Standard for Terrestrial Ecosystem Mapping in British Columbia

Prepared by
Ecosystems Working Group
Terrestrial Ecosystems Task Force
Resources Inventory Committee

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Abstract

This report describes British Columbia standards for ecosystem mapping at scales of 1:5000 to 1:50 000. The information here has been developed for, and approved by, the Resources Inventory Committee (RIC), a provincial committee responsible for developing inventory standards for the province.

These mapping standards use a three-level classification hierarchy of ecological units, including ecoregion units and biogeoclimatic units at broader levels, and site units and vegetation developmental stages (combined as ecosystem units) at a more detailed scale. Ecoregion classification is hierarchical, with five levels of generalization; the lowest level, ecosection, is used here. Biogeoclimatic classification includes four levels, including zone, subzone, variant, and phase. Ecoregion and biogeoclimatic units are broad-level delineations derived from provincial maps. Within these broader units, site-level polygons describe ecosystem units composed of site series, site modifiers, and structural stages.

At the first stage of ecosystem mapping, ecosystem units are delineated on aerial photographs following a bioterrain approach. To draw and label polygons, the mapper considers vegetation, topographic, and terrain (surficial geology) features. Site, vegetation and terrain attributes are recorded in a polygon database, and final map completed. The polygons are digitized and compiled in a geographic information system, and stored in a provincial database.

Outlined here are the standards established for ecosystem unit characterization, symbology, sampling, mapping procedures, interpretations and legends. Core data attributes to be collected for all ecosystem mapping projects in British Columbia are also described, in addition to other attributes that are recommended in order to support interpretations for various land management activities.

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The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report “The Future of our Forests.”

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This report was developed by the Ecosystems Working Group, part of the Terrestrial Ecosystems Task Force under the Resources Inventory Committee (RIC). Substantial contributions for this report have been provided by Barbara von Sacken, Robert Maxwell, Ted Lea, and Carmen Cadrin of the BC Ministry of Environment, Lands and Parks, and Del Meidinger and Allen Banner of the BC Ministry of Forests. Corey Erwin, Jo-Anne Stacey, and Tracy Fleming assisted with final preparation of the document. Richard Sims of Geomatics International provided materials on map reliability, assessment, and quality assurance. Many discussions were held and comments received from Ministry of Forests Regional Ecologists Tom Braumandl, Ray Coupé, Craig DeLong, Dennis Lloyd, Fred Nuszdorfer, and Ordell Steen. Thanks also go to participants (consultants, industry, and provincial government personnel) at a November 1996 workshop in Victoria, BC, who aided in finalizing the standards. As well, many practitioners were originally consulted as to what attributes were required for developing interpretations from ecosystem maps.

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This report has borrowed extensively from previous mapping methodology papers that are cited in the text. We would like to acknowledge the technical contributions of Bob Mitchell, Bob Green, Graeme Hope, Karel Klinka, Dennis Demarchi, Ted Lea, Mike Fenger, and Andrew Harcombe who documented previous methods for ecosystem mapping in British Columbia. We also acknowledge the co-operation and leadership of RIC co-chairs, Dave Gilbert, Mike Bonnor, and Jim Mattison, and the Terrestrial Ecosystems Task Force co-chairs, Imre Spandli, Bruce Pendergast, and A.Y. Omule. The Ecosystems Working Group consists of the following individuals: Allen Banner, Carmen Cadrin, Dave Campbell, David Kilshaw, Ted Lea, Herb Luttmerding, Barry McDougall, Shirley Mah, Robert Maxwell, Del Meidinger, and Barbara von Sacken.

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1.0 Introduction

The purpose of this report is to provide standards for terrestrial ecosystem mapping (TEM) in British Columbia. These standards should be used for all medium- and large-scale ecological mapping projects, to ensure that a consistent approach is applied. Common **scales** of ecological mapping are 1:20 000 to 1:50 000, though larger scales—such as 1:10 000 or 1:5000—may be carried out to support specific interpretations. This report is a product of the Resources Inventory Committee (RIC), whose objective is to provide integrated standards for all resource inventories in the province.

Ecosystem mapping is the stratification of a landscape into map units, according to a combination of ecological features, primarily climate, physiography, **surficial material**, bedrock geology, soil, and vegetation. Ecosystem mapping provides:

- a biological and ecological framework for land management;
- a means of integrating abiotic and biotic ecosystem components on one map;
- basic information on the distribution of ecosystems from which management interpretations (e.g., broad-scale **landscape planning**, site-specific interpretations) can be developed;
- a basis for rating values of resources or indicating sensitivities in the landscape;
- a historic record of ecological site conditions that can be used as a framework for monitoring ecosystem response to management; and
- a demonstration tool for portraying ecosystem and landscape diversity.

Ecosystem maps, along with associated interpretations, supply valuable information for many uses, particularly planning resource allocation. The maps are used, for example, to meet many Forest Practices Code-related needs, including landscape unit planning, forest development planning, range use planning and the development and application of biodiversity guidelines, riparian guidelines, and the proposed **identified wildlife** management strategy.

Data requirements are outlined for interpretations related to five broad subject areas: forest management, range management, wildlife management, biodiversity management, and terrain/soils.

This methodology has evolved from two previous methods manuals produced by the Ministry of Forests (Mitchell *et al.*, 1989) and the Ministry of Environment, Lands, and Parks (Demarchi *et al.*, 1990), and recent experience with application of 1995 standards (RIC, 1995). It builds on the collective experience with mapping and field methods that have been tested and proven effective in different parts of the province over the last 20 years.

The approach to the mapping described here combines aspects of the biogeoclimatic ecosystem classification (BEC) of the Ministry of Forests with aspects of the **ecoregion** classification of the Ministry of Environment, Lands, and Parks. Regional, local, and developmental ecosystems from four classifications are mapped: ecoregion (ecoregion units),

zonal (biogeoclimatic units), site (**site series**), and vegetation developmental (**structural stages** and **seral community types**). Figure 1.1 illustrates the relationship between these four classifications.

