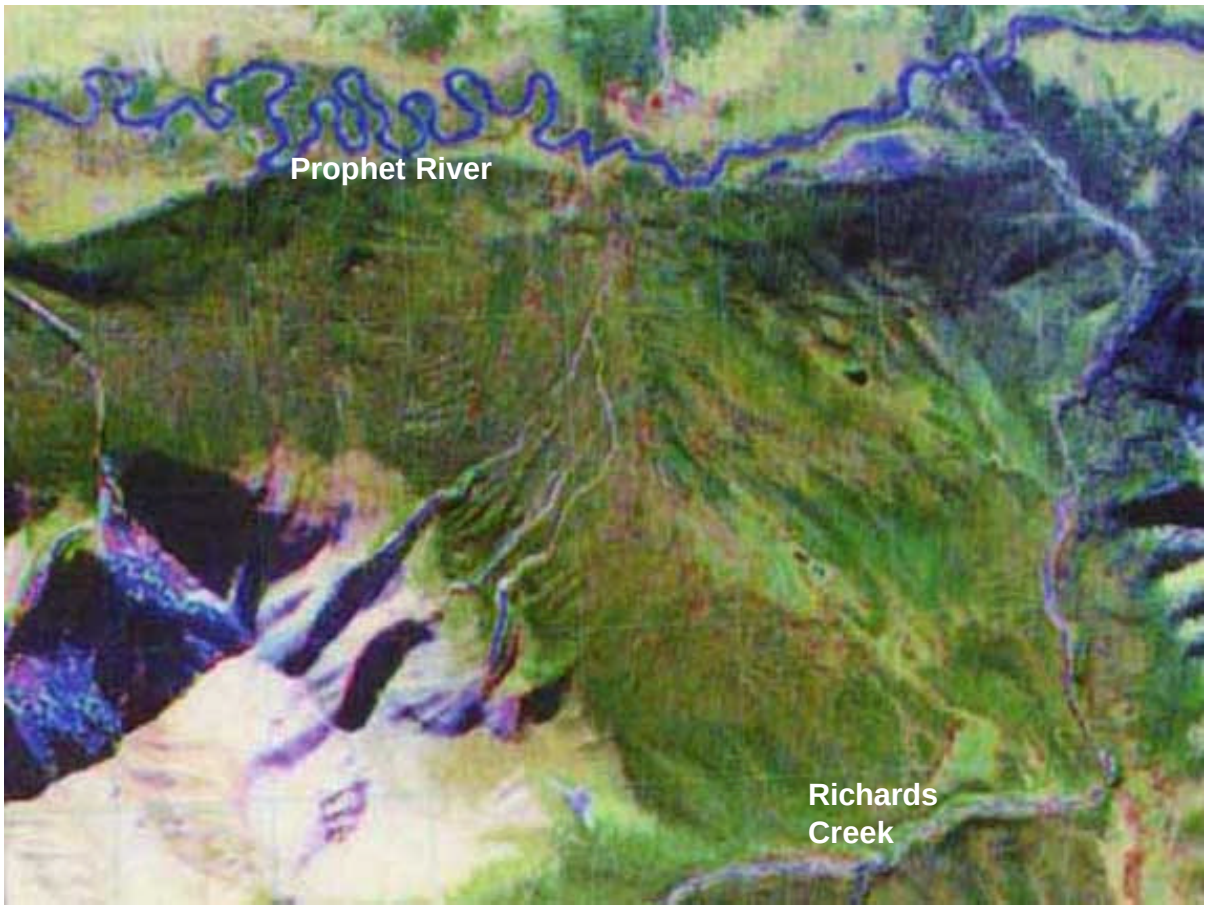

Figure 6: A section of the Besa-Prophet Study Area illustrating the results of combining Landsat TM and SPOT satellite imagery. This image composite shows, among other features, a winding portion of the Prophet River (top of image) and a portion of Richards Creek (bottom of image).

The Study Area was covered by two full SPOT panchromatic scenes and two Landsat TM Quads. Clear imagery was found for both TM and SPOT data on September 23 and September 25, 1997.

3.1.3 Digital Elevation Model (DEM)

Geographic Data British Columbia's 25m Gridded DEM (obtained from the BC MELP Geographic Data Web Page) was used for orthorectifying the satellite imagery at both 25m and 10m resolution, and for orthorectifying the scanned air-photos containing linework.

3.2 Photo-Interpretation of Bioterrain and Ecosystem Units

There were many photo-interpretation activities associated with polygon delineation and data collection (Fig. 9). The first step was to establish terrain, ecosystem and administrative boundaries. These boundaries were determined, in consultation with the MELP project monitor, by sorting through different data sources such as standard manuals, BEC maps and expert opinion.

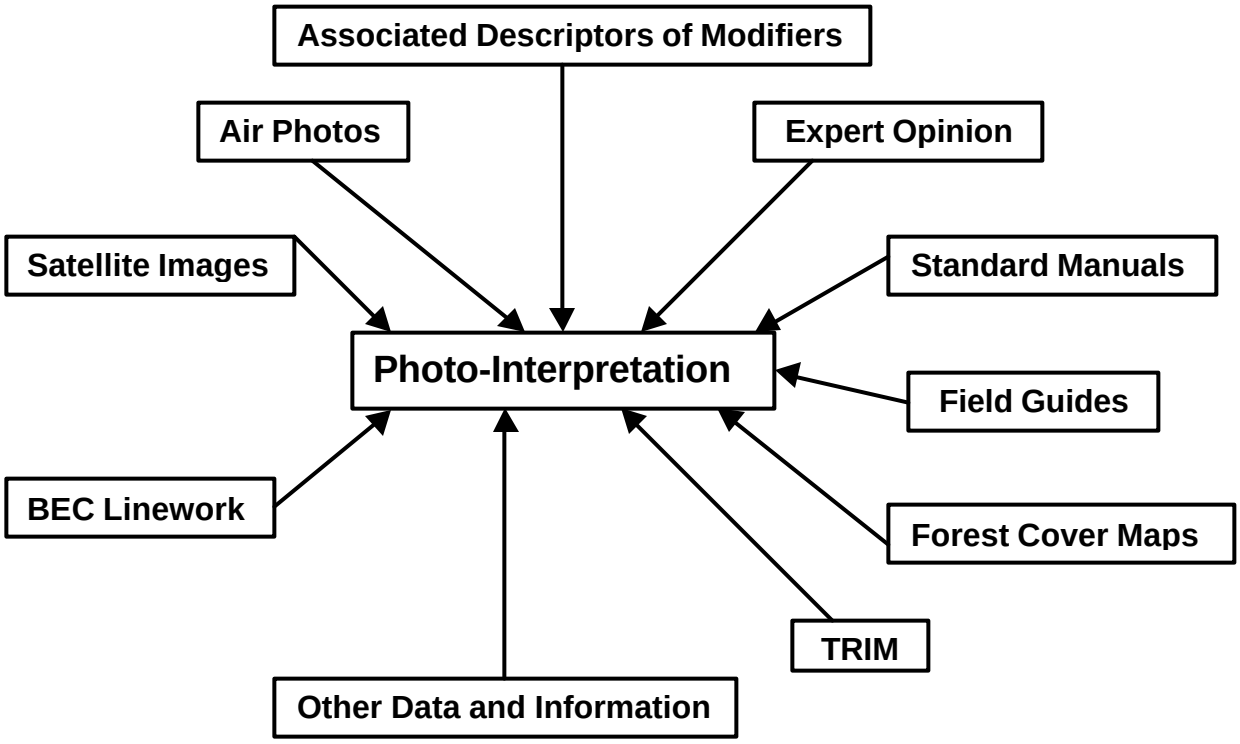

Figure 7: Flowchart summarizing photo-interpretation activities associated with the Besa/Prophet Area TEM project. Interpretation was initially conducted using 1:60 000 scale photos, in association with other data / information, to produce typed photos for transfer into a Geographic Information System, then remote sensing data was used to improve and augment interim interpretations.

Terrain, ecosystem and administrative boundaries were initially delimited on the air-photos. In order to digitally separate different types of linework from each other and from the photo background after scanning (described later), specific linework and labels were identified by unique colours.

The initial stage of bioterrain photo-interpretation involved the assignment of basic terrain labels. Standard procedures and conventions, mainly as outlined by Howes and Kenk (1997), were followed for this. Bioterrain enhancement symbols (including drainage, slope, bedrock type and geomorphic process subclass descriptor) were then added for each polygon on each boxed photo (Fig 10). RIC standards (1997) for bioterrain mapping were closely followed for all bioterrain photo typing.

The next stage of air photo interpretation involved designation of Biogeoclimatic Subzones boundaries and the determination of Subzones (Fig. 10B), Variants, and Ecosection boundary locations. Potential boundaries were delineated by studying available 1:250,000 scale ecosystem maps, in consultation with:

- Ecosystem guides (including Delong *et al*. 1990, 1994, MacKinnon *et al*. 1990) and other sources of published information; and,
- MoF Regional Ecologist and other experts.

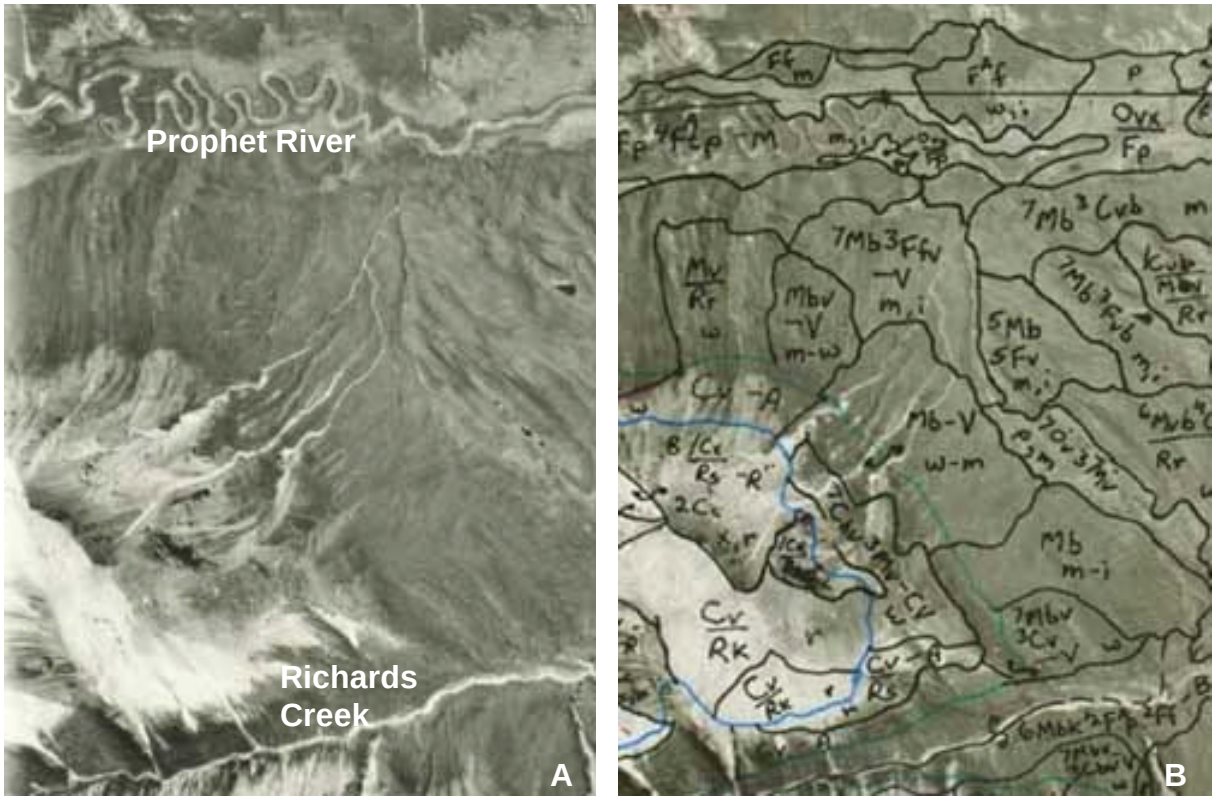

Figure 8: Photo A (left) illustrates an untyped 1:60 000 scale air photo showing a winding section of the Prophet River to the north and a section of Richards Creek to the south. Photo B (right) illustrates a typed air photo for the same area. The air photo has been typed to show the various simple and complex terrain polygons. Coloured lines represent AT (blue line) and SWBmks (green line) BEC boundaries.

The final stage of photo interpretation involved the derivation and assignment of ecosystem unit labels. This stage involved the systematic assignment of Site Series for all delineated polygons. This step involved synthesizing and incorporating data and information from several sources including:

- Published ecosystem field guides;
- Other published and unpublished literature;
- Available ecosystem field data; and,
- In-house photo typing keys and other conceptual tools.

Photo-typing keys were developed to help guide the mappers. Such "tools" are considered to be important and fundamental for a TEM project, in that they help in the development of "mental models" of the terrain/ecosystem relationships that exist within an area (cf. RIC, 1998).

3.3 Geographic Information System Processing

The next component involved the photo-to-map transfer and the Geographic Information System (GIS) setup of TEM mapping outputs, both in digital and hard copy formats. GIS treatment of TEM digital information is conducted to RIC standards. The steps involved in the GIS processing are outlined in Figure 9.

3.3.1 Import of Air-Photo Linework

The coloured linework with the background photographs were scanned on a flatbed scanner. Each photo was scanned at 200DPI, an equivalent of 7.5m resolution in RGB mode.

3.3.2 Orthorectifying Scanned Photos With Linework

In order to correct distortions in the images caused by the camera lens, camera tip and tilt, terrain relief, and scale, a camera model and the digital elevation model (DEM) were used to calculate the precise location of every pixel in the scanned photograph. Ground control points (GCPs), information on the camera's focal length and the fiducial marks were used to calculate the camera model. This model describes the camera's location in XYZ orientation during the acquisition of the photo.

GCPs are physical points on the ground whose positions are known with respect to some horizontal co-ordinate system and/or vertical datum. When mutually identifiable on the ground and on a map or photographic image, ground control points can be used to establish the exact spatial position and orientation of the image to the ground. Terrain Resource Inventory Management maps (TRIMs), planimetric vectors and 10m colourized satellite imagery were used as ground truth for the collection of ground control points. Since the TRIM vectors were originally derived from the photos, it was safe to use water features for tie down. A minimum of 10 GCPs were collected from each photo.

The scanned images, combined with the camera model and the DEM, were orthorectified using PCI's EASI/PACE. The resulting digital image (Figure 8) is a corrected version of the scanned photo with the linework that shows features in their true ground position. This type of corrected air-photo is called an orthophoto. Each image was orthorectified into its own file with a 10m resolution.