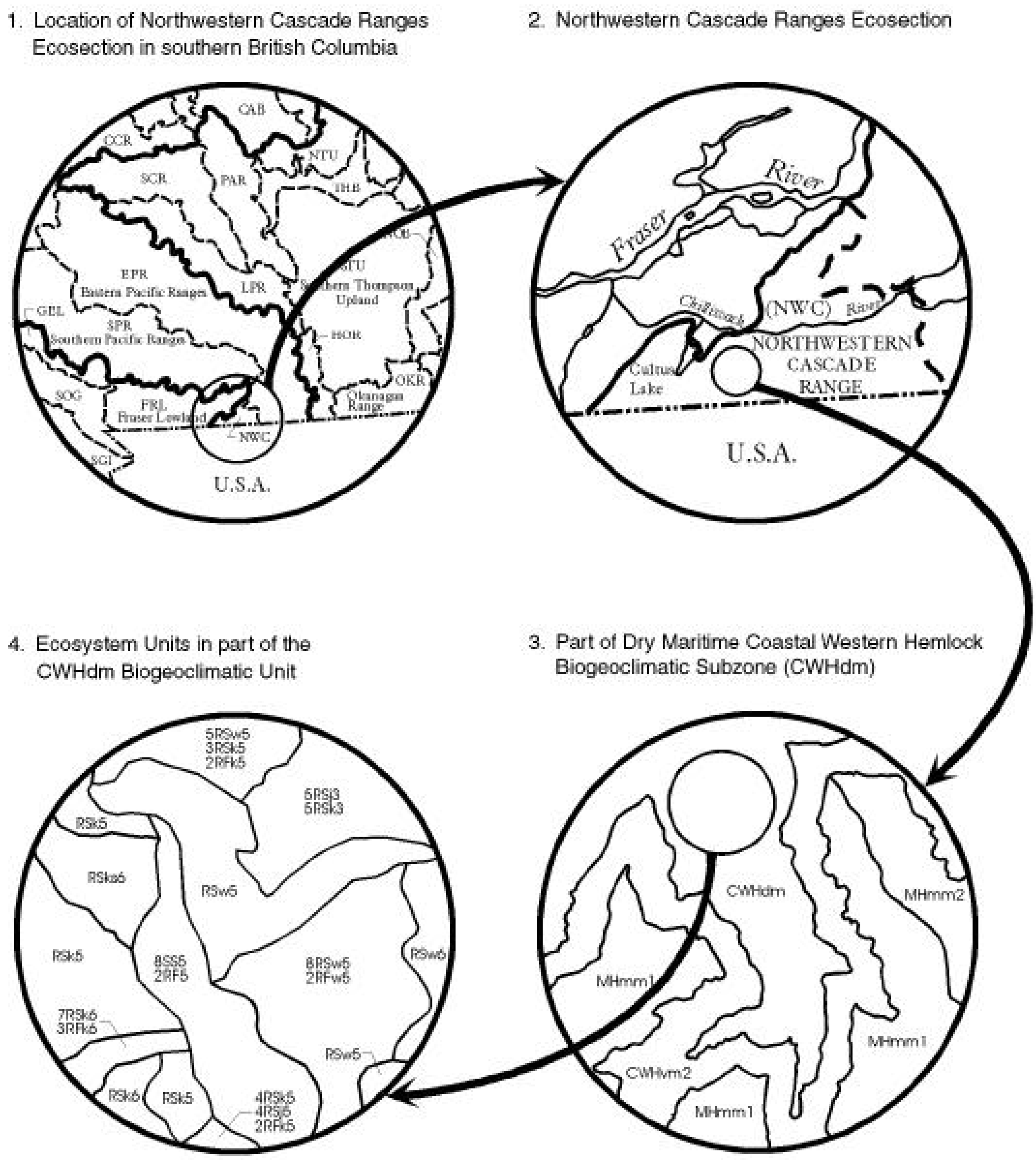


Figure 1.1 Hierarchy of ecological land classifications in British Columbia

Ecoregion and biogeoclimatic **polygons** represent broad level regional and climatic landscape units. Maps typically depict **ecosections** and biogeoclimatic zones, subzones, and variants. Within this framework, site level units, termed "**ecosystem units,**" are defined based on the integration of vegetation, terrain (surficial material), topography and soil characteristics. Ecosystem units are generally derived from the site series classification within the BEC, by being further differentiated based on more specific site conditions (e.g., **site modifiers**), structural developmental stages, and (sometimes) seral community types.

The ecosystem units are mapped using a bioterrain approach, a procedure that focuses on observable site and biological features assumed to determine the function and distribution of plant communities on the landscape. Map units are delineated using a combination of **aerial photograph** interpretation and field sampling to verify ecosystem identification and boundaries.

Presented here is information about terrestrial ecosystem unit characterization and mapping, symbology, polygon **attributes**, interpretations, legends, and mapping and field survey procedures. Core polygon attributes to be recorded for all ecosystem mapping projects are also described, in addition to other attributes that are recommended for specific interpretations. Maps produced using this methodology should be incorporated into Geographic Information Systems (GIS). These digital maps and their associated databases allow the storage and retrieval of much larger amounts of polygon-based data than can be visually portrayed on a single map itself. The use of GIS also facilitates the integration of terrestrial ecosystem mapping with other resource inventories, contributing towards a provincial map database.

2.0 Classification and Mapping Concepts

Ecosystem classification provides the taxonomic framework for describing the nature and pattern of ecological units within a landscape. Ecosystem mapping uses the classification to depict the spatial distribution of the ecological units. This section describes the classification hierarchy and how it is used in TEM.

Three ecosystem integration levels are combined in TEM (Figure 2.1): the regional ecosystem level, where the classification units are ecosections and **biogeoclimatic subzones** and variants; the local ecosystem level, where site series is the classification; and the vegetation developmental level, where structural stages and seral community types are used.

Ecosystem units, described in more detail below, are a conceptual group of sites that are similar enough to be grouped together as one mapping individual. In TEM, this is a combination of site and vegetation developmental units. It is important to remember however, that the ecosystem unit is an abstract unit of classification, which, each time it is mapped, will have a certain range of characteristics that make it unique from other ecosystem units.

Map units represent mapped portions of the landscape (Valentine, 1986). Each unit is established as a result of applying a classification to a map polygon. Ecosystem maps contain three kinds of map units: ecoregion map units, biogeoclimatic map units, and **ecosystem map units**. An ecosystem map unit contains either predominantly one mapping individual (simple map unit) or more than one (compound map unit). Each may also contain a certain proportion of other ecosystem units which are unmappable at the scale of mapping (Valentine, 1986). Ecoregion and biogeoclimatic map units are always mapped as simple map units.