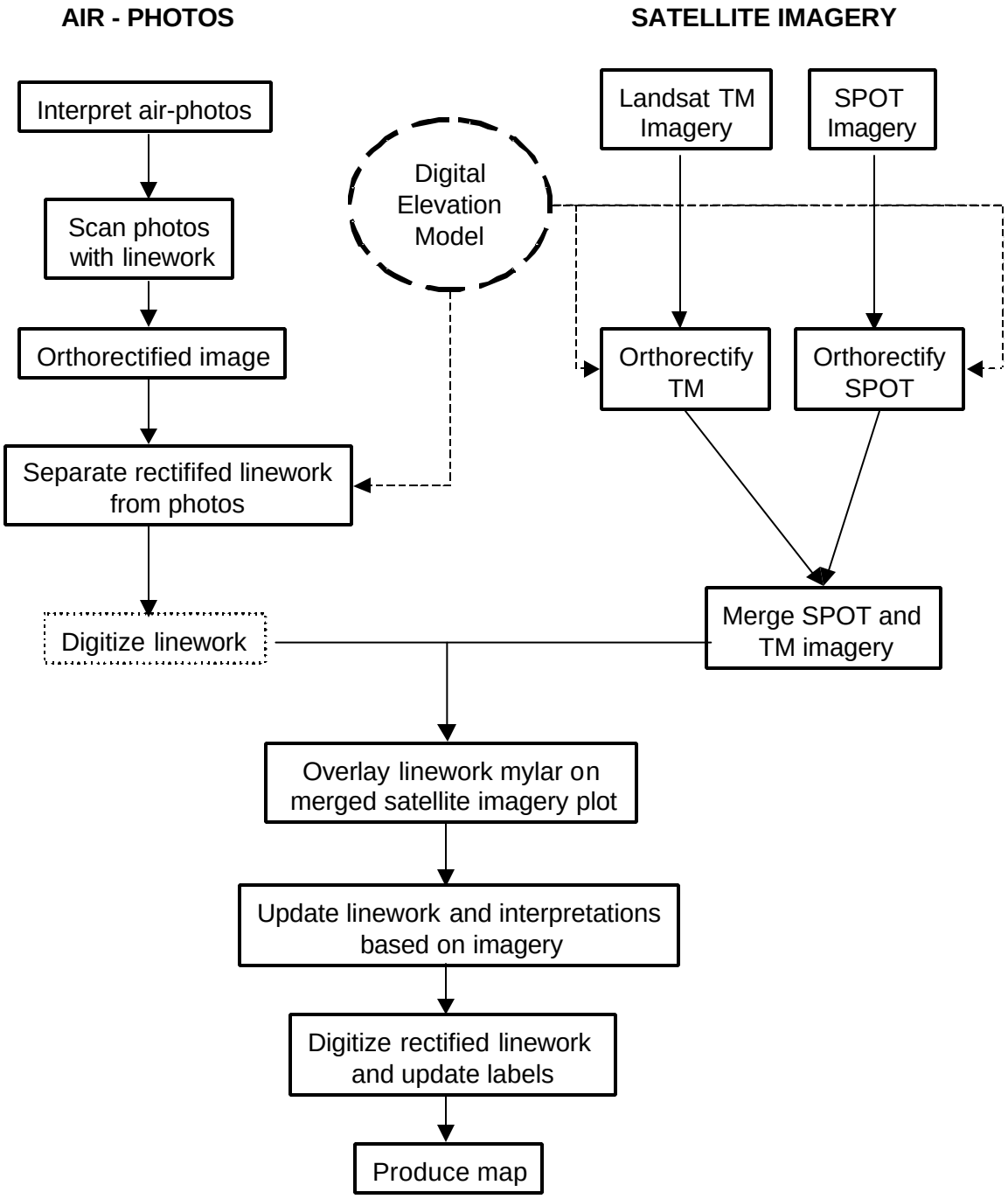

Figure 9. Flowchart of the process followed to incorporate satellite imagery-based information into the Terrestrial Ecosystem Mapping methodology.

3.3.3 Separating Lines from Photo Background

After the photos were orthorectified, a group of photos were then mosaiced into their corresponding 1: 50,000 map area. Only the areas containing linework were extracted from each photo and stitched together with the neighbouring photos.

The linework was then separated from the background of each photo. The colourized lines were separated from the grey-scale imagery by converting the photo from RGB colour space to Lab colour. The "L" channel contains all the greyscale information, while the "ab"channels distinguish all the colours.

Linework drawn in colour was identified by selecting all similar colours and saving the selection. Linework defined using a black marker was distinguished from the various shades of grey in the photo by adjusting the brightness levels of the "L" channel by making any pixels that are not near black, bright. The resulting black/white image was then edited to remove any conflicting dark areas that were originally in the photos, such as shadows.

All of the linework was edited to remove noise and lines that were duplicated by the mosaicing process. This editing process was done with the original photos in-hand to verify the photo-interpreters intent.

3.3.4 Digitization of Revised Linework

After the linework was separated from the photo, the raster linework was then digitized so that it could be used within the GIS. However, the raster linework can be overlaid directly on the satellite imagery, bypassing this step. The final linework was then plotted on mylar.

3.3.5 Orthorectifation of Satellite Imagery

After the Landsat TM and SPOT imageries were acquired, both were orthorectified using the same technique as described for the air-photos. GCPs where collected from the TRIM planimetric data and a shaded relief image derived from the DEM. The shaded relief was helpful in trying to locate areas in common between the georeferenced source (vectors) and the raw satellite imagery.

PCI's Ortho-Engine® software was used for this process. A satellite model was derived from the orbit information supplied with the imagery and the GCPs collected. Around 20 GCPs were collected for each image.

3.3.6 Landsat-SPOT Merge

The detail of the SPOT panchromatic imagery was colourized with the multispectral information of the lower resolution TM image. The technique to perform this merging converts the RGB band combination of the TM imagery into IHS (Intensity, Hue and Saturation) colour space. The intensity is replaced by the detailed SPOT panchromatic imagery and the image is then converted back into RGB colour space. The resulting image has the detailed information of the SPOT panchromatics data, and the colours of the TM imagery. High resolution photographic plots were then printed of each of the 1:50,000 mapsheets for the Study Area.

The band combination of 5,4,2 was used to create the colour composite. This combination shows the vegetation variations well and also has a normal colour appearance (i.e., trees are green, water is blue, etc…).

3.3.7 Overlay of Rectified Linework on Satellite Image

The linework mylars were then overlaid on the corrected satellite imagery (Figure 11).

3.3.8 Linework Update

The satellite imagery shows the vegetation in its recent state, the linework derived from the aerial photos shows the state of the vegetation as it was 12 years ago. It is now possible to update the lines and the labels to the current imagery. This was done by drawing directly on the mylar plots.

3.3.9 Digitizing of Updated Linework

The updated and georeferenced lines on the mylar were then digitized into the GIS. We considered the automatic conversion of the separated orthorectified raster lines into vectors, but this proved to be problematic. The linework contained inconsistent widths and colours and too much effort was required to clean up the linework before it was converted. Following the conversion from raster to vector, further editing of the vector linework would also be required.

3.4 Field Sampling Strategy

The approach to field sampling for this project, and preliminary summaries of the main findings of the summer, 1998 TEM sampling, were previously summarized in two documents. These documents were the "Besa/Prophet Area TEM Project Summer 1998 Sampling Plan" (Geomatics International Inc., 1998a) and the "Besa/Prophet TEM Progress Report on the Summer 1998 Field Season" (Geomatics International Inc., 1998b). As part of the milestone progress activities for the Besa/Prophet TEM project, these reports were submitted to the Fort St. John office of the Oil and Gas Division of MELP. Only a brief summary of field sampling is provided here.

3.4.1 Schedule of Field Program

The field sampling was conducted from July 3rd to July 16th, 1998 (excluding travel days). Two 3-person crews (a crew consisted of a soil scientist, a plant ecologist and a wildlife ecologist) (Fig. 10). The field effort was augmented for three days with additional expertise provided by the following Ministry of Environment correlators: Carmen Cadrin (Vegetation Ecologist), Bob Maxwell (Bioterrain Specialist) and Andy Stewart (Wildlife Habitat Specialist).

Figure 10: Field crew collecting TEM data. MELP Project correlators spent three days in the field with R.A. Sims and Associates' field crews; Bob Maxwell (far right) was the Bioterrain Correlator for this project.

3.4.2 Initial Field Efforts

Initial field efforts (i.e., completed within the first days of field sampling) included:

- Reconnaissance overviews (by helicopter) of the Study Area to initiate site selection procedures for plot establishment;
- On-site training and group review exercises to finalize sampling protocols, and conduct some team-based exercises to calibrate and standardize ecosystem sampling methodologies, measurements and conventions for estimating percent cover and other features; and,
- Particular efforts were made to establish, test and then standardize wildlife sampling conventions, and to refine wildlife sampling methodologies.

3.4.3 Establishment of Ecosystem Field Plots

TEM mapping is being conducted within the Study Area to enable interpretations as they relate to forestry, geology, wildlife, range, local resource planning, and broader landscape management planning. For this purpose, the Besa/Prophet TEM field sampling was conducted at what is referred to as "a survey with 20% polygon visitation" as defined in the "Standards for Terrestrial Ecosystems Mapping" manual (RIC, 1998).

Ecosystem field sampling was conducted using a combination of 3 types of point-based field sampling, and using 3 different sets of forms: FS882 ("Full Plot") Forms, Ground Inspection ("Visual Plot") Forms, and Visual Call ("Air/Ground Plot") Forms.

Total numbers of plots that were sampled during summer, 1998 for the Study Area were allocated as follows:

- 31 FS882 Full Plots
- 102 Ground Inspection Plots
- 404 Visual Calls

Ground Inspection Plots and Visual Calls were mainly used to help describe ecosystems and their attributes (*ie*, to help improve overall mapping reliability) rather than for classification purposes.

3.4.4 Stratification of Field Sampling

The strategy for field sampling involved the careful and systematic selection of field plots for visitation, to best facilitate the TEM mapping process. In general, this meant that efforts were directed so that over-sampling of some regularly occurring and common ecosystem conditions did not occur, and that rare and discrete features were not overlooked. Special attention was given to wetlands, Alpine Tundra and scrub parkland, and other non-forested units, as these were previously poorly described from the general area using TEM approaches. Sampling began in the upper Prophet River in the eastern portion of the Study Area, proceeded to the southern end of the Study Area in the Nevis Creek area, and then moved north toward the Prophet River visiting each major drainage and mountain system.

A "field sampling matrix" was created as an aid to field sampling. This matrix summarized all possible combinations of site series and structural stages according to BEC subzone/ variant within the Study Area. This matrix was consulted, as plots were installed, to ensure that adequate visitation occurred for the range of ecosystem conditions that were anticipated / encountered.

The majority of Full Plots installed during the field program were allocated to Alpine Tundra, Parkland, regenerating burns and wetland areas. A limited number of Full Plots were allocated to the subzones for soil/site confirmation.

There was an overlap with the NE Burn Study Area and the Besa/Prophet Study Area. As field sampling proceeded, the NE Burn polygons (linework and contents) within the Besa/Prophet Study Area were closely examined. One critical aspect of the work was to update, to current standards, the NE Burn polygons within the Besa/Prophet TEM Study Area. One objective of this exercise, however, was to efficiently resolve any differences that existed between the two mapping projects.

Field sampling sites were located using maps and satellite images, in conjunction with stereo viewing of 1:60,000 pre-typed air photo pairs. First, general areas for visitation were selected and then located on the maps. Then sets of air photos for the selected area were viewed. Possible ground visitation locations were then noted on the air photos, as well as potential helicopter landing areas.

Sets of marked maps and air photos were then carried into the field during site visitation and sampling. The maps were generally used to navigate to the plot locations, and then the air photos

were used to pinpoint landing spots closes to sampling areas. Once the sampling area has been reached, plots were installed with the location pin-pricked onto the air photos. In cases where landing areas were not accessible for the helicopter, and where the exact site or a very close alternative could not be reached, the default approach for field crews was to at least install visual plots in locations that otherwise would have been established with full plots.

Plot forms were accumulated and recorded within the various matrix cells. As sampling proceeded, the Sample Matrix was regularly reviewed by the field team, and used as a tool to help focus future sampling. The matrix was examined daily to ensure that more common Structural Stage / Site Series combinations were not being over-sampled. Once an adequate number of plots for a particular Structural Stage / Site Series combination was obtained, such conditions were then avoided. As the field season progressed, the regularly updated sample matrix was also used to help identify and track which Structural Stage / Site Series combinations appeared to not physically exist within the Study Area.

Field data collection to assist in polygon delineation and classification involved the establishment of 31 Full Plots (FS882 ecosystem plots, as described in "Standards for Terrestrial Ecosystems Mapping in BC." (RIC, 1998). Ground Inspection and Air/Ground Call plots, rather than Full (FS882) Plots, were established in Site Series that had previously been relatively well described by Full Plots in adjacent locations.

Proper georeferencing of ALL field plots was paramount. All field plots were accurately located by pinpricks on field copies of 1:60,000 scale b & w photographs that were carried into the field. Specific directions to the plot were provided, wherever possible, on field data forms. Hand-held (Garmin GPS II Plus) GPS units and barometric altimeters were also used at all established plots, and this geolocational data was used as a back-up to the pin-pricked locations on air photos.

The locations of Full Plots and Ground Inspection Plots are provided in Appendix A.

4.0 QUALITY ASSURANCE

4.1 Database

All data were entered into a Microsoft Access© database. A series of quality assurance checks and routines were then undertaken to identify and correct errors arising from photo-interpretations, transcription and data entry. These checks included searches for several potential error sources within the polygon description database:

- duplicate polygon numbers;
- verified that the sum of complex polygon deciles equaled 100%;
- verified that each polygon had no missing data;
- verified that each polygon was in the correct Ecosection, and BEC zone;
- search for all possible typing errors;
- verified that the site modifiers and structural stages listed are possible within the listed ecosystem unit.

4.2 Map Production

The first mapping QA was undertaken after the network of ortho-corrected polygon linework had been accomplished. This task was accomplished by comparing the orthorectified results to the original input photos. An interim check plot was produced. Using this product, the linework on the map coverage was compared to the linework on the airphotos to ensure that no lines had been lost in the transfer.

Polygons, along the border, were edge-matched. The linework was then converted into vectors and given topology to create polygons. The polygons underwent several internal QA checks to ensure that polygon labels were in the proper polygons and that all linework had been corrected for overshoots and undershoots.

The last step before final ecosystem maps production was to produce and send draft maps to MELP Project Correlators for external QA. Draft maps were forwarded, along with supporting photo and satellite imagery materials, to MELP, Victoria, for QA review in late December, 1998. Reviews were undertaken stages and review comments and corrections were received back on February 15, 1999. A second stage of review was also completed in March and early April. Changes to ecosystem units, modifiers, and legend format were all undertaken and incorporated into the final map outputs.

5.0 Bioterrain and Ecosystem Map Symbols

This section of the Final Report summarizes conventions used in the mapping process. In general, standard procedures as outllined in the TEM Standards (RIC, 1998) were followed. In TEM, Bioterrain and Ecosystem Map Symbols are composed of a sequence of letters were each letter defines a specific characteristic. The position of the letters in the sequence augments the information described by the letter grouping (Figures 11, 12 and 13).

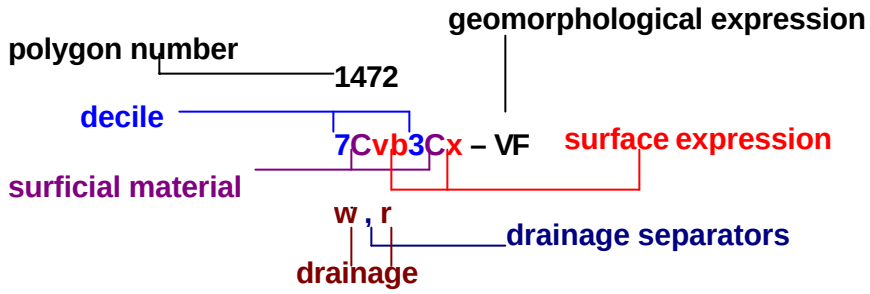

Figure 11. Bioterrain map symbols and map label format.

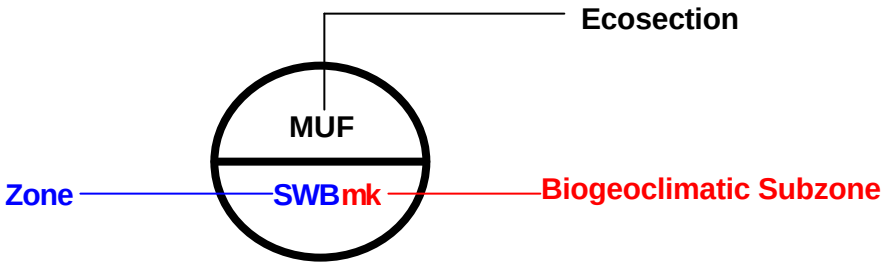

Figure 12. Ecosystem map Biogeoclimatic Zone Symbols.

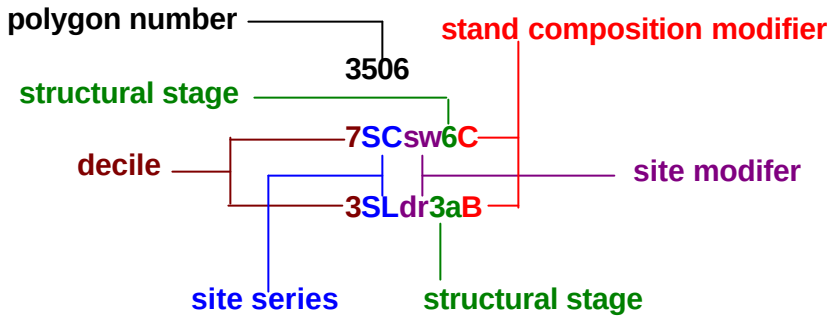

Figure 13. Ecosystem map symbols and map label format.

5.1 Bioterrain Map Symbols

The bioterrain terrain classification system was specifically developed to provide an inventory of the terrain features in the landscape and to show their distribution, extent and location (Howes and Kenk, 1997). The data is described on maps by the use of symbols, which are conducive to computer digital storage, management and processing. The symbol sequence describes the following terrain characteristics: texture and type of surficial material, surface expression, geomophologic processes, and qualifiers.

5.1.1 Texture

Texture refers to the size, shape and sorting of particles in clastic sediments, and the proportion and degree of decomposition of plant fibre in organic sediments. Table 3 describes the letter codes that are used to define the texture of a polygon. The texture of surficial materials can vary both laterally and vertically within a polygon.

Table 3: Letter codes that can be used when defining terrain texture.

Code	Name	Description[1]
A	Blocks	Angular particles greater than 256 mm in size
B	Boulders	Rounded particles greater than 256 mm in size
K	Cobbles	Rounded particles between 64 and 256 mm in size
P	Pebbles	Rounded particles between 2 and 64 mm in size
S	Sand	Particles between 0.0625 and 2 mm in size
Z	Silt	Particles between 2 µm and 0.0625 mm in size
C	Clay	Particles less than 2 µm in size
D	Mixed fragments	A mixture of rounded and angular particles greater than 2 mm in size
X	Angular fragments	A mixture of angular fragments greater than 2 mm in size
G	Gravel	A mixture of two or more size ranges of rounded particles greater than 2 mm in size; may include interstitial sand
R	Rubble	Angular particles between 2 and 256 mm; may include interstitial sand.
M	Mud	A mixture of silt and clay; may also contain a minor fraction of fine sand.
E	Fibric	The least decomposed of all organic materials. It contains amounts of well-preserved fibre (40% or more) that can be identified as to botanical origin upon rubbing
U	Mesic	Organic material at a stage of decomposition intermediate between fibric and humic
H	Humic	Organic material at an advanced stage of decomposition; it has the lowest amount of fibre, the highest bulk density, and the lowest saturated water-holding capacity of the organic materials; fibres that remain after rubbing constitute less than 10% of the volume of the material

[1] Howes and Kenk, 1997.

5.1.2 Surficial Materials

Surficial materials constitute the parent material of most soils. Howes and Kenk (1997) define surficial materials as non-lithified, unconsolidated sediments. These materials are produced by weathering, sediment deposition, biological accumulation, human and volcanic activity. Surface materials are classified by way they were formed. The most important fact to remember when describing surficials materials is that specific processes produce materials that have specific sets of physical characteristics (Howes and Kenk, 1997). Table 4 lists the letter codes that can be used to describe a polygon's surficial material.

Table 4: Letter codes that can be used when defining a polygons' surficial materials.

Code	Name	Description[1]
C	Colluvium	Materials that have reached their present positions as a result of direct, gravity-induced movement involving no agent of transportation such as water or ice, although the moving material may have contained water and/or ice.
F	Fluvial	Materials transported and deposited by streams and rivers; synonymous with alluvium.
F^G	Glaciofluvial	Materials that exhibit clear evidence of having been deposited by glacial meltwater streams either directly in front of, or in contact with, glacier ice.
I	Ice	Areas of snow and ice where evidence of active glacier movement is present.
L^G	Glaciolacustrine	Lacustrine materials deposited in or along the margins of glacial (ice-dammed) lakes; includes sediments that were released by the melting of floating ice.
M	Morainal	Material deposited directly by glacier ice without modification by any other agent of transportation.
O	Organic	Sediments composed largely of organic materials resulting from the accumulation of vegetative matter. They contain at least 30% organic matter by weight (17% or more organic carbon).
R	Bedrock	Bedrock outcrops and rock covered by a thin mantle (up to 10cm thick) of unconsolidated or organic materials.

[1] Howes and Kenk, 1997.

5.1.3 Surface Expression

Howes and Kenk (1997) define surface expression as the assemblage of slopes and pattern of forms expressed by a surficial material at the land surface and also describe the manner in which unconsolidated surficial materials relate to the underlying substrate. Classification is according to slope, geometric shape and spatial pattern. Table 5 lists the letter codes used to describe a polygon's surface expression.

Table 5: Describes letter codes that can be used when defining surface expression.

Code	Name	Description[1]
a	Moderate slope	An unidirectional (planar) surface with a slope 16° to26° (27 to 50%), and a smooth, longitudinal profile that is either straight, or slightly concave or convex; local surface irregularities generally have a relief of less than 1 metre.
b	Blanket	A layer of unconsolidated material thick enough to mask minor irregularities of the surface of the underlying material, but still conforms to the general underlying topography. A blanket is greater than 1 metre thick and possesses no constructional forms typical of the materials genesis; outcrops of the underlying unit are rare.
c	Cone	A cone or sector of a cone with a relatively smooth surface, and mostly steeper than 15° (26%), and a longitudinal profile that is either straight, or slightly concave or convex.
f	Fan	A fan is a relatively smooth sector of a cone with a slope gradient from apex to toe up to and including 15° (26%), and a longitudinal profile that is either straight, or slightly concave or convex.
h	Hummock	Steep sided hillock(s) and hollow(s) with multidirectional slopes dominantly between 15° and 35° (26 to 70%) if composed of unconsolidated materials; bedrock slopes may be steeper. Local relief is greater than 1 metre. In plan, an assemblage of non-linear, generally chaotic forms that are rounded or irregular in cross-profile.
j	gentle slope	An unidirectional (planar) surface with slope gradient 4 to 15° (7 to 26%), and a smooth, longitudinal profile that is either straight, or slightly concave or convex; local surface irregularities generally have a relief of less than 1 metre.
k	Moderately steep slope	An unidirectional (planar) surface with slope gradient 27 to 35° (50 to 70%), and a smooth, longitudinal profile that is either straight, or slightly concave or convex; local surface irregularities generally have a relief of less than 1 metre.
m	Rolling	Elongate hillock(s) with slopes dominantly between 3 and 15° (5 to 26%) with local relief greater than 1 metre. In plan, an assemblage of parallel or sub-parallel linear forms with subdued relief.
p	Plain	A level or very gently sloping, unidirectional (planar) surface with gradients 0 to 3° (0 to 5%); local surface irregularities generally have a relief of less than 1 metre.
r	Ridge	Elongate hillock(s) with slopes dominantly between 15 and 35° (26 to 70%) if composed of unconsolidated materials; bedrock slopes may be steeper. Local relief greater than 1 metre. In plan, an assemblage of parallel or sub-parallel linear forms.
s	steep slope	An unidirectional (planar) surface with gradients greater than 35° (70%), and a smooth longitudinal profile that is either straight, or slightly concave or convex; local surface irregularities generally have a relief of less than 1 metre; bedrock slopes may be more irregular.
t	Terrace	A single or assemblage of step-like forms where each step-like form consists of a scarp face and a horizontal or gentle inclined surface (tread) above it.
v	Veneer	A layer of unconsolidated materials too thin to mask the minor irregularities of the surface of the underlying material. It is between about 10 cm and 1 m in thickness, and possesses no constructional form typical of the material genesis.
x	thin veneer	A very thin layer of unconsolidated material about 2-20 cm in thickness.

[1] Howes and Kenk, 1997.

5.1.4 Geomorphological Processes

Geomorphological expressions are natural mechanical processes that result in the modification of the surficial materials and landforms at the earth's surface. The following are the natural mechanisms that create the expression: weathering, erosion and deposition. Table 6 lists the letter codes used to describe a polygon's geomorphological processes.

Table 6: Describes letter codes that can be used when defining geomorphological expression.

Code	Name	Description[1]
B	Braiding	Active channel zone is characterized by many diverging and converging channels separated by unvegetated bars. Many channels are dry at moderate and low flows, but during major floods, the entire channel zone may be occupied by flowing water.
C	Cryoturbation	Movement of surficial materials by heaving and/or churning due to frost action (repeated freezing and thawing).
F	Slow Mass Movement	Slow downslope movement of masses of cohesive or non-cohesive surficial material and/or bedrock by creeping, flowing or sliding.
I	Irregular Channel	A clearly defined main channel displaying irregular turns and bends without repetition of similar features; backchannels may be common, and minor side channels and a few bars and islands may be present, but regular and irregular meanders are absent.
J	Anastamosing Channel	A channel zone where channels diverge and converge around many islands. The islands are vegetated and have surfaces that are relatively far above mean maximum discharge levels. Some channels are dry at moderate or low flows.
M	Meandering Channels	A clearly defined channel characterized by a regular and repeated pattern of bends with relatively uniform amplitude and wave length.
N	Nivation	Erosion of bedrock or surficial materials beneath and along the margin of snow patches by freeze-thaw processes (frost shattering and heave), meltwater action and snow creep.
R	Rapid Mass Movement	Rapid downslope movement by falling, rolling, sliding or flowing of dry, moist or saturated debris derived from surficial material and/or bedrock.
S	Solifluction	Slow gravitational downslope movement of saturated non-frozen overburden across a frozen or otherwise impermeable substrate.
U	Inundation	Terrain seasonally under standing water which results from high watertable.
V	Gully Erosion	The modification of unconsolidated and consolidated surfaces by various processes such as running water, mass movement and snow avalanching, resulting in the formation of parallel and sub-parallel long, narrow ravines.
X	Permafrost	Processes controlled by the presence of permafrost, and permafrost aggradation or degradation. "Permafrost" is earth material whose temperature remains below 0°C continuously for two years or longer.
Z	Periglacial Processes	Solifluction, cryoturbation and nivation occurring together within a single terrain unit.

[1] Howes and Kenk, 1997

5.2 Ecosystem Map Symbols

Ecosystem maps contain three kinds of map units: ecoregion map units, biogeoclimatic map units, and ecosystem map units. RIC (1998) defines ecosystem map units as derivatives of site series classification of BEC which are further differentiated by more specific site conditions and structural developmental stages.

5.2.1 Map and BEC Site Series

Map and BEC Site Series are related to a specific range of soil moisture and nutrient regimes within a subzone. Section 6 of this report describes the map and BEC Site Series symbols and definitions. Table 7 lists the codes and definitions for non-vegetated, sparsely vegetated, and anthropogenic units.

Table 7: Sparsely Vegetated, Non vegetated, and Anthropogenic Units as Defined by the Standard for Terrestrial Ecosystem Mapping in British Columbia (RIC, 1998).

Ecosystem Unit	Definition	Site modifiers	Structural Stages Present
CL Cliff	A steep, vertical or overhanging rock face.[3]	q, z	1
GB Gravel Bar	An elongated landform generated by waves and currents and usually running parallel to the shore. It is composed of unconsolidated small rounded cobbles, pebbles, stones, and sand.	not applicable	1
GL Glacier	A mass of perennial snow and ice with definite lateral limits. It typically flows in a particular direction. [2]	not applicable	not applicable
LA Lake	A naturally occurring static body of water, greater than 2m deep in some portion. The boundary for the lake is the natural high water mark. [2]	not applicable	not applicable
MO Moraine	An unvegetated landform consisting of unstratified glacial drift that is usually till and taking a variety of shapes, ranging from plains to mounds and ridges that are initial forms independent of underlying bedrock or older material.[4]	k, w	1
RO Rock Outcrop	A gentle to steep, bedrock escarpment or outcropping, with little soil development and sparse vegetative cover.	k, r, w	1
RU Rubble	Rubble is common on the ground surface in and adjacent to alpine areas, on ridgetops, gentle slopes and flat areas due to the effects of frost heaving. [2, 4]	k, r, w	1
TA Talus	Angular rock fragments of any size accumulated at the foot of steep rock slopes as a result of successive rock falls. It is a type of colluvium	k, r, w	1

[1] Dunster and Dunster (1996)
[2] Resources Inventory Committee (1997)
[3] Sinnemann (1992)
[4] Howes and Kenk (1997)

5.2.2 Site Modifiers

Each site series has been described by a "typical" set of environmental conditions. These conditions are focused on site, soil, and terrain characteristics. Compensating effects of different environmental characteristics can result in some site series having a wide range of physical site conditions. Site modifiers are descriptive terms for certain site conditions, to describe conditions outside those considered typical. Table 8 lists the site modifiers that could be used when describing an ecosystem unit.

Table 8: Possible site series site modifers used to describe atypical conditions.

Code	Name	Description[1]
a	active floodplain	occurs on an active fluvial floodplain (level or very gently sloping surface bordering a river that has been formed by river erosion and deposition), where evidence of active sedimentation and deposition is present.
g	gullying occurring	occurs within a gully, indicating a certain amount of variation from the typical, or the site series has gullying throughout the area being delineated.
h	hummocky terrain	occurs on hummocky terrain, suggesting a certain amount of variability.
j	gentle slope	occurs on topography less than 25% slope.
k	cool aspect	occurs on cool, northerly or easterly aspects (285° - 135°), on moderately steep slopes (25% to 100%).
n	fan	occurs on a fluvial fan (most common), or on a colluvial fan or cone.
q	very steep cool aspect	occurs on very steep slopes (> 100%) with cool, northerly or easterly aspects (285° - 135°).
r	ridge	occurs throughout an area of ridged terrain, or it occurs on a ridge crest.
t	terrace	occurs on a fluvial or glaciofluvial terrace, lacustrine terrace, or rock cut terrace.
w	warm aspect	occurs on warm, southerly or westerly aspects (135° - 285°), on moderately steep slopes (25% to 100%).
z	very steep warm aspect	occurs on very steep slopes (> 100%) with warm, southerly or westerly aspects (135° - 285°).
c	coarse-textured soils	occurs on soils with a coarse texture, including sand and loamy sand; and also sandy loam, loam and sandy clay loam with greater than 70% coarse fragment volume.
d	deep soil	occurs on soils greater than 100 cm to bedrock.
f	fine-textured soils	occurs on soils with a fine texture including silt and silt loam with less than 20% coarse fragment volume; and clay, silty clay, silty clay loam, clay loam, sandy clay and heavy clay with less than 35% coarse fragments volume.
m	medium-textured soils	occurs on soils with a medium texture, including sandy loam, loam and sandy clay loam with less than 70% coarse fragment volume; silt loam and silt with more than 20% coarse fragment volume; and clay, silty clay, silty clay loam, clay loam, sandy clay and heavy clay with more than 35% coarse fragment volume.
p	peaty material	occurs on deep organics or a peaty surface (15-60 cm)[3] over mineral materials.
s	shallow soils	occurs where soils are considered to be shallow to bedrock (20-100 cm).
v	very shallow soils	occurs where soils are considered to be very shallow to bedrock (less than 20 cm).