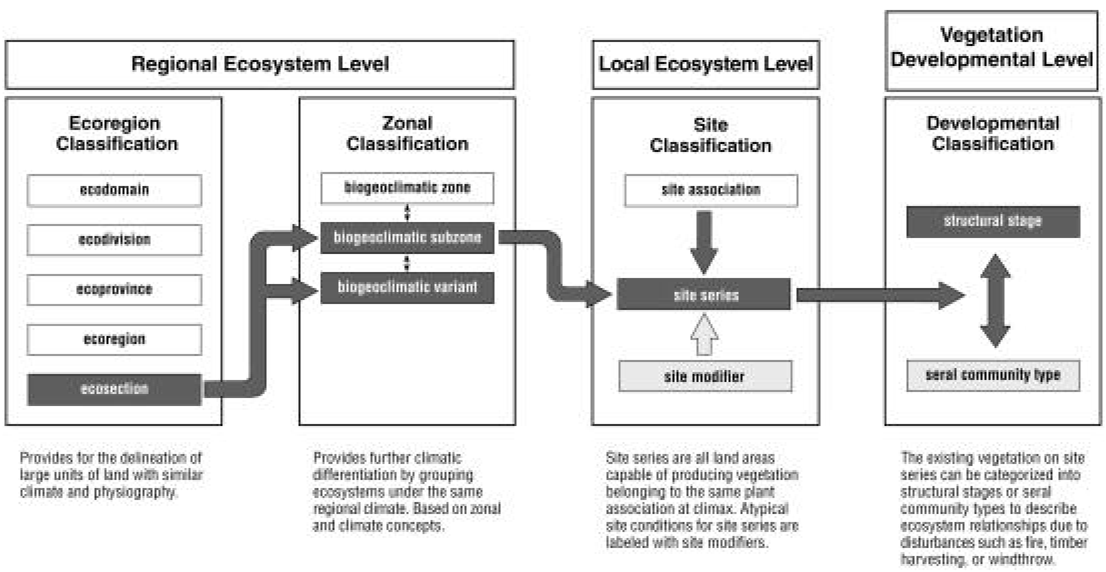


Figure 2.1 Levels of ecosystem integration and classification in terrestrial ecosystem mapping

2.1 Ecoregion Units

The ecoregion classification developed and mapped for British Columbia provides a systematic view of the broad geographic relationships of the province (Demarchi *et al.*, 1990; Demarchi, 1993). This "regional" classification is based on the interaction of macroclimatic processes (Marsh, 1988) and physiography (Holland, 1976; Mathews, 1986). It is a hierarchical system, stratifying the province according to five levels:

Ecodomain	This is an area of broad climatic uniformity (e.g., the Humid Temperate Ecodomain is one of three ecodomains occurring in British Columbia).
Ecodivision	This is an area of broad climatic and physiographic uniformity (e.g., the Humid Maritime and Highlands is one of seven ecodivisions occurring within British Columbia).
Ecoprovince	This is an area with consistent climate, relief, and plate tectonics (e.g., the Coast and Mountains Ecoprovince is 1 of 10 ecoprovinces occurring in British Columbia).
Ecoregion	This is an area with major physiographic and minor macroclimatic variation (e.g., the Pacific Ranges is one of 39 terrestrial ecoregion units occurring in British Columbia).
Ecosection	This is an area with minor physiographic and macroclimatic variation (e.g., the Eastern Pacific Ranges is one of 101 terrestrial ecosection units occurring in British Columbia).

Ecodomains and ecodivisions are very broad and place British Columbia in a global context. Ecoprovinces, ecoregions, and ecosections are progressively more detailed and narrow in scope and relate the province to other parts of North America, or segments of the province to each other.

The ecosection is the classification unit depicted in terrestrial ecosystem mapping. At present, British Columbia is mapped to the ecosection level at two scales of presentation: 1:2 000 000 (Demarchi, 1993) and 1:250 000 (BC Ministry of Forests, 1995).

Ecosections represent map delineations at the highest level of ecosystem generalization on a terrestrial ecosystem map, and are mapped as simple units that stratify the landscape into broad physiographically and climatically uniform units. Ecosections are named after specific geographic or physiographic features.

2.2 Biogeoclimatic Units

The biogeoclimatic ecosystem classification (BEC) is a hierarchical classification scheme that includes separate zonal (climatic) and site classifications. Meidinger and Pojar (1991) and Pojar *et al.* (1987) describe the system in detail. **Biogeoclimatic units** represent geographic areas under the influence of the same regional climate. The biogeoclimatic subzone is the basic unit. Subzones are then grouped into zones and divided into variants and phases, reflecting similarities and differences in regional climate.

A **biogeoclimatic subzone** consists of unique sequences of geographically related ecosystems. Its climatic **climax ecosystems** are members of the same zonal plant association. Such sequences are influenced by one type of regional climate. To date, about 100 subzones are recognized in British Columbia (Meidinger and Pojar, 1991).

Subzones with similar climatic characteristics and zonal ecosystems are grouped into **biogeoclimatic zones**. A zone is a large geographic area with a broadly homogeneous macroclimate. Fourteen biogeoclimatic zones are recognized in British Columbia (Meidinger and Pojar, 1991).

Subzones contain considerable variation and can be divided into **biogeoclimatic variants,** which reflect further differences in regional climate. Variants are generally recognized for areas that are slightly drier, wetter, snowier, warmer, or colder than other areas in the subzone. These climatic differences result in corresponding differences in vegetation, soil, and ecosystem productivity. The differences in vegetation are evident as a specific climax plant subassociation on zonal sites.

In the regional climate of subzones and variants, **biogeoclimatic phase** accommodates the variation resulting from local relief. Phases are useful in designating significant areas that are, for topographic or topo-edaphic reasons, atypical for the regional climate. Examples could be extensive areas of grassland occurring only on steep, south-facing slopes in an otherwise forested subzone, or valley-bottom, frost-pocket areas in mountainous terrain. To date, only a few phases are recognized in the province.

Biogeoclimatic subzones and variants are the units mainly used in TEM. Phases are mapped when present. British Columbia is mapped to the **biogeoclimatic zone** level at 1:2 000 000 and at the subzone/variant level for all forest regions at scales ranging from 1:100 000 to 1:500 000.

2.3 Ecosystem Units

Within ecosection and biogeoclimatic units, local and vegetation developmental level units termed **ecosystem units**, are defined. Ecosystem units are generally derived from the site series classification of BEC, by being further differentiated according to more specific site conditions (thus defining more homogeneous site units) and structural developmental stages (thus defining more homogeneous vegetation structural stages) (Figure 2.2). Additional attributes, such as seral community type or stand composition, can be added to map symbols to serve the needs of a particular client.

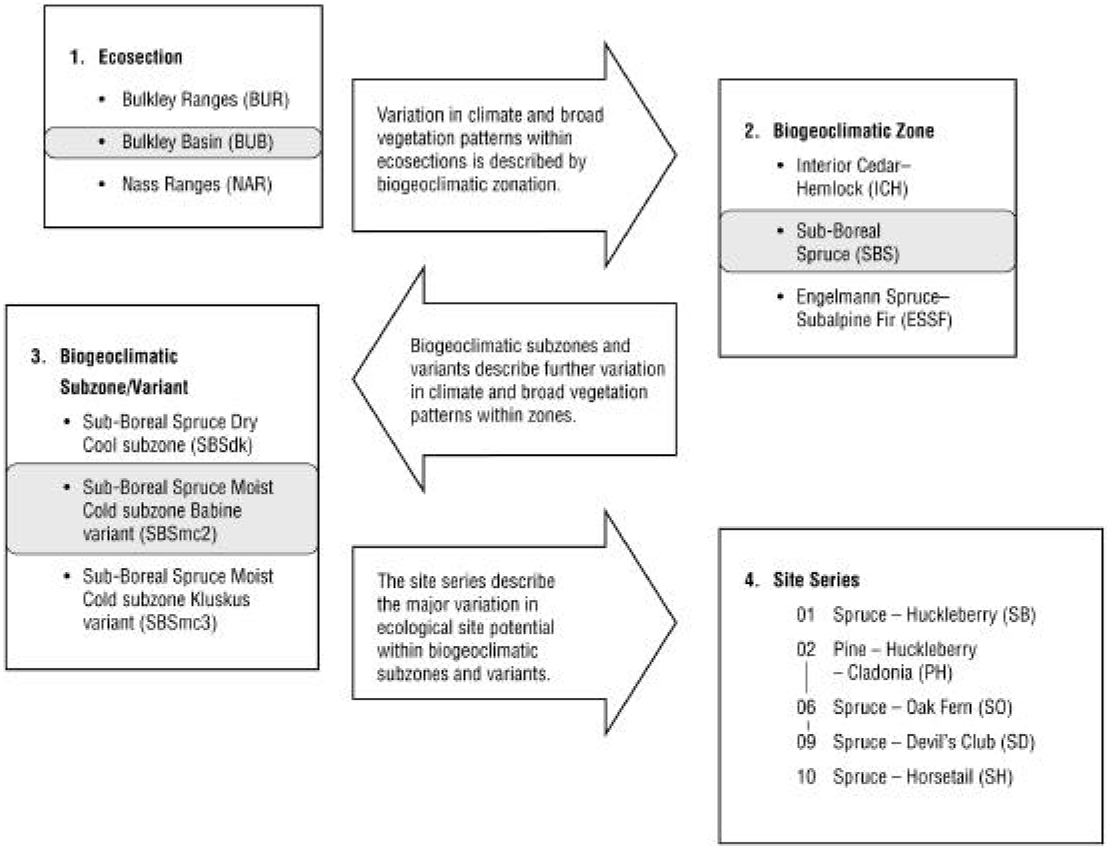


Figure 2.2 Hierarchy of TEM classification levels

2.3.1 Site series

Variation in site conditions encountered within a biogeoclimatic unit is accommodated within the site classification of BEC. The **site series** describe all land areas capable of supporting specific climax vegetation. This can usually be related to a specified range of soil moisture and **nutrient regimes** within a subzone or variant, but sometimes other factors, such as **aspect** or disturbance history, are important determinants as well. Ecologically similar site series occurring under more than one climatic regime (e.g., in more than one subzone or variant) are grouped together to form a **site association** (see Meidinger and Pojar, 1991 for more details). A classification of site series for most of the biogeoclimatic units of the province has been developed by the BC Ministry of Forests and is presented in regional field guides.

2.3.2 Site modifiers

Ecosystems with the same **vegetation potential** are grouped and classified to the site series level. However, compensating effects of different environmental characteristics can result in some site series having a wide range of physical site conditions. In TEM, this variation is dealt with by defining the "typical" conditions for a site series (RIC, 1997b) and then using site modifiers (see Table 3.2), a set of descriptive terms for certain site conditions, to describe conditions outside those considered typical. The typical environmental conditions were determined by reviewing each of the Ministry of Forests Regional Field Guides and selecting the "typical" characteristics of each site series.

2.3.3 Vegetation developmental units

While the site series describes site potential, actual stand conditions will vary considerably, depending on disturbance history, stand age, species composition, and chance. Many study areas will contain a complex of early to late seral and climax vegetation units. The level of detail required in descriptions of seral communities will be largely determined by the survey objectives and sampling intensity. Several attributes, outlined below, can be used to describe seral and structural variation in plant communities. Section 3.2.3 describes the standard coding to be used for each attribute in more detail.

The structural stage is the only mandatory vegetation developmental unit. The more detailed modifiers and seral community types will only be used to serve specific project objectives.

Structural stages

For studies emphasizing structural habitat characteristics, the **structural stage** category will generally be sufficient to describe seral variation within a site series. Structural stages describe the existing dominant stand appearance or physiognomy for the ecosystem unit, and are derived from the seral and stand structure classifications recommended by Hamilton (1988), and Oliver and Larson (1990). Stand structure substages and additional modifiers can be used to better differentiate non-forested categories (e.g., forb-dominated versus graminoid-dominated herb stage) and forested categories (e.g., single storied, multi-storied, coniferous versus broadleaf forests). Forested **structural stage modifiers** and **stand composition modifiers** are useful for developing wildlife and silvicultural interpretations, and will be used wherever specific project objectives require them.

Seral community types

Within BEC, the **seral association** describes present vegetation where the plant association is not in a climax or near-climax state. Seral associations represent non-climax plant associations belonging to the successional sequence of ecosystems within one or more site series. A formal, correlated classification of seral associations has not yet been developed for the province, although efforts are under way in some of the forest regions.

In mapping projects requiring differentiation of successional communities, a less formal approach will generally be taken in describing seral vegetation. Seral community types will be defined, describing more generalized seral units dominated by a similar group of species, often in the upper strata (tree and/or shrub layers in the case of forest and shrub communities), but being more variable in understory composition. By examining site and soil characteristics, and identifying soil moisture and nutrient regimes, it should be possible to identify the site series to which the seral community type belongs (e.g., site potential). However, seral communities typically span a much broader range of site characteristics than do site series, and thus the same seral community type may belong to the successional sequence of more than one site series.

The data collected in mapping projects and used to develop preliminary seral community types will be useful in eventually developing a correlated provincial classification of seral associations. Such a classification would be developed within the site series framework, with associations being differentiated using a diagnostic combination of species.

2.4 Terrain Units

In TEM, terrain (surficial geology) classification follows Howes and Kenk (1997), while **soil drainage** classification follows the Canada Soil Survey Committee (1978). Terrain features and soil drainage are used as delineation criteria and to describe characteristics of ecosystems. Attributes considered include surficial material, **terrain texture**, **surface expression**, qualifying descriptor, **geomorphological processes**, and soil drainage (RIC, 1994; Howes and Kenk, 1997).

3.0 Mapping Conventions

The following rules and standards apply to TEM in British Columbia. A list of core polygon attributes, which must be captured in the map database, are presented in Section 4.1.

3.1 Ecoregion/Biogeoclimatic Units

Ecoregion and biogeoclimatic polygons are labeled according to the ecoregion and biogeoclimatic units they represent. Ecosection units are given a three-letter code. Biogeoclimatic units receive codes of up to nine characters in length (Figure 3.1). Both ecosection and biogeoclimatic unit codes are available on the TEM website (see Appendix B).