[1] Resources Inventory Committee (RIC), 1998.

5.2.3 Structural Stages

Structural stages describe the existing dominant stand appearance and structural features are emphasized over age criteria. Table 9 defines the various vegetation structural stages.

Table 9: Structural stage categories and modifiers used to describe ecosystem units.

Structural Stage	Code	Definition[1,2]
Sparse/Bryoid	1 (NS)	Initial stages of primary and secondary succession; bryophytes and lichens often dominant; time since disturbance < 20 yrs for normal forest succession, may be prolonged (50-100+ years) where there is little or no soil development.
Sparse	1a (SP)	Less than 10% vegetation cover
Bryoid	1b (BR)	Bryophyte and lichen-dominated communities; total shrub and herb cover < 20% and total tree cover < 10%.
Herb	2 (H)	Early successional stage or restricted development because of environmental conditions or disturbance; dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree cover < 10%, shrubs <20% or < 33% of total cover, herb-layer cover > 20%, or > 33% of total cover; time since disturbance < 20 yrs for normal forest succession; many non-forested communities are perpetually maintained in this stage.
Forb-dominated	2a (FO)	Includes non-graminoid herbs and ferns.
Graminoid-dominated	2b (GR)	Includes grasses, sedges, reeds, and rushes
Dwarf shrub-dominated	2d (DS)	Dominated by dwarf woody species such as *Arctostaphylos alpina*, *Salix reticulata*, *Cassiope tetragona*.
Shrub/Herb	3 (SH)	Early successional stage or restricted development because of environmental limitations or disturbance; dominated by shrubby vegetation; seedlings and advance regeneration may be abundant; tree cover < 10%, shrub cover > 20% or > 33% of total cover.
Low shrub	3a (LS)	Dominated by shrubby vegetation < 2m tall; time since disturbance < 20 yrs for normal forest succession; may be perpetuated indefinitely by environmental conditions or disturbance.
Tall shrub	3b(TS)	Dominated by shrubby vegetation that is 2 – 10 m tall; time since disturbance < 40 yrs for normal forest succession; may be perpetuated indefinitely.
Pole/Sapling	4 (PS)	Trees > 10m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous; older stagnated stands are also included; self-thinning and vertical structure not yet evident in the canopy; time since disturbance < 40 yrs for normal forest succession; up to 100+ years for dense stagnant stands.
Young forest	5 (YF)	Self-thinning has become evident and the forest canopy has begun to differentiate into distinct layers; vigorous growth and a more open stand than in PS stage; begins as early as age 30 and extends to 50 – 80 yrs; time since disturbance generally 40 – 80 years, depending on tree species and ecological conditions.
Mature forest	6 (MF)	Trees established after the last disturbance have matured; a second cycle of shade-tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance generally 80 – 140 years for BGC BWBSmw and 80 – 250 for BGC SWBmk.
Old growth forest	7 (OF)	Old , structurally complex stands comprised mainly of shade-tolerant and regenerating tree species, although older seral and long lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition and patchy understories typical; time since disturbance generally > 140 yrs for BGC BWBSmw and > 250 yrs for SWBmk.

[1] Resources Inventory Committee (RIC). 1998.

[2] Modifiers for stand composition (Structural Stages 3-7 only): **C** = coniferous (> 75% of total tree cover is coniferous); **B** = broadleaf (> 75% of total tree cover is broadleaf); **M** = mixed (neither coniferous or broadleaf account for > 75% of total tree cover)

6.0 MAPPED ECOSYSTEMS

Each ecosystem unit that was mapped within the Besa/Prophet Study Area is listed in one or more of the following tables. The tables are organized by BGC Zone, and include brief ecosystem unit descriptions. Only those structural stages that were mapped are listed within the tables. A summary table of all map units (including site series/units and non-vegetated units) with typical terrain and vegetation can be found in Appendix B.

Table 10: Fort Nelson Moist Warm Boreal White and Black Spruce (BWBSmw2) site series/units identified within the Besa/Prophet Study Area.

Map code	Site Series	Site Series Name	Structural Stages	Typical Situation	Assumed Modifiers	SMR	SNR	Mapped Modifiers
SF	00	Sedge-Fen	2b	Fen; deep organic wetland; not distinguished as WREC.	p	hygric - subhydric	P - R	a
WB	00	Drummond's willow-Bluejoint low bench/swamp	3aB	Level - gentle slopes; deep medium textured, moderately drained soils ; fluvial seepage sites on valley bottoms.	-	mesic - hygric	M - R	a, k, p
AM	01	SwAt-Step moss	2b, 2aB, 3bC, 5C, 5M, 6C, 6M	Gentle slope; deep, medium-textured soils.	d, j, m	mesic	P - R	c, g, k, r, s, w
BK	03	Sb-Lingonberry-Knight's plume	6C	Gentle slope; crest position; deep medium-textured soils.	d,j,m,r	submesic	VP - M	c, k, w
BL	04	Sb-Lingonberry-Coltsfoot	3bC, 6C	Gentle slope; lower slope or toe position; deep medium-textured soil.	d, j, m	submesic	VP - M	w
SH	05	Sw-Currant-Horsetail	3aB, 3aM, 3bC, 5M, 6C, 6M	Gentle slope to level; moist, receiving sites ; coarse-textured soil.	c, j	subhygric	M - R	a, g, t

Table 11: Moist Cool Spruce – Willow – Birch (SWBmk) site series/units.

Map code	Site Series	Site Series Name	Structural Stages	Typical Situation	Assumed Modifiers	SMR	SNR	Mapped Modifiers
PL	00	Pl-Juniper-Lichen	3bC, 5C, 6C	Significant slope; warm aspect; shallow soils over bedrock.	w, s	xeric - subxeric	P	c, g, k
SB	00	Sw-Bog birch	2b, 3aB, 3aC, 3aM, 3bB, 3bC, 3bM, 4C, 5B, 5C, 5M, 6B, 6C, 6M, 7C	Gentle slope; deep medium-textured soils.	d, j, m	mesic	P - M	c, r, s, w, f, g, h, k, v, z
SC	00	Sw-Crowberry	3aB, 3aM, 3bC, 3bM	Significant slope, cool aspect; deep medium-textured soils.	d, k, m	subhygric	P	g, s, p, j
SF	00	Sedge-Fen	2b	Fen; deep organic wetland; not distinguished as WREC.	p	hygric - subhydric	P - R	a
SH	00	Sw-Horsetail	3aB, 3aC, 3aM, 3bC, 3bM, 5B, 5C, 5M, 6C, 6M	Gentle slope; deep, coarse-textured soils.	c, d, j	subhygric - hygric	M - R	a, f, g, h, n, m, p, t, w
SK	00	Sw-Kinnikinnick	2b, 3aB, 3aC, 3aM, 3bC, 4C, 5C, 6C, 6M	Significant slope; warm aspects; deep, medium-textured soils.	d, m, w	xeric - subxeric	M	c, g, k, h, j, r, s, v
SL	00	Sw-Labrador tea	2a, 3aB, 5C, 6C, 6M	Significant slope; cool aspects; deep, medium-textured soils.	d, k, m	submesic - subhygric	M	c, s, g, j, r, w
SS	00	Sw-Step moss	3aB, 3aM, 3bC, 3bM, 5C, 6C, 6M	Gentle slope; deep, medium-textured soils.	d, j, m	subhygric	VP - P	a, c, f, n, w, g, h, k, s, p, r, t
SW	00	Sw-Willow	2b, 3aB, 3aM, 3bC, 3bM, 4C, 4M, 5B, 5C, 5M, 6C, 6M	Gentle slope; deep, medium-textured soils.	d, j, m	submesic - mesic	M	c, k, s, w, f, g, h, n, r
TC	00	Shrub-Carr	3aB	Moist, mineral soils at low elevations ; usually in association with cold air drainage or periodic flooding.	d, j, m	mesic- hygric	M - P	p
WF	00	Willow-Sedge wetland	3aB	Level sites ; deep, coarse-textured soils.	c, d, j	mesic - hygric	M - R	a, f, h, g, p, s
WM	00	Willow-Mountain sagewort	3aB	Significant slope; cool aspect; deep, meduim-textured soils; shrub dominated community.	d, m, k	mesic - subhygric	M - R	j, g, p, s
WS	00	Willow-Bog birch -Sedge	3aB	Organic wetland; valley floors.	p	hydric		a, h

Table 12: Moist Cool Scrub Spruce – Willow – Birch (SWBmks) site series/units.

Map code	Site Series	Site Series Name	Structural Stages	Typical Situation	Assumed Modifiers	SMR	SNR	Mapped Modifiers
AD	00	Arnica-Daisy	2a	Medium-textured soils on predominantly warm aspects; lower to mid slope.	d, m, j	submesic - mesic	R - VR	f, g, h, k, s, w
BS	00	Birch-Fescue	1a, 3aB	Rapidly drained coarse soils; variable slope; in complex with talus; vegetation dense to sparse.	w, c, s	xeric - submesic	P	d, h, k, j, s, v
BV	00	Birch-Vaccinium	1a, 2d	Crest position, coarse shallow soil over bedrock in sparse windswept areas. In complexes with rubble typically.	c, r, s, j	xeric - subxeric	VP - P	k, v, w
FB	00	Subalpine fir-Five-leaved bramble	3aC, 3bC	Significant slope; cool aspect; deep coarse-textured soils; krummholz site.	c, d, k	submesic		g, s, h, j, r, w
FL*	00	Fescue-Arctic lupine	2b	Upper, crest position; shallow, rapidly-drained, medium-textured soils.	m, s	submesic - mesic	M - R	c, j, k, g, r, w, v
MA	00	Entire-leaved white mountain avens- Arctic lupine	1a, 2a	Significant slope, warm aspect; shallow coarse-textured soils over bedrock; herb dominated.	c, s, w	subxeric - submesic	P - M	d, g, j, k, r, v, m, q, z
PL	00	Pl-Juniper-Lichen	3bC, 5C, 6C	Significant slope; warm aspect; shallow soils over bedrock.	w, s	xeric - subxeric	P	
SB	00	Sw-Bog birch	2b, 3aB, 3aC, 3bC, 5C, 6C, 6M	Gentle slope; deep medium-textured soils.	d, j, m	mesic	P - M	c, k, g, w, h, s, r, t
SC	00	Sw-Crowberry	3aC, 3bC, 3bM	Significant slope, cool aspect; deep medium-textured soils.	d, k, m	subhygric	P	g, j, s, w
SF	00	Sedge-Fen	2b	Fen; deep organic wetland; not distinguished as WREC.	p	hygric - subhydric	P - R	f
SH	00	Sw-Horsetail	3aB, 3bC, 6C	Gentle slope; deep, coarse-textured soils.	c, d, j	Subhygric - hygric	M - R	a, f, s
SK	00	Sw-Kinnikinnick	2b, 3aB, 3aC, 3bB, 3bC, 5C, 6C,	Significant slope; warm aspects; deep, medium-textured soils.	d, m, w	xeric - subxeric	M	c, k, s, g, j
SL	00	Sw-Labrador tea	3aB, 6C	Significant slope; cool aspects; deep, medium-textured soils.	d, k, m	submesic - subhygric	M	g, w
SW	00	Sw-Willow	3aB, 3bC, 6C, 7C	Gentle slope; deep medium-textured soils.	d, j, m	submesic - mesic	M	c, k, w, f, s
WF	00	Willow-Sedge wetland	3aB	Level sites; deep, coarse-textured soils.	c, d, j	mesic - hygric	M - R	a, f, p, k, s
WM	00	Willow- Mountain sagewort	3aB	Significant slope cool aspect; deep medium textured soils; shrub dominated.	d, m, k	mesic - subhygric	M - R	j, w, c, g, q, r, s
WV	00	Willow-Sitka valerian	3aB	Gentle slopes; deep medium-textured soils, moist shrub units.	d, j, m	mesic-subhygric		w, k, s, g, h, r, z, v

* The map code FL has now been changed to FA. FL appears on the printed maps, however, FA is contained in all digital databases, including the Provincial data warehouse

Table 13: Alpine Tundra (AT) map site series units.

Map code	Site Series	Site Series Name	Structural Stages	Typical Situation	Assumed Modifiers	SMR	SNR	Mapped Modifiers
AD	00	Arnica-Daisy	2a	Medium textured soils on predominantly warm aspects ; lower to mid slope.	d, j, m	submesic - mesic	R - VR	s, w
BV	00	Birch-Vaccinium	2d	Crest position ; coarse shallow soil over bedrock in sparse windswept areas. In complexes with rubble typically.	c, r, s, j	xeric - subxeric	VP - P	
FB	00	Subalpine fir-Five-leaved bramble	3aC, 3bC	Significant slope; cool aspect; deep coarse-textured soils ; krummholz site.	c, d, k	submesic		g, s
FL*	00	Fescue-Arctic lupine	1a, 2b	Upper crest position; shallow rapidly drained medium textured soils.	m, s	submesic - mesic	M - R	j, k, w, r
MA	00	Entire-leaved white mountain avens- Arctic lupine	1a, 2a	Significant slope, warm aspect; shallow soils over bedrock; coarse-textured soils ; herb dominated community.	c, s, w	subxeric - submesic	P - M	v, k, f, g, h, r, j, z
MB	00	Entire-leaved white mountain avens-Bog birch	2d	Significant slope, cool aspect; shallow soils over bedrock; coarse-textured soils ; herb dominated community.	c, k, s	submesic - mesic		g, w
WM	00	Willow- Mountain sagewort	3aB	Significant slope, cool aspect; deep medium-textured soils; shrub dominated community.	d, m, k	mesic - subhygric	M - R	j, g, s
WV	00	Willow-Sitka valerian	1a, 2d, 3aB, 3aC, 3bB	Gentle slopes ; deep medium-textured soils, moist shrub units.	d, j, m	mesic-subhygric		g, k, v, w

*The map code FL has now been changed to FA. FL appears on the printed maps, however, FA is contained in all digital databases, including the Provincial data warehouse

7.0 ECOSYSTEM DESCRIPTION GUIDE

Ecosystem unit descriptions in this Section were developed from Full Plot and Ground Inspection Plot data collected during summer, 1998 field sampling. Descriptions are provided here for all Site Series that were encountered and mapped during the Terrestrial Ecosystem Mapping project, but not for anthropogenic conditions and some of the non-vegetated mapping units (e.g., gravel bar, lake, etc…). In general, descriptions are aligned with the current (April, 1999) Provincial Site Series standards. However, descriptions should be considered as provisional; future refinements should be expected, as additional data concerning forest ecosystems and non-forest ecosystems are gathered within and adjacent to the Besa/Prophet Study Area, and within similar ecosystem units elsewhere in BC.

BWBSmw2 was not common in the Study Area, and it was generally restricted to valley bottoms within the MUF. Observations were made during the field data collection so that its extent could be mapped within the Study Area. Field crews closely scrutinized ground locations within watershed valleys where BWBSmw2 could potentially have been expected to occur.

Some SWB ecosystems were especially difficult to distinguish among, because of a lack of sufficient descriptive data. Young seral stages, for example, remain poorly described, and the overall effects of frequent fires upon the successional patterns of young seral stages, especially for SWB units, are not well understood. Futher directed studies of these ecosystems are warranted.

The Wetland Riparian Ecosystem Classification (WREC; MacKenzie and Banner, 1997) was not used when mapping riparian areas. The system was not appropriate for the scale of TEM mapping (1:50,000) that was undertaken with the current project. WREC is focussed upon a more precise classification level (e.g., 1:20,000 TEM). In the current project, "mappable" riparian areas were more simply designated as "Sedge Fens".