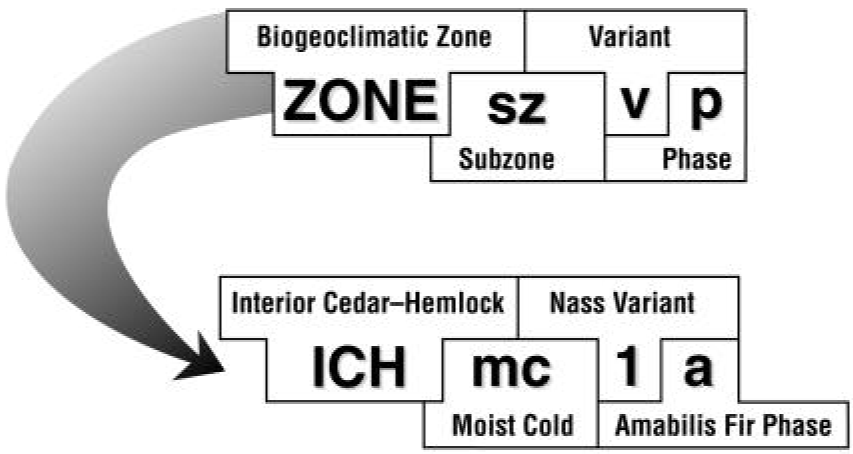


Figure 3.1 Symbols for Biogeoclimatic Units

The ecosection unit symbol is generally presented above the biogeoclimatic unit symbol, with both enclosed by a circle (see Figure 3.2). A new symbol is placed on the map whenever one or both of the units change.

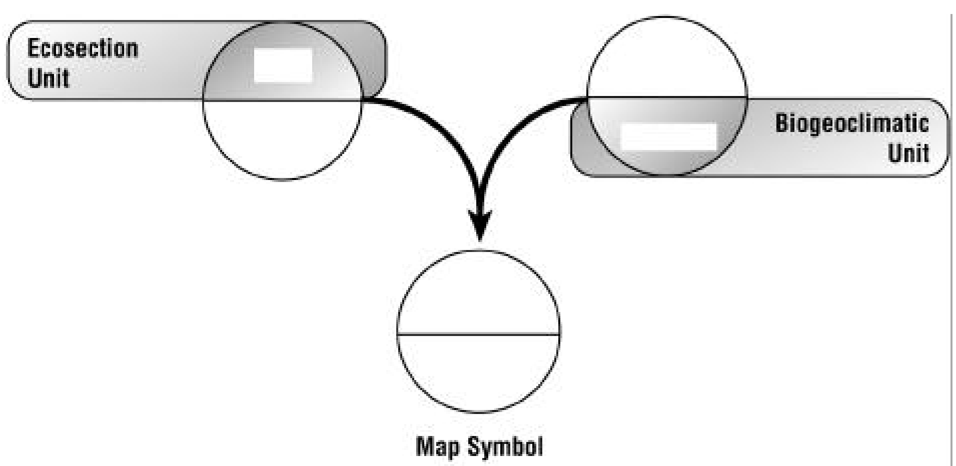


Figure 3.2 Symbols for Ecosection and Biogeoclimatic Units

3.2 Ecosystem Units

Each component of the ecosystem unit is described in this section. The label for a simple ecosystem map unit is portrayed in Figure 3.3. An example ecosystem map is presented in Figure 3.4.

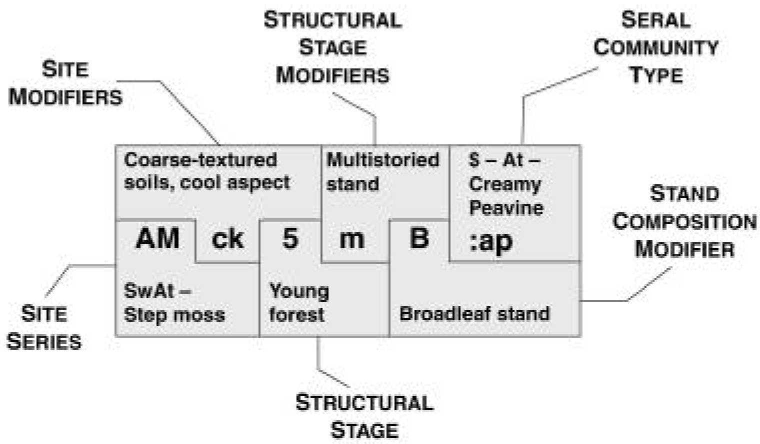


Figure 3.3 Symbology for Ecosystem Units

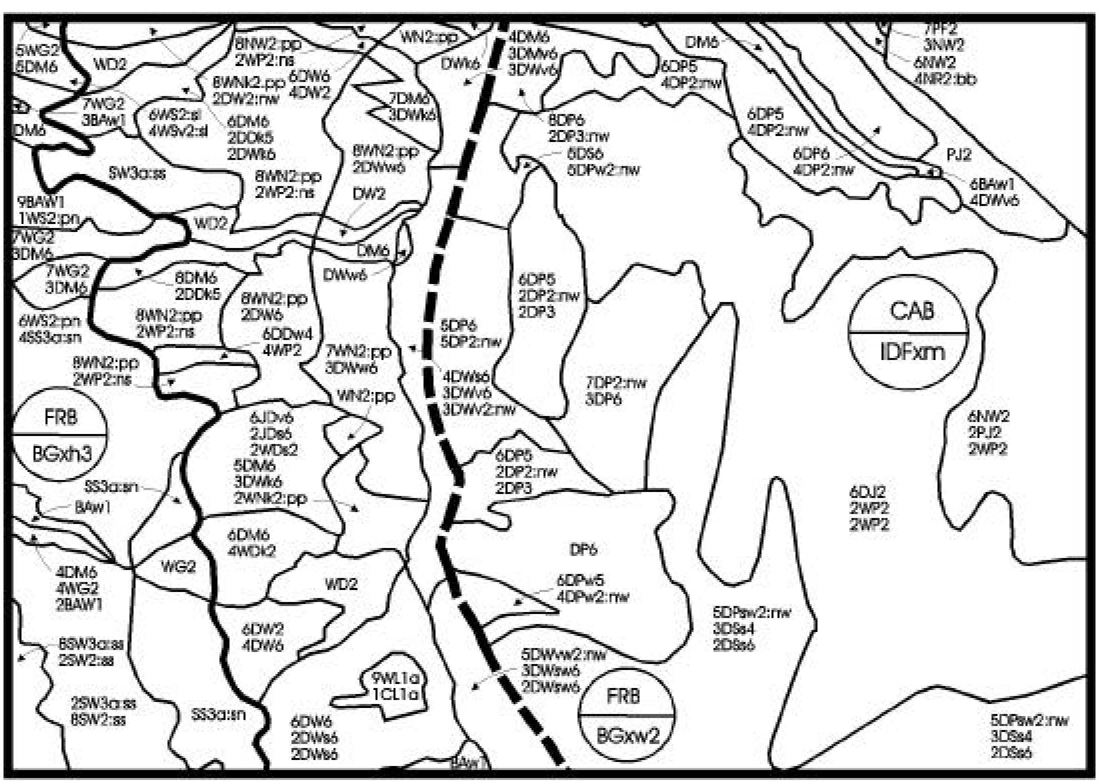
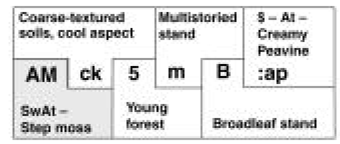


Figure 3.4 Example ecosystem map of Dog Creek

3.2.1 Site series

Site series is the first component of an ecosystem unit. A list of two-letter codes for all site series currently defined is provided on the TEM website (see Appendix B). Site series codes are unique within a subzone/variant (see Figure 3.5). Generally in forested ecosystems, the first letter of the code refers to the tree species. In all other cases, the codes represent the common names of dominant and/or **indicator species**.



IDFdk3 subzone

Ministry of Forests Site Series Number	Site Series Code	Name
01	LP	FdPl – Pinegrass – Feathermoss
02	DW	Fd – Snowberry – Bluebunch wheatgrass
03	DJ	Fd – Juniper – Pinegrass
04	DY	Fd – Pinegrass – Yarrow
05	SG	SxwFd – Gooseberry – Feathermoss
06	SH	Sxw – Horsetail
07	WS	Willow – Sedge

Figure 3.5 RIC and Ministry of Forests site series codes

Unclassified site units

Additional site series will be developed as inventory and classification of the province continues. These will be for areas that were not well sampled in the initial BEC program, or for particular kinds of ecosystems like grasslands, non-forested **wetlands**, **parkland**, and **alpine** areas. New site series for a particular area must be accepted by the Regional Ecologist of the Ministry of Forests, Forest Sciences Section, before being mapped.

In many projects, plant communities which cannot be identified by the existing site series will be encountered. At the level of sampling being conducted, however, it may not be possible to classify them rigorously through the BEC system. In these cases (e.g., non-forested communities, such as meadows and alpine, as well as high-elevation subalpine forested communities), a more generalized classification will need to be developed for mapping purposes. Broader units will be defined using **dominant species** and general landscape type (e.g., Mountain–heather–Partridgefoot subalpine meadow). Regional Ecologists of the Ministry of Forests should be consulted for help in defining these units. The new units will be added to the *Provincial Site Series Mapping Codes and Typical Environmental Conditions*, located on the TEM website (see Appendix B), to ensure correlation between mapping projects.

Combining site series

In some subzones, site series have been defined that may be difficult to distinguish one from another through aerial photograph interpretation. In such cases, the code for the most common site series expected on a particular kind of site should be used, and any other site series that may be defined within the ecosystem unit indicated in the **map legend**. If actual field sampling allows for confirmation of the site series for specific polygons, then the mapper should indicate in the attribute database part of the "Comments" field that a sample or inspection has been done for that component of the map unit, and that the ecosystem component is confirmed as one or the other site series.

Non-vegetated, sparsely vegetated, and anthropogenic site units

Units that occur in the landscape but are not defined site series, such as rock outcrops, cliffs, talus, urban/suburban areas, cultivated fields, and water bodies, are also mapped using a two-letter code. Standardized codes and definitions for these are listed in Table 3.1, as are site modifiers and structural stages. Some units, such as lakes (LA), will not have site modifiers or structural stages. If a site series code occurs that is the same as one of the codes below, the site series code takes precedence and a new code must be used for the non-vegetated, sparsely vegetated, or anthropogenic unit.

Table 3.1 Codes and definitions for non-vegetated, sparsely vegetated, and anthropogenic units

Code	Ecosystem Unit	Definition	Common Modifiers	Structural Stage
AL	Alkaline Pond	A body of fresh water with a pH greater than 7 and a depth less than 2 m.[1]	not applicable	not applicable
BA	Barren	Land devoid of vegetation due to extreme climatic or edaphic conditions.[1]	k, r, w	1
BE	Beach	The area that expresses sorted sediments reworked in recent time by wave action. It may be formed at the edge of fresh or salt water bodies.[2]	not applicable	1
BF	Blockfields, Blockslopes, Blockstreams	Level or gently sloping areas that are covered with moderately sized or large, angular blocks of rock derived from the underlying **bedrock** or drift by weathering and/or frost heave, and that have not undergone any significant downslope movement.[1]	k, r, w	1
CA	Canal	An artificial watercourse created for transport, drainage, and/or irrigation purposes.	not applicable	not applicable
CB	Cutbank	A part of a road corridor or river course situated upslope of the road or river, which is created by excavation and/or erosion of the hillside.[2]	k, w	1

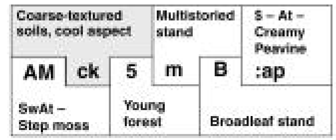
Code	Ecosystem Unit	Definition	Common Modifiers	Structural Stage
CF	Cultivated Field	A flat or gently rolling, non-forested, open area that is subject to human agricultural practices (including plowing, fertilization and non-native crop production) which often result in long-term soil and vegetation changes.	not applicable	1, 2, 3
CL	Cliff	A steep, vertical or overhanging rock face.[3]	q, z	1
CO	Cultivated Orchard	An agricultural area composed of single or multiple tree species planted in rows. Pruning maintains low, bushy trees.	not applicable	3
CV	Cultivated Vineyard	An agricultural area composed of single or multiple species of grapes planted in rows, usually supported on wood or wire trellises.	not applicable	3
ES	Exposed Soil	Any area of exposed soil that is not included in any of the other definitions. It includes areas of recent disturbance, such as mud slides, debris torrents, avalanches, and human-made disturbances (e.g., pipeline rights-of-way) where vegetation cover is less than 5%.[2]	k, r, w	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
GC	Golf Course	Flat to gently rolling grass-covered throughways and open areas set out for the playing of golf. The fairways are usually separated by isolated rows or patches of trees, shrubs and small bodies of water (forested areas and water bodies to be mapped as separate units).	not applicable	2–7
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
GP	Gravel Pit	An area exposed through the removal of sand and gravel.[2]	k,w	1
LA	Lake	A naturally occurring static body of water, greater than 2 m deep in some portion. The boundary for the lake is the natural high water mark.[2]	not applicable	not applicable
LB	Lava Bed	An area where molten rock has flowed from a volcano or fissure and cooled to form	k, r, w	1