Following consultations with project correlators, some conventions were adopted. In general, considerably more ecological field work would be required to fully understand and document successional trajectories for the various ecosystem units within the Study Area, partcularly those that are fire-affected ecosystems. As an example of a developed convention, we found that SC and SL ecosystem units were consistently difficult to differentiate during field work and subsequently in the photo interpretation and mapping phases. A mechanism was needed, to ensure some consistency. Based upon conversations with the project correlators, the procedure followed was that SC would only be mapped as a herbaceous, low shrub or tall shrub condition, whiile SL would only be mapped as a pole/sapling, young forest, mature forest or old growth forest.

The following two-page factsheets describe each ecosystem unit using a standardized format. Factsheets are organized according to the BEC Subzone in which they first appear in the TEM map legend and Appendix B. In general, they are ordered from lower- to higher-elevation BEC units. Table 14 summarizes the order of presentation, and page references for each factsheet.

Each factsheet consists of:

- A *standardized header* which provides the ecosystem name, the BCG unit, and the two-letter mapping code that was used.

- A brief description of the *general distribution of each unit* within the Study Area. Where appropriate, commonly associated ecosystem units are also noted, in particular units that commonly co-occur with the unit in complex polygons.
- A summary description of *ecological features of each unit* as pertains to conditions within the Study Area. Summary information includes typical slope position, soil moisture and soil nutrient regimes, and soil drainage, and an overview description of vegetational physiognomy.
- The *"typical" ecosystem unit description*, from the current (April, 1999) Provincial Site Series List that is maintained by MELP.
- A summary of those *applied mapping modifiers* that were used during TEM mapping in association with the unit, listing what they mean.
- For most of the ecosystem units, *one or more photographs* illustrate some of the characteristics and general appearances of associated soils, terrain and vegetation.
- *Structural stage*s for each unit are organized and presented, with supporting vegetational and other data. This material is presented in tabular form for each ecosystem unit and the source of the information is identified as to whether it was "sampled" (i.e., supported by field plot data) or "not sampled", and "mapped" or "not mapped".
- *Common plant species* are also tabled, and associated to each structural stage. (NOTE: Plant species are mainly listed by 7-letter codes; Appendix C lists these codes along with each plant's scientific and common name. Codes are based upon the scientific plant names, and are composed of the first four letters of the genus and the first three letters of the species [e.g., the code for ***Picea*** *glauca* (white spruce) is **Pice** gla].)

NOTE: Additional information about each ecosystem unit is summarized, in tabular form, in Appendix B.

Table 14. Index to ecosystem unit factsheets for the Besa/Prophet Study Area: summary information includes the two-letter ecosystem unit's TEM mappng codes (first column), site series names (second column), associated BEC Subzones within the Besa/Prophet Study Area (third column), and – for quick reference – the page numbers they are found on within this report (final column).

Map Code	Site Series	Associated BEC Subzones	Factsheet Page Numbers
SF	00 – Sedge – Fen	BWBSmw2 SWBmk SWBmks	40-41
WB	00 – Drummond's willow – Bluejoint low bench / swamp	BWBSmw2	42-43
AM	01 – SwAt –Step moss	BWBSmw2	44-45
BK	03 – Sb – Lingonberry – Knight's plume	BWBSmw2	46-47
BL	04 – Sb – Lingonberry – Coltsfoot	BWBSmw2	48-49
SH	05 – Sw – Currant – Horsetail	BWBSmw2	50-51
PL	02 – Pl – Juniper – Lichen	SWBmk SWBmks	52-53
SB	01 – Sw – Bog birch	SWBmk SWBmks	54-55
SC	06 – Sw – Crowberry	SWBmk SWBmks	56-57

Map Code	Site Series	Associated BEC Subzones	Factsheet Page Numbers
SH	08 – Sw – Horsetail	SWBmk SWBmks	58-59
SK	03 – Sw – Kinnikinnick	SWBmk SWBmks	60-61
SL	05 – Sw – Labrador tea	SWBmk SWBmks	62-63
SS	07 – Sw – Step moss	SWBmk	64-65
SW	04 – Sw – Willow	SWBmk SWBmks	66-67
TC	00 – Shrub – Carr	SWBmk	68-69
WF	00 – Willow – Sedge wetland	SWBmk SWBmks	70-71
WM	00 – Willow – Mountain sagewort	SWBmk SWBmks AT	72-73
WS	00 – Willow – Bog birch – Sedge	SWBmk	74-75
TA	Talus	SWBmk SWBmks AT	76-77
AD	00 – Arnica – Daisy	SWBmks AT	78-79
BS	00 – Birch – Fescue	SWBmks	80-81
BV	00 – Birch – Vaccinium	SWBmks AT	82-83
FB	00 – Subalpine fir – Five-leaved bramble	SWBmks AT	84-85
FL[1]	00 – Fescue – Arctic lupine	SWBmks AT	86-87
MA	00 – Entire-leaved white mountain avens – Arctic lupine	SWBmks AT	88-89
WV	00 – Willow – Sitka valerian	SWBmks AT	90-91
MB	00 – Entire-leaved white mountain avens – Bog birch	AT	92-93

[1]The map code **FL** has now been changed to **FA**. **FL** appears on the printed maps, however **FA** is contained in all digital databases, including the Provincial data warehouse.

(bes_el.pdf)

8.0 PR0JECT DELIVERABLES

The project deliverables that accompany this Final Report include the following (as per the original contract specifications):

- A folio of *TEM 1:50,000 Maps* (digital copy + 1 hard copy + 1 mylar) with an accompanying legend, and clearly labeled with polygon numbers and Ecosystem unit symbols, for the entire Study Area.

- Sets of *Digital TEM Map Files* (in ARC/INFO © and Access©, following current standardized MoF formats).

- *1:50,000 WHI Suitability Maps* (as digital ARC/INFO plot files) for 11 species, based upon derived algorithms, and accompanying legends, explanations / interpretations, liner notes and text.

- Sets of *Digital WHI Map Files* (in ARCVIEW 3.0).

- *TEM and WHI Map Legends, Liner Notes and Text Explanations* that make use of existing standards and conventions (RIC, 1998).

- *Digital Field Data*, including TEM plot data, and associated wildlife observational data, in established formats (mainly in Access and VENUS formats), according to TEM standards.

- A *Final Report* (submitted in two volumes, Parts 1 and 2) describing the project methodologies, Site Series descriptions, expanded legends, WHI calculations, look-up tables and algorithms, and other outputs of the overall project.

Section 9.0 provides a list of digital datafiles that accompany the Final Report on CD-ROM. Other tabular materials are provided in appendices.

9.0 DIGITAL PROJECT FILES

All digital project files, including both TEM and wildlife files, are on a CD-ROM contained as Appendix H in Part 2: Wildlife Report. The contents of the CD-ROM are listed in Table 14.

Table 15. Contents of the CD-ROM listed as Appendix H in Part 2: Wildlife Report. All directories are listed. Only important files are listed.

Directory Filename	**File Type**	**Description**
\	Dir	Root directory.
Besa-Readme.txt	Text file	A text file describing the contents and use of the CD-ROM.
\Wildlife	Dir	All project wildlife data.
Wildlife-Readme.txt	Text file	Describes contents of wildlife directory
\Wildlife\Field data		Field data files.
Bwgif.mdb	Venus 3.0	WHA data for ground inspections. Note: WHAs done for a full plot are contained in the TEM field data directory.
\Wildlife\Besa-Wildlife	Dir	Arcview files
Readme.txt	Text	Describes the use of the ArcView files.
Besa-wildlife.apr	ArcView	ArcView Project file for viewing the wildlife maps.
\Wildlife\Plot data	Dir	Arc/Info plot files for selected seasons and uses.
\Wildlife\Polygon ratings	Dir	Models used to generate polygon wildlife ratings.
MALAL-polygon ratings.mdb (one for each species)	MS Access	Polygon ratings model for moose. There is one model for each species.
\Wildlife\Ratings table models	Dir	Models used to generate wildlife ratings for each EU.
M-ALAL-model-BP.mdb (one for each species)	MS Access	Ratings table model for moose. There is one model for each species.
\TEM	Dir	All project TEM data.
\TEM\Field data	Dir	Field data
Besa-full.mdb	Venus 3.0	Full plot data
Besa-GIFs.mdb	MS Access	GIF data
Besa-vistas.mdb	MS Access	Vista data
\TEM\Attribute data	Dir	TEM attribute data.
Besa_project.csv	Text	Project data.
Lecp_besa.csv	Text	Polygon data.
Besa-Prophet polygon data.mdb	MS Access	Polygon data in MS Access.
\TEM\Spatial data	Dir	TEM spatial data
	Arc export	Arc export file containing the spatial data.

10.0 REFERENCES

Agriculture Canada Expert Committee on Soil Survey. 1987. The Canadian System of Soil Classification, Second Edition. Agric. Can. Publ. No. 1646. Supply and Services Canada, Ottawa, Ont. 164 pp.

And Interpretation Of Ecosystems of the Northwest Portion of the Prince George Forest Region. Research Br., BC Min. of Forests, Victoria, B.C.

Chilton, R. 1990. Fort Nelson and Area Average Winter Maximum Snowpack Mapping. Wildlife Working Report No. WR-49. Wildlife Program, MELP, Fort St. John, BC. 12 pp.

Delong, C., A. MacKinnon and L. Jang. 1990. A Field Guide For Identification And Interpretation Of Ecosystems Of The Northeast Portion Of The Prince George Forest Region. Land Management Handbook No. 22. BC Ministry of Forests.

Delong, C., M.J. Jull, and D. Tanner. 1994. A Field Guide For Site Identification and Interpretation For The Northern Rockies Portion Of The Prince George Forest Region. Research Br., BC Min. of Forests, Victoria, BC.

Delong, C., R.M. Annas and A.C. Stewart.1991. Chapter 16: Boreal White and Black Spruce Zone. *In* D. Meidinger and J. Pojar (eds). Ecosystems of British Columbia. Special Report Series, No. 6. BC Min. of Forests, Victoria, BC.

Demarchi, D.A. 1996. Introduction to the ecoregions of British Columbia. BC Min. Environment, Lands and Parks, Resource Inventory Br., Victoria, BC (via MELP website).

Demarchi, D.A., 1995. Ecoregions of British Columbia (4th Edition). 1:2,000,000 Scale Map. BC Min. Environment, Lands and Parks, Victoria, BC.

Dunster, J and K. Dunster.1996. Dictionary of Natural Resource Management. UBC Press, Vancouver, BC.

Geomatics International Inc. 1998a. Besa/Prophet TEM Project: March, 1998 Progress Report. Submitted to Oil and Gas Division, MELP, Ft. St. John, BC. March, 1998. Geomatics International Inc., Vancouver, BC. Unpubl. Rep.

Geomatics International Inc. 1998b. Besa/Prophet Area TEM Project: Summer, 1998 Sampling Plan. Submitted to Oil and Gas Division, MELP, Ft. St. John, BC. May, 1998. Geomatics International Inc., Vancouver, BC. Unpubl. Rep.

Geomatics International Inc. 1998c. Besa/Prophet TEM Project: Progress Report on the Summer, 1998 Field Season. Submitted to Oil and Gas Division, MELP, Ft. St. John, BC. August, 1998. Geomatics International Inc., Vancouver, BC. Unpubl. Rep.

Holland, S.S. 1976. Landforms of British Columbia, A Physiographic Outline. Bulletin 48. BC Department of Mines and Petroleum Resources, Victoria, BC. 138 pp.

Howes, D.E. and E. Kenk. 1997. Terrain Classification System for British Columbia. Version 2. MOE Manual 10. Updated by Resources Inventory Branch, MELP, Victoria, BC.

Luckhurst, A.J. 1973. Stone Sheep and their habitat in the Northern Rocky Mountains Foothills of British Columbia. M.Sc. Thesis. Dept. of Plant Science, University of British Columbia. 150 pp.

Mackenzie, W., and A. Banner. 1997. Classification of wetland and riparian ecosystems in British Columbia, working draft. Forest Renewal BC. Project HQ#690

MacKinnon, A., C. Delong, and D. Meidinger. 1990. A Field Guide For Identification

Meidinger, D. and J. Pojar (eds.). 1991. Ecosystems of British Columbia. Special Report Series, No. 6. BC Min. of Forests, Victoria, BC. 330 pp.

Pojar, J. and A.C. Stewart. 1991a. Spruce – Willow – Birch Zone. Pp. 251-262 *in* D. Meidinger and J. Pojar (eds). Ecosystems of British Columbia. Special Rep. Ser. No. 6. BC Min. of Forests, Victoria, BC.

Pojar, J. and A.C. Stewart. 1991b. Alpine Tundra Zone. Pp. 263-274 *in* D. Meidinger and J. Pojar (eds). Ecosystems of British Columbia. Special Rep. Ser. No. 6. BC Min. of Forests, Victoria, BC.

Resources Inventory Committee (RIC). 1998. Standards for Terrestrial Ecosystem Mapping in British Columbia. Ecosystem Working Group, Terrestrial Ecosystems Task Force, Min. Environment, Lands and Parks, Victoria, BC. 190 pp.

Resources Inventory Committee (RIC). 1996. Guidelines and Standards to Terrain Mapping in British Columbia. Surficial Geology Task Group, Earth Science Task Force, Victoria, BC. 216 pp.

Resources Inventory Committee (RIC). 1997. British Columbia Land Cover Classification. March, 1997. Terrestrial Ecosystems – Vegetation Series, Victoria, BC.

Sinnemann, C. 1992. Cliff Evaluation in the South Okanagan. University of Victoria Work Term Report for the BC Min. Environment, Victoria, BC.

APPENDIX A

Full Plot and Ground Inspection Plot Locations for the Besa/Prophet TEM Study Area

Plot Number	Mapsheet	Plot Location	
		Latitude	Longitude
Full Plots			
9800166	94F009	57 31 28	124 14 36
9800167	94G012	57 39 33	123 57 48
9800168	94F009	57 33 35	124 11 30
9800169	94G006	57 25 04	123 20 26
9800170	94G009	57 34 43	124 08 09
9800171	94G012	57 40 17	123 51 15
9800172	94F009	57 37 06	124 04 07
9800173	94G012	57 38 23	123 35 13
9800174	94G005	57 21 40	123 33 49
9800175	94G011	57 38 45	123 15 07
9800176	94G006	57 23 03	123 21 20
9800177	94G011	57 33 58	123 21 18
9800178	94G006	57 26 17	123 28 49
9800179	94G006	57 22 11	123 16 39
9800180	94G006	57 29 03	123 22 59
9800181	94G006	57 27 55	123 17 11
9800182	94G006	57 29 18	123 28 29
9800183	94G006	57 26 49	123 14 10
9800184	94G012	57 38 34	123 32 13
9800185	94G012	57 44 06	123 42 27
9800316	94G006	57 25 29	123 28 48
9800317	94F009	57 33 33	124 19 32
9800318	94G011	57 36 26	123 24 59
9800319	94F009	57 38 00	124 09 09
9800320	94G012	57 32 49	123 39 52
9800321	94G005	57 27 17	123 37 04
9800322	94G012	57 35 02	123 45 08
9800323	94G006	57 20 50	123 12 14
9800324	94G012	57 35 33	123 50 24
9800325	94G006	57 27 36	123 11 57
9800326	94G012	57 38 48	123 31 54
GIF Plots			
002	94F009	57 31 40	124 14 42
003	94F009	57 31 45	124 14 45
004	94F009	57 33 32	124 11 25
006	94F009	57 33 53	124 11 48
007	94F/09	57 34 21	124 08 33
018	94F/09	57 36 46	124 04 25

Plot Number	Mapsheet	Plot Location	
		Latitude	Longitude
028	94G/06	57 19 56	123 30 13
041	94G/05	57 21 51	123 33 30
042	94G/05	57 21 51	123 33 29
043	94G/05	57 23 06	123 34 37
049	94G/06	57 20 19	123 26 20
060	94G006	57 19 45	123 25 50
061	94G/06	57 19 25	123 25 43
066	94G006	57 22 57	123 21 36
080	94G/06	57 25 38	123 28 45
081	94G/06	57 25 57	123 28 48
083	94G/06	57 26 20	123 29 11
084	94G/06	57 26 38	123 29 24
085	94G/05	57 28 36	123 34 25
089	94G/05	57 28 32	123 34 02
091	94G/05	57 28 32	123 33 36
094	94G/06	57 29 11	123 22 38
096	94G/06	57 28 46	123 22 15
097	94G/06	57 29 00	123 28 49
108	94G/12	57 31 42	123 34 46
122	94G/12	57 31 38	123 35 24
123	94G/12	57 31 36	123 35 34
131	94G/11	57 36 16	123 24 57
132	94G/11	57 59 46	123 41 07
135	94G/11	57 37 04	123 29 30
136	94G012	57 39 10	123 29 17
137	94G/11	57 37 10	123 29 03
138	94G/11	57 37 11	123 28 42
163	94G/05	57 28 35	123 36 40
164	94G/05	57 28 35	123 37 07
165	94G/05	57 28 31	123 37 13
167	94G/12	57 35 16	123 45 23
168	94G/12	57 35 12	123 45 46
176	94G/12	57 33 15	123 45 27
184	94G/12	57 35 20	123 50 41
221	94G/12	57 43 55	123 42 23
222	94G/12	57 43 35	123 43 12
223	94G/12	57 43 33	123 43 20
227	94G/12	57 42 45	123 39 02
244	94G/11	57 34 40	123 14 24
251	94F/09	57 33 33	124 21 59
252	94F/09	57 37 44	124 09 01
255	94F/09	57 37 56	124 08 45
256	94F/09	57 40 55	124 06 19

Plot Number	Mapsheet	Plot Location	
		Latitude	Longitude
257	94F009	57 39 21	124 00 05
258	94F/09	57 33 24	124 19 16
260	94F/09	57 34 21	124 22 24
261	94F009	57 34 22	124 22 38
265	94F/09	57 39 08	124 01 15
292	94G005	57 27 42	123 37 15
293	94G/05	57 25 15	123 31 05
294	94G/05	57 20 44	123 12 10
313	94G/06	57 20 44	123 12 10
314	94G/06	57 34 14	123 17 70
315	94G/06	57 22 48	123 11 17
316	94G/06	57 37 68	123 18 71
317	94G/06	57 22 47	123 11 38
328	94G006	57 26 51	123 13 47
329	94G/06	57 26 53	123 13 34
330	94G/06	57 26 41	123 13 17
331	94G/06	57 24 23	123 15 00
345	94G/06	57 24 28	123 14 50
350	94G/10	57 22 05	123 16 41
351	94G/06	57 30 20	123 20 2
352	94G/06	57 30 39	123 20 32
353	94G/06	57 30 42	123 20 37
354	94G/11	57 31 47	123 16 04
355	94G/11	57 30 05	123 15 00
382	94G/11	57 33 59	123 21 08
383	94G/11	57 32 11	123 18 54
384	94G/11	57 53 78	123 31 15
385	94G/11	57 32 51	123 16 06
386	94G/11	57 33 09	123 17 46
387	94G/11	57 33 11	123 17 06
389	94G/11	57 38 52	123 14 50
390	94G/11	57 39 03	123 16 15
391	94G/11	57 89 01	123 17 42
392	94G011	57 40 35	123 26 59
393	94G/11	57 67 22	123 44 34
394	94G/12	57 36 01	123 34 30
395	94G/11	57 36 16	123 35 16
396	94G/12	57 38 17	123 35 17
420	94G/11	57 37 09	123 20 19
421	94G/12	57 39 42	123 38 27

Plot Number	Mapsheet	Plot Location	
		Latitude	Longitude
424	94G/12	57 39 31	123 38 16
425	94G/12	57 39 34	123 38 27
450	94G/12	57 37 25	123 56 20
452	94G/12	57 37 12	123 55 46
454	94G/12	57 61 61	123 92 82
455	94G/12	57 42 08	123 53 41
460	94G/12	57 42 13	123 53 14
464	94G/12	57 40 26	123 51 10
480	94G/12	57 41 21	123 56 39
486	94G/12	57 39 25	123 58 17
497	94G/06	57 21 41	123 27 35
498	94G/06	57 21 45	123 27 49

APPENDIX B

Full Plot and Ground Inspection Plots Listed by Ecosystem Unit

BGC unit	Site Series	Structural Stage	Plot Numbers
AT	FW	3a	293
AT	MA	1b	9800172
AT	MA	2a	043, 085, 256, 028
AT	MB	2a	097
AT	TA	1	261, 002, 003,
BWBSmw2	AM	6	391
BWBSmw2	BL	3b	9800184
BWBSmw2	SH	6	9800326
BWBSmw2	SS	6	094
SWBmk	BF	3a	351, 317, 132, 9800176
SWBmk	FA	2b	168
SWBmk	FL	2a	392, 049
SWBmk	FS	2b	9800320
SWBmk	FW	3a	480
SWBmk	MA	2d	260
SWBmk	PL	3b	353
SWBmk	SB	6	464, 9800169
SWBmk	SB	1b	9800324
SWBmk	SB	2b	167
SWBmk	SB	3a	9800170
SWBmk	SB	3b	386, 9800321, 9800175
SWBmk	SB	6	137, 136, 042
SWBmk	SC	3a	221
SWBmk	SC	3b	135, 460, 313, 123, 455, 486
SWBmk	SF	2b	352, 9800171, 9800181, 9800174
SWBmk	SH	6	354, 420, 330, 421, 328, 9800167, 390, 255, 329, 355
SWBmk	SH	3a	096
SWBmk	SK	2b	393
SWBmk	SK	3a	389
SWBmk	SK	3b	222
SWBmk	SL	6	223, 424, 425
SWBmk	SL	2b	9800177
SWBmk	SL	3b	9800173, 9800178
SWBmk	SL	6	265
SWBmk	SS	6	084, 498
SWBmk	SS	3a	9800325
SWBmk	SS	3b	314, 9800317
SWBmk	SS	6	257
SWBmk	SW	3	252
SWBmk	SW	4	387
SWBmk	SW	6	083, 454, 384, 350, 9800183
SWBmk	SW	7	452

BGC unit	Site Series	Structural Stage	Plot Numbers
SWBmk	SW	2a	9800319
SWBmk	SW	3	122
SWBmk	SW	3b	383, 385
SWBmk	SW	6	060, 138, 9800323
SWBmk	TC	3a	497, 9800322
SWBmk	WH	3a	184, 9800185, 061
SWBmk	WM	3a	091
SWBmk	WS	3a	041, 9800179
SWBmks	AD	2a	9800182, 9800166
SWBmks	BF	2d	395
SWBmks	BF	3a	244
SWBmks	BV	1b	9800318
SWBmks	BV	2d	316, 345, 315, 331
SWBmks	FL	2a	292, 080, 066
SWBmks	FL	2b	131, 9800316
SWBmks	FL	2d	382
SWBmks	FW	2d	394
SWBmks	FW	3a	108, 165, 006
SWBmks	MA	2a	176, 450, 227, 007
SWBmks	SB	3a	164
SWBmks	SB	3b	018
SWBmks	SF	2b	163
SWBmks	SH	6	396
SWBmks	SK	6	294
SWBmks	SL	6	081
SWBmks	SS	3b	258, 251
SWBmks	WH	3a	004
SWBmks	WM	3a	089, 9800168

APPENDIX C

Vascular and Non-Vascular Plant Lists for the Besa/Prophet TEM Study Area

Code	Scientific Name	Common Name
ABIELAS	*Abies lasiocarpa*	subalpine fir
ACHIMIL	*Achillea millefolium*	yarrow
ACONCOL1	*Aconitum delphiniifoilum*	Columbian monkshood
AGOSAUR	*Agoseris aurantiaca*	orange agoseris
AGROFRA	*Agropyron fragile*	Siberian wheatgrass
AGROPYR	*Agropyron sp.*	wheatgrass
AGROSTI	*Agrostis sp.*	bentgrass
ALECSAR	*Alectoria sarmentosa*	common witch's hair
ALECTOR	*Alectoria sp.*	hair lichen species
ALNUCRI	*Alnus crispa*	green alder
ALNUTEN	*Alnus tenuifolia*	mountain alder
ANEMNAR	*Anemone narcissiflora*	narcissus anemone
ANEMPAR	*Anemone parviflora*	northern anemone
ANEMONE	*Anemone sp.*	anemone
ANTEPUL	*Antennaria pulcherrima*	showy pussytoes
ANTENNA	*Antennaria sp.*	pussytoes
AQUIFOR	*Aquilegia formosa*	red columbine
ARABIS	*Arabis sp.*	rockcress species
ARCTALP	*Arctostaphylos alpina*	alpine bearberry
ARCTALP2	*Arctostaphylos alpina var. rubra*	red bearberry
ARCTOST	*Arctostaphylos sp.*	bearberry species
ARCTUVA	*Arctostaphylos uva-ursi*	kinnikinnick
ARNILES	*Arnica lessingii*	purple arnica
ARNIMOL	*Arnica mollis*	hairy arnica
ARNICA	*Arnica sp.*	arnica
ARTENOR	*Artemisia norvegica*	mountain sagewort
ARTETIL	*Artemisia tilesii*	Aleutian mugwort
ASTEALP	*Aster alpinus*	alpine aster
ASTESIB	*Aster sibiricus*	arctic aster
ASTER	*Aster sp.*	aster species
ASTRAGA	*Astragalus sp.*	milk-vetch species
AULAPAL	*Aulacomnium palustre*	glow moss
AULACOM	*Aulacomnium sp.*	glow moss species
BARBLYC	*Barbilophozia lycopodioides*	common leafy liverwort
BETUGLA	*Betula glandulosa*	scrub birch
BETUPAP	*Betula papyrifera*	paper birch
BIDEVUL	*Bistorta vivipara*	tall beggarticks
BOTRICH	*Botrychium virgianum*	grape-fern
BRACHYT	*Brachythecium sp.*	ragged moss species
BROMINE	*Bromus inermis*	smooth brome

Code	Scientific Name	Common Name
BROMVUL	*Bromus vulgaris*	Columbia brome
BRYONOA	*Bryonora sp.*	
BRYOFUS	*Bryoria fuscescens*	speckled horsehair
BRYORIA	*Bryoria sp.*	horsehair lichen species
CALACAN	*Calamagrostis canadensis*	bluejoint
CALANDR	*Caldonia sp.*	
CAMPLAS	*Campanula lasiocarpa*	mountain harebell
CAREALB	*Carex albonigra*	two-toned sedge
CAREAQU	*Carex aquatilis*	water sedge
CARECAP	*Carex capillaris*	hairlike sedge
CARECOI	*Carex concinna*	low northern sedge
CAREDIA	*Carex diandra*	lesser panicled sedge
CAREGYN	*Carex gynocrates*	yellow bog sedge
CAREINT	*Carex interior*	inland sedge
CAREINE	*Carex interrupta*	green-fruited sedge
CARELAS	*Carex lasiocarpa*	slender sedge
CAREMED	*Carex media*	Scandinavian sedge
CARENIG	*Carex nigricans*	black alpine sedge
CAREPOD	*Carex podocarpa*	graceful mountain sedge
CAREPRT	*Carex praticola*	meadow sedge
CAREX	*Carex sp.*	sedge
CARESUP1	*Carex supina ssp. spaniocarpa*	spreading arctic sedge
CARUM	*Carum sp.*	caraway species
CASSTET	*Cassiope tetragona*	four-angled mountain-heather
CASTMIN	*Castilleja miniata*	scarlet paintbrush
CASTPAR	*Castilleja parviflora*	small-flowered paintbrush
CASTILL	*Castilleja sp.*	paintbrush
CERAARV	*Cerastium arvense*	field chickweed
CERABEE	*Cerastium beeringianum*	Bering chickweed
CETRACU	*Cetraria aculeata*	spiny heath
CETRACU	*Cetraria cucullata*	spiny heath
CETRARI	*Cetraria sp.*	icelandmoss lichens
CLADARB2	*Cladina arbuscula ssp. mitis*	green reindeer lichen
CLADRAN	*Cladina rangiferina*	grey reindeer lichen
CLADCOR	*Cladonia cornuta*	horn cladonia
CLADMET	*Cladonia metacorallifera*	
CLADPYX	*Cladonia pyxidata*	brown pixie cup
CLADONI	*Cladonia sp.*	cladonia species
CORATRI	*Corallorhiza trifida*	yellow coralroot
CORNCAN	*Cornus canadensis*	bunchberry
DACTARC	*Dactylina arctica*	few-finger lichen

Code	Scientific Name	Common Name
DELPGLA	*Delphinium glaucum*	tall larkspur
DESCCES	*Deschampsia cespitosa*	tufted hairgrass
DICRFUS	*Dicranum fuscescens*	curly heron's-bill moss
DICRPAI	*Dicranum pallidisetum*	pale-stalked broom moss
DICRSCO	*Dicranum scoparium*	broom moss
DICRANU	*Dicranum sp.*	broom moss species
DRABA	*Draba sp.*	
DREPUNC	*Drepanocladus uncinatus*	sickle moss
DRYADRU	*Dryas drummondii*	yellow mountain-avens
DRYAINT	*Dryas integrifolia*	entire-leaved mountain-avens
ELYMHIR	*Elymus hirsutus*	hairy wildrye
ELYMUS	*Elymus sp.*	wildrye
ELYMTRA	*Elymus trachycaulus*	slender wheatgrass
EMPENIG	*Empetrum nigrum*	crowberry
EMPETRU	*Empetrum sp.*	crowberry species
EPILANA	*Epilobium anagallidifolium*	alpine willowherb
EPILANG	*Epilobium angustifolium*	fireweed
EPILCIL	*Epilobium ciliatum*	purple-leaved willowherb
EPILLAC	*Epilobium lactiflorum*	white-flowered willowherb
EQUIARV	*Equisetum arvense*	common horsetail
EQUIPRA	*Equisetum pratense*	meadow horsetail
EQUISCI	*Equisetum scirpoides*	dwarf scouring-rush
EQUISYL	*Equisetum sylvaticum*	wood horsetail
EQUIVAR	*Equisetum variegatum*	northern scouring-rush
ERIGPER	*Erigeron peregrinus*	subalpine daisy
ERIGPHI	*Erigeron philadelphicus*	Philadelphia fleabane
ERIOGON	*Eriogonum sp.*	
ERIOCHA	*Eriophorum chamissonis*	Chamisso's cotton-grass
FESTALT	*Festuca altaica*	Altai fescue
FESTSAX	*Festuca saximontana*	Rocky Mountain fescue
FESTUCA	*Festuca sp.*	fescue
FESTVII	*Festuca viviparoidea*	viviparous fescue
FRAGVIR	*Fragaria virginiana*	wild strawberry
GALIBOR	*Galium boreale*	northern bedstraw
GENTGLA	*Gentiana glauca*	glaucous gentian
GENTPRS	*Gentiana prostrata*	moss gentian
GEOCLIV	*Geocaulon lividum*	bastard toad-flax
GEUMALE	*Geum aleppicum*	yellow avens
GEUMMAC	*Geum macrophyllum*	large-leaved avens
GLYCSTR	*Glyceria striata*	fowl mannagrass
GOODREP	*Goodyera repens*	dwarf rattlesnake orchid