Code	Ecosystem Unit	Definition	Common Modifiers	Structural Stage
		solidified rock.[2]		
MI	Mine	An unvegetated area used for the extraction of mineral ore and other materials.[1]	not applicable	1
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 materials.[4]	k, w	1
MS	Rubbly Mine Spoils	Discarded overburden or waste rock moved so that ore can be extracted in a mining operation.[2]	not applicable	1
MU	Mudflat Sediment	Flat plain-like areas dominated by fine-textured sediments. These areas are found in association with freshwater, saltwater or estuarine bays (at low tide), lakes, ponds, rivers and streams.[2]	not applicable	1
OW	Shallow Open Water	A wetland composed of permanent shallow open water and lacking extensive emergent plant cover. The water is less than 2 m deep. (If vegetated, these units should developed into site series groups for interpretation.)	not applicable	not applicable
PD	Pond	A small body of water greater than 2 m deep, but not large enough to be classified as a lake (e.g., less than 50 ha).	not applicable	not applicable
PG	Patterned Ground	An unvegetated land surface with a distinctive arrangement of stones or microtopography due to the effects of ground freezing and seasonal frost.[1]	not applicable	1
PS	Permanent Snow	Snow or ice that is not part of a glacier but is found during summer months on the landscape.[2]	not applicable	not applicable
RE	Reservoir	An artificial basin created by the impoundment of water behind a human-made structure such as a dam, berm, dyke, or wall.[2]	not applicable	not applicable
RG	Rock Glacier	A tongue-shaped or lobate, ridged accumulation of angular fragments containing interstitial ice. These areas, which move slowly downslope, are morphologically similar to glaciers.[1]	k, w	1
RI	River	A watercourse formed when water flows between continuous, definable banks. The	not applicable	not applicable

Code	Ecosystem Unit	Definition	Common Modifiers	Structural Stage
		flow may be intermittent or perennial. An area that has an ephemeral flow and no channel with definable banks is not considered a river.[2]		
RM	Reclaimed Mine	A mined area that has plant communities composed of a mixture of agronomic or native grasses, forbs, and shrubs.	k, r, w	1, 2, 3
RN	Railway Surface	A roadbed with fixed rails for possibly single or multiple rail lines.[2]	not applicable	not applicable
RO	Rock Outcrop	A gentle to steep, bedrock escarpment or outcropping, with little soil development and sparse vegetative cover.	k, r, w	1
RP	Road Surface	An area cleared and compacted for the purpose of transporting goods and services by vehicles.[2]	not applicable	not applicable
RR	Rural	Any area in which residences and other human developments are scattered and intermingled with forest, range, farm land, and native vegetation or cultivated crops. (Forested areas and cultivated fields should be mapped as separate units.)[1]	not applicable	not applicable
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
SW	Saltwater	Any body of water that contains salt or is considered to be salty.[2]	not applicable	not applicable
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.[2, 4]	k, r, w	1
TS	Mine Tailings	Solid waste materials directly produced in the mining and milling of ore.[2]	not applicable	1
UR	Urban/ Suburban	An area in which residences and other human developments form an almost continuous covering of the landscape. These areas include cities and towns, subdivisions, commercial and industrial parks, and similar developments both inside and outside city limits. (Forested areas, such as parks, should be mapped as separated units.)[1]	not applicable	not applicable

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

3.2.2 Site modifiers



Each site series within the Ministry of Forests biogeoclimatic ecosystem classification has been described by a "typical" set of environmental conditions focusing specifically on important site, soils, and terrain characteristics (see *Provincial Site Series Mapping Codes and Typical Environmental Conditions* TEM website in Appendix B). The variation within some site series may be well described by the typical conditions; for others, the typical conditions may describe only one possible set. In TEM, site modifiers (presented in Table 3.2) are used to describe these atypical conditions for each ecosystem. Site modifiers provide additional descriptors for an ecosystem, and, if applicable, are displayed as the second component of an ecosystem unit.

If a site series occurs over a considerable range of site conditions in the landscape, site modifiers will be used for mapping the entire range of sites that do not meet the typical situation for that site series, within the limits of the modifiers described in Table 3.2. For example, the zonal site series for a particular biogeoclimatic unit usually occurs on gentle slopes with deep, medium-textured soils and mesic moisture regime. As an example, the symbol LP would be used for the zonal FdPl–Pinegrass–Feathermoss site series in the IDFdk3 biogeoclimatic subzone. If this site series was found to occur on cool aspects with deep soils, it would be mapped as LPk (Figure 3.6). If it also occurred on shallow soils of cool aspects, it would then be mapped as LPks. Up to two site modifiers can be used in defining an ecosystem unit in the map labels. If more site modifiers are applicable, they can be added in the database comments field. Site modifiers should be listed alphabetically in map symbols.

Table 3.2 Site modifiers for atypical conditions

Code	Criteria
Topography	
a	active floodplain[1] – the site series 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[1] occurring – the site series 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[1] terrain (optional modifier) – the site series occurs on hummocky terrain, suggesting a certain amount of variability. Commonly, hummocky conditions are indicated by the terrain surface expression but occasionally they occur in a situation not described by terrain features.
j	gentle slope – the site series occurs on gently sloping topography (less than 25% in the interior, less than 35% in the CWH, CDF, and MH zones).
k	cool aspect – the site series occurs on cool, northerly or easterly aspects (285°–135°), on moderately steep slopes (25%–100% slope in the interior and 35%–100% slope in the CWH, CDF and MH zones).
n	fan[1] – the site series occurs on a fluvial fan (most common), or on a colluvial fan or cone.
q	very steep cool aspect – the site series occurs on very steep slopes (greater than 100%

Code	Criteria
	slope) with cool, northerly or easterly aspects (285°–135°).
r	ridge[1](optional modifier) – the site series occurs throughout an area of ridged terrain, or it occurs on a ridge crest.
t	terrace[1] – the site series occurs on a fluvial or glaciofluvial terrace, lacustrine terrace, or rock cut terrace.
w	warm aspect – the site series occurs on warm, southerly or westerly aspects (135°–285°), on moderately steep slopes (25%–100% slope in the interior and 35%–100% slope in the CWH, CDF and MH zones).
z	very steep warm aspect – the site series occurs on very steep slopes (greater than 100%) on warm, southerly or westerly aspects (135°–285°).
Moisture	
x	drier than typical (optional modifier) – describes part of the range of conditions for circummesic ecosystems with a wide range of soil moisture regimes or significantly different site conditions. For example, SBSmc2/01 (Sxw–Huckleberry) has three site phases described, and the submesic phase can be labeled with the “drier than average” modifier (e.g., SBx). This code should be applied only after consultation with the Regional Ecologist.
y	moister than typical (optional modifier) – describes part of the range of conditions for circummesic ecosystems with a wide range of soil moisture regimes or significantly different site conditions. For example, SBSmk1/06 (Sb–Huckleberry–Spirea) is “typically” described as submesic to mesic. When this site series is found on subhygric or hygric sites, the “y” modifier is used (e.g., BHy). This code should be applied only after consultation with the Regional Ecologist.
Soil	
c	coarse-textured soils[2] – the site series 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 – the site series occurs on soils greater than 100 cm to bedrock.
f	fine-textured soils[2] – the site series 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 with less than 35% coarse fragment volume.
m	medium-textured soils – the site series 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 – the site series occurs on deep organics or a peaty surface (15–60 cm)[3] over mineral materials (e.g., on organic materials of sedge, sphagnum, or decomposed wood).
s	shallow soils – the site series occurs where soils are considered to be shallow to bedrock (20–100 cm).
v	very shallow soils – the site series occurs where soils are considered to be very shallow to bedrock (less than 20 cm).