Code	Scientific Name	Common Name
HEDYALP	*Hedysarum alpinum*	alpine hedysarum
HEDYBOR	*Hedysarum boreale*	northern hedysarum
HEDYSAR	*Hedysarum sp.*	
HERALAN	*Heracleum lanatum*	cow-parsnip
HIERALP	*Hierochloe alpina*	alpine sweetgrass
HIPPVUL	*Hippuris vulgaris*	common mare's-tail
HYLOCOM	*Hylocomium sp.*	step moss species
HYLOSPL	*Hylocomium splendens*	step moss
ICMAERI	*Icmadophila ericetorum*	spraypaint
JUNICOM	*Juniperus communis*	common juniper
KOBRESI	*Kobresia sp.*	
LATHNEV	*Lathyrus nevadensis*	purple peavine
LATHOCH	*Lathyrus ochroleucus*	creamy peavine
LEDUGRO	*Ledum groenlandicum*	Labrador tea
LEYMINN	*Leymus innovatus*	fuzzy-spiked wildrye
LICHENT	*Lichens*	lichens
LINNBOR	*Linnaea borealis*	twinflower
LUPIARC	*Lupinus arcticus*	arctic lupine
LUZUPAR	*Luzula parviflora*	small-flowered woodrush
LUZULA	*Luzula sp.*	woodrush
LYCOANN	*Lycopodium annotinum*	stiff clubmoss
LYCOCOM	*Lycopodium complanatum*	ground-cedar
MERTLON	*Mertensia longiflora*	long-flowered bluebells
MERTPAN	*Mertensia paniculata*	tall bluebells
MITEBRE	*Mitella breweri*	Brewer's mitrewort
MITENUD	*Mitella nuda*	common mitrewort
MITEPEN	*Mitella pentandra*	five-stamened mitrewort
MNIUM	*Mnium sp.*	leafy moss
MOEHLAT	*Moehringia lateriflora*	blunt-leaved sandwort
MONEUNI	*Moneses uniflora*	single delight
MYOSALP	*Myosotis alpestris*	mountain forget-me-not
MYOSOTI	*Myosotis sp.*	forget-me-not species
ORTHSEC	*Orthilia secunda*	one-sided wintergreen
OXYRDIG	*Oxyria digyna*	mountain sorrel
OXYTNIG	*Oxytropis nigrescens*	blackish locoweed
PARMSUL	*Parmelia sulcata*	powdered shield
PARNASS	*Parnassia sp.*	
PEDIBRA	*Pedicularis bracteosa*	bracted lousewort
PEDIGRO	*Pedicularis groenlandica*	elephant's-head lousewort
PEDILAB	*Pedicularis labradorica*	Labrador lousewort
PEDIOED	*Pedicularis oederi*	Oeder's lousewort

Code	Scientific Name	Common Name
PEDICUL	*Pedicularis sp.*	lousewort
PEDISUD	*Pedicularis sudetica*	Sudeten lousewort
PELTAPH	*Peltigera aphthosa*	freckle pelt
PELTIGE	*Peltigera sp.*	pelt lichens
PETAFRI	*Petasites frigidus*	sweet coltsfoot
PETAFRI3	*Petasites frigidus var. palmatus*	palmate-leaved coltsfoot
PETASAG	*Petasites sagittatus*	arrow-leaved coltsfoot
PETASIT	*Petasites sp.*	coltsfoot species
PHLEALP	*Phleum alpinum*	alpine timothy
PICEGLA	*Picea glauca*	white spruce
PICEMAR	*Picea mariana*	black spruce
PINUCON	*Pinus contorta*	lodgepole pine
PLATOBT	*Platanthera obtusata*	one-leaved rein orchid
PLEUSCH	*Pleurozium schreberi*	red-stemmed feathermoss
PLEUROI	*Pleurozium sp.*	feathermoss species
POA ALP	*Poa alpina*	alpine bluegrass
POA PAL	*Poa palustris*	fowl bluegrass
POA	*Poa sp.*	bluegrass
POHLIA	*Pohlia sp.*	
POLECAE	*Polemonium caeruleum*	tall Jacob's-ladder
POLEPUL	*Polemonium pulcherrimum*	showy Jacob's-ladder
POLEMON	*Polemonium sp.*	Jacob's-ladder species
POLYPOL	*Polygonum polygaloides*	Kellogg's knotweed
POLYVIV	*Polygonum viviparum*	alpine bistort
POLYVIR	*Polypodium virginianum*	Virginia polypody
POLYCOM	*Polytrichum commune*	haircap moss species
POLYJUN	*Polytrichum juniperinum*	juniper haircap moss
POLYLOG	*Polytrichum longisetum*	
POLYPIL	*Polytrichum piliferum*	awned haircap moss
POPUBAL	*Populus balsamifera*	balsam poplar
POPUTRE	*Populus tremuloides*	trembling aspen
POTEFRU	*Potentilla fruticosa*	shrubby cinquefoil
POTEHYP	*Potentilla hyparctica*	arctic cinquefoil
POTEPAL	*Potentilla palustris*	marsh cinquefoil
POTENTI	*Potentilla sp.*	cinquefoil species
PTILCRI	*Ptilium crista-castrensis*	knight's plume
PYROASA	*Pyrola asarifolia*	pink wintergreen
PYROCHL	*Pyrola chlorantha*	green wintergreen
PYROMIN	*Pyrola minor*	lesser wintergreen
RACOCAN	*Racomitrium canescens*	grey rock moss
RANUUNC	*Ranunculus uncinatus*	little buttercup

Code	Scientific Name	Common Name
RHIZGEO	*Rhizocarpon geographicum*	green map lichen
RHIZGRA	*Rhizocarpon grande*	
RHIZOCA	*Rhizocarpon sp.*	
RHODLAP	*Rhododendron lapponicum*	Lapland rosebay
RHYTROB	*Rhytidiopsis robusta*	pipecleaner moss
RHYTRUG	*Rhytidium rugosum*	crumpled-leaf moss
RIBEHUD	*Ribes hudsonianum*	northern blackcurrant
RIBELAC	*Ribes lacustre*	black gooseberry
RIBES	*Ribes sp.*	currant or gooseberry
RIBETRI	*Ribes triste*	red swamp currant
ROSAACI	*Rosa acicularis*	prickly rose
RUBUARC	*Rubus arcticus*	nagoonberry
RUBUCHA	*Rubus chamaemorus*	cloudberry
RUBUPED	*Rubus pedatus*	five-leaved bramble
RUBUPUB	*Rubus pubescens*	trailing raspberry
RUBUS	*Rubus sp.*	raspberry species
RUMEACO3	*Rumex acetosa ssp. alpestris*	green sorrel
RUMEACT	*Rumex acetosella*	sheep sorrel
RUMEX	*Rumex sp.*	sorrel species
SALIALA	*Salix alaxensis*	Alaska willow
SALIALA1	*Salix alaxensis var. alaxensis*	Alaska willow
SALIBAC	*Salix barclayi*	Barclay's willow
SALIBEB	*Salix bebbiana*	Bebb's willow
SALICOM	*Salix commutata*	variable willow
SALIDRU	*Salix drummondiana*	Drummond's willow
SALIGLA	*Salix glauca*	grey-leaved willow
SALILUC	*Salix lucida*	shining willow
SALIMAC	*Salix maccalliana*	MacCalla's willow
SALIMYR	*Salix myrtillifolia*	bilberry willow
SALIPLA	*Salix planifolia*	tea-leaved willow
SALIPOL	*Salix polaris*	polar willow
SALIPRO	*Salix prolixa*	Mackenzie's willow
SALIRET	*Salix reticulata*	dwarf willow
SALISCO	*Salix scouleriana*	Scouler's willow
SALISER	*Salix serissima*	autumn willow
SALIX	*Salix sp.*	willow species
SALIVES	*Salix vestita*	rock willow
SAXIAIZ	*Saxifraga aizoides*	evergreen saxifrage
SAXILYA	*Saxifraga lyallii*	red-stemmed saxifrage
SAXINEL	*Saxifraga nelsoniana*	cordate-leaved saxifrage
SAXIOPP	*Saxifraga oppositifolia*	purple mountain saxifrage

Code	Scientific Name	Common Name
SAXIFRA	*Saxifraga sp.*	saxifrage
SAXITRI	*Saxifraga tricuspidata*	three-toothed saxifrage
SEDUINT	*Sedum integrifolium*	roseroot
SENELUG	*Senecio lugens*	black-tipped groundsel
SENEPAC	*Senecio pauciflorus*	rayless alpine butterweed
SENECIO	*Senecio sp.*	
SENETRI	*Senecio triangularis*	arrow-leaved groundsel
SETAVIR	*Shagnum sp.*	green bristlegrass
SHEPCAN	*Shepherdia canadensis*	soopolallie
SIBBPRO	*Sibbaldia procumbens*	sibbaldia
SILEACA	*Silene acaulis*	moss campion
SOLIMUL	*Solidago multiradiata*	northern goldenrod
SPHAANU	*Sphagnum angustifolium*	poor-fen sphagnum
SPHACAI	*Sphagnum capillifolium*	common red sphagnum
SPHAGNU	*Sphagnum sp.*	
SPIRROM	*Spiranthes romanzoffiana*	hooded ladies' tresses
STELCAL	*Stellaria calycantha*	northern starwort
STELGRA	*Stellaria graminea*	grass-leaved starwort
STELLOG	*Stellaria longipes*	long-stalked starwort
STELLAR	*Stellaria sp.*	starwort
STERPAS	*Stereocaulon paschale*	cottontail lichen
STEREOC	*Stereocaulon sp.*	lichen species
TARAOFF	*Taraxacum officinale*	common dandelion
THALOCC	*Thalictrum occidentale*	western meadowrue
THALVEN	*Thalictrum venulosum*	veiny meadowrue
THAMNOL	*Thamnolia sp.*	lichen species
THAMVER	*Thamnolia vermicularis*	rock worm lichen
TIMMIA	*Timmia sp.*	
TOFIPUS	*Tofieldia pusilla*	common false asphodel
TOFIELD	*Tofieldia sp.*	
TOMENIT	*Tomentypnum nitens*	golden fuzzy fen moss
TRISSPI	*Trisetum spicatum*	spike trisetum
UMBIHYP	*Umbilicaria hyperborea*	blistered rocktripe
UMBILIC	*Umbilicaria sp.*	rocktripe lichens
VACCCAE	*Vaccinium caespitosum*	dwarf blueberry
VACCMEM	*Vaccinium membranaceum*	black huckleberry
VACCSCO	*Vaccinium scoparium*	grouseberry
VACCINI	*Vaccinium sp.*	blueberry, huckleberry
VACCULI	*Vaccinium uliginosum*	bog blueberry
VACCVIT	*Vaccinium vitis-idaea*	lingonberry
VALEDIO	*Valeriana dioica*	marsh valerian

Code	Scientific Name	Common Name
VALESIT	*Valeriana sitchensis*	Sitka valerian
VERAVIR	*Veratrum viride*	Indian hellebore
VEROWOR	*Veronica wormskjoldii*	alpine speedwell
VIBUEDU	*Viburnum edule*	highbush-cranberry
VICIAME	*Vicia americana*	American vetch
ZIGAELE	*Zigadenus elegans*	mountain death-camas

APPENDIX D

Summary Table of All Site Series/Units Mapped in the Besa/Prophet TEM Study Area

Zone	Subzone	Variant	Site Series	Map code	Site Series Name	Structural Stages	Typical situation	Assumed Modifiers	SMR	SNR	Mapped modifer	Bioterrain	Dom-Vegetation	Plots
BWBS	mw	2		GB	Gravel bar	1	An elongated landform generated by waves and currents and usually running parallel to the shore.							
BWBS	mw	2	00	SF	Sedge-Fen	2b	Fen; deep organic wetland; not distinguished as WREC.	p	hygric - subhydric	P - R	a		Careaqu, Betugla, Salimac, Aulapal, Tomenit, Calacan, Carelas	
BWBS	mw	2	00	WB	Drummond's willow-Bluejoint low bench/swamp	3aB	Level - gentle slopes; deep medium textured, moderately drained soils; fluvial seepage sites on valley bottoms.		mesic - hygric	M - R	a, k, p			
BWBS	mw	2	01	AM	SwAt-Step moss	2b, 2aB, 3bC, 5C, 5M, 6C, 6M	Gentle slope; deep, medium-textured soils.	d, j, m	mesic	P - R	c, g, k, r, s, w	gsFt, spkFt-J	Picegla, Vibuedu, Rosaaci, Linnbor, Corncan, Hylospl, Ptilcri	391, 94
BWBS	mw	2	03	BK	Sb-Lingonberry-Knight's plume	6C	Gentle slope; crest position; deep medium-textured soils.	d, j, m, r	submesic	VP - M	c, k, w			
BWBS	mw	2	04	BL	Sb-Lingonberry-Coltsfoot	3bC, 6C	Gentle slope; lower slope or toe position; deep medium-textured soils.	d, j, m	submesic	VP - M	w	cgzCv	Pinucon, Ledugro, Corncan, Vaccvit, Pleusch, Ptilcri	9800184
BWBS	mw	2	05	SH	Sw-Currant-Horsetail	3aB, 3aM, 3bC, 5M, 6C, 6M	Gentle slope to level; moist, receiving sites; coarse-textured soils.	c, j	subhygric	M - R	a, g, t	pFv, spkFp-J, zFx	Betupap, Picegla, Rosaaci, Vibuedu, Corncan, Mitenud	9800326, 330, 96
SWB	mk		00	PL	Pl-Juniper-Lichen	3bC, 5C, 6C	Significant slope; warm aspect; shallow soils over bedrock.	w, s	xeric - subxeric	P	c, g, k		Pinucon, Pleusch, Sterpas, Ledugro, Lichen spp.	353
SWB	mk		00	SB	Sw-Bog birch	2b, 3aB, 3aC, 3aM, 3bB, 3bC, 3bM, 4C, 5B, 5C, 5M, 6B, 6C, 6M, 7C	Gentle slope; deep medium-textured soils.	d, j, m	mesic	P - M	c, r, s, w, f, g, h, k, v, z	gFGt, gzCv, czM	Picegla, Pinucon, Salix spp., Rosaaci, Festalt, Mertpan, Hylospl	9800175, 9800324, 9800321, 9800169, 9800179, 167, 136, 42, 137, 386, 464

Zone	Subzone	Variant	Site Series	Map code	Site Series Name	Structural Stages	Typical situation	Assumed Modifiers	SMR	SNR	Mapped modifer	Bioterrain	Dom-Vegetation	Plots
SWB	mk		00	SC	Sw-Crowberry	3aB, 3aM, 3bC, 3bM	Significant slope, cool aspect; deep medium-textured soils.	d, k, m	subhygric	P	g, s, p, j	rC	Picegla, Betugla, Equisci, Hylospl, Ledugro, Salicom, Salix spp., Sphagnum spp., Empenig	313,221, 455, 123, 486, 460
SWB	mk		00	SF	Sedge-Fen	2b	Fen; deep organic wetland; not distinguished as WREC.	p	hygric - subhydric	P - R	a	uOx-L, eOp, zFAp	Careaqu, Betugla, Salimac, Aulapal, Tomenit, Calacan, Carelas	9800171, 9800181, 9800174, 168, 352, 2
SWB	mk		00	SH	Sw-Horsetail	3aB, 3aC, 3aM, 3bC, 3bM, 5B, 5C, 5M, 6C, 6M	Gentle slope; deep, coarse-textured soils.	c, d, j	subhygric - hygric	M - R	a, f, g, h, n, m, p, t, w	C, Fp	Picegla, Popubal, Poputre, Delpgla, Equiarv, Hedyalp, Rubupub, Rosaaci	9800167, 354, 420, 421, 390, 255, 328
SWB	mk		00	SK	Sw-Kinnikinnick	2b, 3aB, 3aC, 3aM, 3bC, 4C, 5C, 6C, 6M	Significant slope; warm aspects; deep, medium-textured soils.	d, m, w	xeric - subxeric	M	c, g, k, h, j, r, s, v	gzM, rC, sgFGtp, (sgFAp)	Picegla, Linnbor, Poa spp., Salicom, Orthsec, Hylospl, Ptilcri, Epilang	329, 222, 355, 393, 389
SWB	mk		00	SL	Sw-Labrador tea	2a, 3aB, 5C, 6C, 6M	Significant slope; cool aspects; deep, medium-textured soils.	d, k, m	submesic - subhygric	M	c, s, g, j, r, w	srC	Picegla, Picemar, Betugla, Salix spp., Ledugro, Vaccvit, Lichen spp., Hylospl	9800173, 9800178, 424, 265, 223, 425
SWB	mk		00	SS	Sw-Step moss	3aB, 3aM, 3bC, 3bM, 5C, 6C, 6M	Gentle slope; deep, medium-textured soils.	d, j, m	subhygric	VP - P	a, c, f, n, w, g, h, k, s, p, r, t	arCx/zcFj, sgFj, sgFt, szpFGt,	Picegla, Salix spp., Festalt, Hylospl, Epilang, Mertpan, Shepcan	9800325, 9800317, 257, 84, 314, 498

Zone	Subzone	Variant	Site Series	Map code	Site Series Name	Structural Stages	Typical situation	Assumed Modifiers	SMR	SNR	Mapped modifer	Bioterrain	Dom-Vegetation	Plots
SWB	mk		00	SW	Sw-Willow	2b, 3aB, 3aM, 3bC, 3bM, 4C, 4M, 5B, 5C, 5M, 6C, 6M	Gentle slope; deep, medium-textured soils.	d, j, m	submesic - mesic	M	c, k, s, w, f, g, h, n, r	rzC, rczM, gFG	Picegla, Pinucon, Populus spp., Betugla, Salicom, Vaccvit, Linnbor, Corncan, Hylospl, Epilang	9800323, 9800319, 9800183, 83, 138, 385, 454, 387, 60, 383, 452, 350, 252, 122, 384
SWB	mk		00	TC	Shrub-Carr	3aB	Moist, mineral soils at low elevations; usually in association with cold air drainage or periodic flooding.	d, j, m	mesic-hygric	M - P	p	szFGt	Betugla, Festalt, Salix spp., Carex spp.	9800322, 497
SWB	mk		00	WF	Willow-Sedge wetland	3aB	Level sites; deep, coarse-textured soils.	c, d, j	mesic - hygric	M - R	a, f, h, g, p, s	zFAv, gzF	Betugla, Salix spp., Carepod, Festalt, Polyviv, Hylospl, Potefru	9800185, 61, 184
SWB	mk		00	WM	Willow-Mountain sagewort	3aB	Significant slope; cool aspect; deep, medium-textured soils; shrub dominated community.	d, m, k	mesic - subhygric	M - R	j, g, p, s	zMb	Saliret, Salix spp., Artenor, Acondel, Festalt, Mertpan, Solimul, Luzupar, Casstet	91
SWB	mk		00	WS	Willow-Bog birch - Sedge	3aB	Organic wetland; valley floors.	p	hydric		a, h	VeOrv-X	Betugla, Lichen spp., Careaqu, Salix spp., Rubus spp.	9800179, 41
SWB	mk			CL	Cliff	1	A steep, vertical, overhanging rock face.				q, z			
SWB	mk			GB	Gravel bar	1	An elongated landform generated by waves and currents and usually running parallel to the shore.							
SWB	mk			LA	Lake		A naturally occurring static body of water.							
SWB	mk			RO	Rock	1	A gentle to steep, bedrock escarpment or outcropping, with little soil development and sparse vegetation.				k, r, w			

Zone	Subzone	Variant	Site Series	Map code	Site Series Name	Structural Stages	Typical situation	Assumed Modifiers	SMR	SNR	Mapped modifer	Bioterrain	Dom-Vegetation	Plots
SWB	mk			TA	Talus	1	Angular rock fragments of any size accumulated at the foot of steep rock slopes as a result of successive rock falls.		xeric - very xeric	P - VR	g, w, k			
SWB	mk	s	00	AD	Arnica-Daisy	2a	Medium-textured soils on predominantly warm aspects; lower to mid slope.	d, m, j	submesic - mesic	R - VR	f, g, h, k, s, w	sFv-JI	Festalt, Senetri, Heralan, Mertpan, Sileaca, Acondel, Polyviv, Carex spp.	9800182, 9800166
SWB	mk	s	00	BS	Birch-Fescue	1a, 3aB	Rapidly drained coarse-textured soils; variable slope; in complex with talus; vegetation dense to sparse.	w, c, s	xeric - submesic	P	d, h, k, j, s, v	rsaCv-R, cgzMb, arCv/Rj, sgMb-C	Betugla, Lichen spp., Picegla, Festalt, Artenor, Hylospl, Vaccvit, Umbilicaria spp.	373, 395, 244
SWB	mk	s	00	BV	Birch-Vaccinium	1a, 2d	Crest position, coarse-textured shallow soils over bedrock in sparse windswept areas. In complexes with rubble typically.	c, r, s, j	xeric - subxeric	VP - P	k, v, w	arsCv-C, zpsMv-C, rCx-C, skMv	Betugla, Vaccvit, Viccinium spp., Artenor, Lichen spp., Festalt, Umbilicaria spp., Sterpas, Rhizgeo, Polyviv	9800318, 345, 315, 316
SWB	mk	s	00	FB	Subalpine fir-Five-leaved bramble	3aC, 3bC	Significant slope; cool aspect; deep coarse-textured soils; krummholz site.	c, d, k	submesic		g, s, h, j, r, w		Abielas, Festalt	
SWB	mk	s	00	FL*	Fescue-Arctic lupine	2b	Upper, crest position; shallow, rapidly-drained, medium-textured soils.	m, s	submesic - mesic	M - R	c, j, k, g, r, w, v	zrCv-C, zMv-C, sxCv, szrCv, srCv	Festalt, Acondel, Lupiarc, Artenor, Dryaint, Senelug, Mertpan, Polyviv	9800316, 382, 80, 131, 292, 66
SWB	mk	s	00	MA	Entire-leaved white mountain avens-Arctic lupine	1a, 2a	Significant slope, warm aspect; shallow coarse- textured soils over bedrock; herb dominated.	c,s,w	subxeric - submesic	P - M	d, g, j, k, r, v, m, q, z	zxCvx, zCv/Rj, rCv, rCbv, apzMv, zrCv/Rj	Dryaint, Lupiarc, Festalt, Polyviv, Saliret, Carex spp., Poaalp, Sileaca	227, 450, 176, 7
SWB	mk	s	00	PL	Pl-Juniper-Lichen	3bC, 5C, 6C	Significant slope; warm aspect ; shallow soils over bedrock.	w, s	xeric - subxeric	P			Pinucon, Pleusch, Sterpas, Ledugro, Lichen spp.	
SWB	mk	s	00	SB	Sw-Bog birch	2b, 3aB, 3aC, 3bC, 5C, 6C, 6M	Gentle slope; deep medium-textured soils.	d, j, m	mesic	P - M	c, k, g, w, h, s, r, t	gFGt, gzCv, czM	Picegla, Pinucon, Salix spp., Rosaaci, Festalt, Mertpan, Hylospl	164, 18

Zone	Subzone	Variant	Site Series	Map code	Site Series Name	Structural Stages	Typical situation	Assumed Modifiers	SMR	SNR	Mapped modifer	Bioterrain	Dom-Vegetation	Plots
SWB	mk	s	00	SC	Sw-Crowberry	3aC, 3bC, 3bM	Significant slope, cool aspect; deep medium-textured soils.	d, k, m	subhygric	P	g, j, s, w	rC	Picegla, Betugla, Equisci, Hylospl, Ledugro, Salicom, Salix spp., Sphagnum spp., Empenig	
SWB	mk	s	00	SF	Sedge-Fen	2b	Fen; deep organic wetland; not distinguished as WREC.	p	hygric - subhydric	P - R	f	uOx-L, eOp, zFAp	Careaqu, Betugla, Salimac, Aulapal, Tomenit, Calacan, Carelas	163
SWB	mk	s	00	SH	Sw-Horsetail	3aB, 3bC, 6C	Gentle slope; deep, coarse-textured soils.	c, d, j	subhygric - hygric	M - R	a, f, s	C, Fp	Picegla, Popubal, Poputre, Delpgla, Equiarv, Hedyalp, Rubupub, Rosaaci	396
SWB	mk	s	00	SK	Sw-Kinnikinnick	2b, 3aB, 3aC, 3bB, 3bC, 5C, 6C,	Significant slope; warm aspects; deep, medium-textured soils.	d, m, w	xeric - subxeric	M	c, k, s, g, j	gzM, rC, sgFGtp, (sgFAp)	Picegla, Linnbor, Poa spp., Salicom, Orthsec, Hylospl, Ptilcri, Epilang	294
SWB	mk	s	00	SL	Sw-Labrador tea	3aB, 6C	Significant slope; cool aspects; deep, medium-textured soils.	d, k, m	submesic - subhygric	M	g, w	srC	Picegla, Picemar, Betugla, Salix spp., Ledugro, Vaccvit, Lichen spp., Hylospl	81
SWB	mk	s	00	SW	Sw-Willow	3aB, 3bC, 6C, 7C	Gentle slope; deep medium-textured soils.	d, j, m	submesic - mesic	M	c, k, w, f, s	rzC, rczM, gFG	Picegla, Pinucon, Populus spp., Betugla, Salicom, Vaccvit, Linnbor, Corncan, Hylospl, Epilang	
SWB	mk	s	00	WF	Willow-Sedge wetland	3aB	Level sites; deep, coarse-textured soils.	c, d, j	mesic - hygric	M - R	a, f, p, k, s	zFAv, gzF	Betugla, Salix spp., Carepod, Festalt, Polyviv, Hylospl, Potefru	251, 4
SWB	mk	s	00	WM	Willow- Mountain sagewort	3aB	Significant slope cool aspect; deep medium-textured soils; shrub dominated.	d, m, k	mesic - subhygric	M - R	j, w, c, g, q, r, s	zMb	Saliret, Salix spp., Artenor, Acondel, Festalt, Mertpan, Solimul, Luzupar, Casstet	9800168, 89

Zone	Subzone	Variant	Site Series	Map code	Site Series Name	Structural Stages	Typical situation	Assumed Modifiers	SMR	SNR	Mapped modifer	Bioterrain	Dom-Vegetation	Plots
SWB	mk	s	00	WV	Willow-Sitka valerian	3aB	Gentle slopes; deep medium-textured soils, moist shrub units.	d, j, m	mesic-subhygric		w, k, s, g, h, r, z, v	zMb, rzCr	Betugla, Festalt, Salicom, Salix spp., Achimil, Arctuva, Epilang	394, 165, 108, 6
SWB	mk	s		CL	Cliff	1	A steep, vertical, overhanging rock face.				q, z			
SWB	mk	s		GB	Gravel bar	1	An elongated landform generated by waves and currents and usually running parallel to the shore.							
SWB	mk	s		LA	Lake		A naturally occurring static body of water.							
SWB	mk	s		MO	Moraine	1	An unvegetated landform consisting of unstratified glacial drift that is usually till and taking a variety of shapes.				k			
SWB	mk	s		RO	Rock	1	A gentle to steep, bedrock escarpment or outcropping, with little soil development and sparse vegetation.				h, k, r, w			
SWB	mk	s		RU	Rubble	1	Rubble is common on the ground surface in and adjacent to alpine areas, on ridgetops, gentle slopes and flat areas due to the effects of frost heaving.				r			
SWB	mk	s		TA	Talus	1	Angular rock fragments of any size accumulated at the foot of steep rock slopes as a result of successive rock falls.				g, k, w			
AT			00	AD	Arnica-Daisy	2a	Medium-textured soils on predominantly warm aspects; lower to mid slope.	d, j, m	submesic - mesic	R - VR	s, w	sFv-JI	Festalt, Senetri, Heralan, Mertpan, Sileaca, Acondel, Polyviv, Carex spp.	
AT			00	BV	Birch-Vaccinium	2d	Crest position; coarse shallow soil over bedrock in sparse windswept areas. In complexes with rubble typically.	c, r, s, j	xeric - subxeric	VP - P		arsCv-C, zpsMv-C, rCx-C, skMv	Betugla, Vaccvit, Vaccinium spp., Artenor, Lichen spp., Festalt, Umbilicaria spp., Sterpas, Rhizgeo, Polyviv	

Zone	Subzone	Variant	Site Series	Map code	Site Series Name	Structural Stages	Typical situation	Assumed Modifiers	SMR	SNR	Mapped modifer	Bioterrain	Dom-Vegetation	Plots
AT			00	FB	Subalpine fir-Five-leaved bramble	3aC, 3bC	Significant slope; cool aspect; deep coarse-textured soils; krummholz site.	c,d,k	submesic		g, s		Abielas, Festalt	
AT			00	FL*	Fescue-Arctic lupine	1a, 2b	Upper crest position; shallow rapidly drained medium textured soils.	m, s	submesic - mesic	M - R	j, k, w, r	zrCv-C, zMv-C, sxCv, szrCv, srCv	Festalt, Acondel, Lupiarc, Artenor, Dryaint, Senelug, Mertpan, Polyviv	
AT			00	MA	Entire-leaved white mountain avens-Arctic lupine	1a, 2a	Significant slope, warm aspect; shallow soils over bedrock; coarse-textured soils; herb dominated community.	c,s,w	subxeric - submesic	P - M	v, k, f, g, h, r, j, z	zxCvx, zCv/Rj, rCv, rCbv, apzMv, zrCv/Rj	Dryaint, Lupiarc, Festalt, Polyviv, Saliret, Carex spp., Poaalp, Sileaca	85, 28, 43, 256
AT			00	MB	Entire-leaved white mountain avens-Bog birch	2d	Significant slope, cool aspect; shallow soils over bedrock; coarse-textured soils; herb dominated community.	c,k,s	submesic - mesic		g, w	arCv		97
AT			00	WM	Willow- Mountain sagewort	3aB	Significant slope, cool aspect; deep medium- textured soils; shrub dominated community.	d, m, k	mesic - subhygric	M - R	j, g, s	zMb	Saliret, Salix spp., Artenor, Acondel, Festalt, Mertpan, Solimul, Luzupar, Casstet	
AT			00	WV	Willow-Sitka valerian	1a, 2d, 3aB, 3aC, 3bB	Gentle slopes; deep medium-textured soils, moist shrub units.	d,j,m	mesic-subhygric		g, k, v, w	zMb, rzCr	Betugla, Festalt, Salicom, Salix spp., Achimil, Arctuva, Epilang	293
AT				CL	Cliff	1	A steep, vertical, overhanging rock face.				q, z			
AT				GL	Glacier		A mass of perennial snow and ice with definite lateral limits							
AT				LA	Lake		A naturally occurring static body of water.							
AT				MO	Moraine	1	An unvegetated landform consisting of unstratified glacial drift that is usually till and taking a variety of shapes.				h, k, w			
AT				RO	Rock	1	A gentle to steep, bedrock escarpment or outcropping, with little soil development and sparse vegetation.				k, r			

Zone	Subzone	Variant	Site Series	Map code	Site Series Name	Structural Stages	Typical situation	Assumed Modifiers	SMR	SNR	Mapped modifer	Bioterrain	Dom-Vegetation	Plots
AT				RU	Rubble	1	Rubble is common on the ground surface in and adjacent to alpine areas, on ridgetops, gentle slopes and flat areas due to the effects of frost heaving.				k, r, w			
AT				TA	Talus	1	Angular rock fragments of any size accumulated at the foot of steep rock slopes as a result of successive rock falls.				w, k, g, n			3, 261

* The map code FL has now been changed to FA. FL appears on the printed maps, however, FA is contained in all digital databases, including the Provincial data warehouse.