[1] Howes and Kenk 1997
[2] Soil textures have been grouped specifically for the purposes of ecosystem mapping.
[3] Canada Soils Survey Committee, 1987

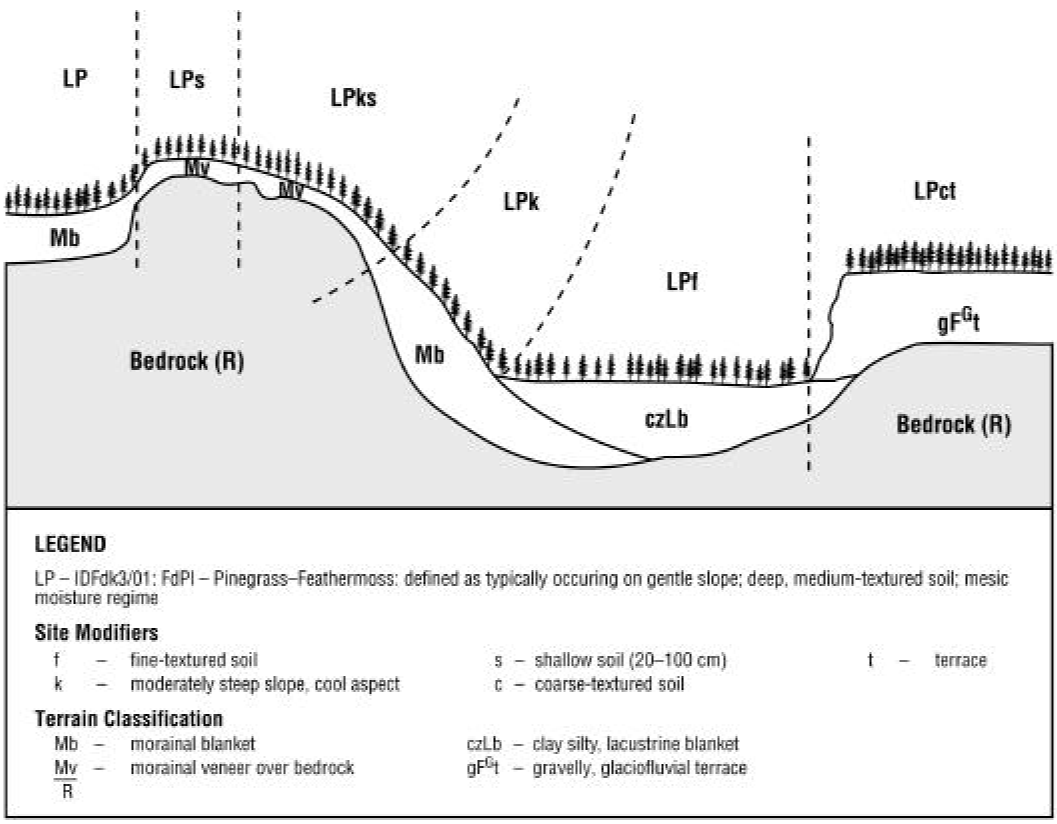
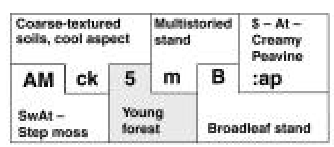


Figure 3.6 Use of site modifiers in mapping site series

3.2.3 Vegetation developmental units

Structural stages



Structural stage numbers (Table 3.3) must be indicated for each ecosystem unit (including non-forested units) except as noted in Table 3.1. Additional substages are used to further differentiate structural stages 1 through 3 according to life form, layers and relative cover of individual strata. Substages 1a, 1b and 2a–d should be used if photo interpretation is possible, otherwise, stage 1 and 2 should be used. Substages 3a, and 3b should be used for permanent shrub communities (e.g., krummholz), and for detailed mapping projects where this differentiation is required for interpretations. Structural stages and substages are described in Table 3.3.

Table 3.3 Structural stages and codes[1]

Structural Stage	Description
Post-disturbance stages or environmentally induced structural development	
1 Sparse/bryoid[2]	Initial stages of primary and secondary succession; bryophytes and lichens often dominant, can be up to 100%; time since disturbance less than 20 years for normal forest succession, may be prolonged (50–100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover less than 20%; total tree layer cover less than 10%.
Substages	
1a Sparse[2]	Less than 10% vegetation cover;
1b Bryoid[2]	Bryophyte- and lichen-dominated communities (greater than 1/2 of total vegetation cover).
Stand initiation stages or environmentally induced structural development	
2 Herb[2]	Early successional stage or herbaceous communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, **flooding**, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree layer cover less than 10%, shrub layer cover less than or equal to 20% or less than 1/3 of total cover, herb-layer cover greater than 20%, or greater than or equal to 1/3 of total cover; time since disturbance less than 20 years for normal forest succession; many herbaceous communities are perpetually maintained in this stage.
Substages	
2a Forb-dominated[2]	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by non-graminoid herbs, including ferns.
2b Graminoid-dominated[2]	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by grasses, sedges, reeds, and rushes.
2c Aquatic[2]	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by floating or submerged aquatic plants; does not include sedges growing in marshes with standing water (which are classed as 2b).
2d Dwarf shrub[2]	Communities dominated (greater than 1/2 of the total herb cover) by dwarf woody species such as *Phyllodoce empetriformis, Cassiope mertensiana, Cassiope tetragona, Arctostaphylos arctica, Salix reticulata,* and *Rhododendron lapponicum.* (See list of dwarf shrubs assigned to the herb layer in the *Field Manual for Describing Terrestrial Ecosystems)*.
3 Shrub/Herb[3]	Early successional stage or shrub communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, **flooding**, intensive grazing, intense fire damage); dominated by shrubby vegetation; seedlings and advance regeneration may be abundant; tree layer cover less than 10%, shrub layer cover greater than 20% or greater than or equal to 1/3 of total cover.

Structural Stage	Description
Substages	
3a Low shrub[3]	Communities dominated by shrub layer vegetation less than 2 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 20 years for normal forest succession.
3b Tall shrub[3]	Communities dominated by shrub layer vegetation that are 2–10 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 40 years for normal forest succession.
Stem exclusion stages	
4 Pole/Sapling[4]	Trees greater than 10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually greater than 10–15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy – this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance is usually less than 40 years for normal forest succession; up to 100+ years for dense (5000–15 000+ stems per hectare) stagnant stands.
5 Young Forest[4]	Self-thinning has become evident and the forest canopy has begun differentiation into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the pole/sapling stage; time since disturbance is generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions.
Understory reinitiation stage	
6 Mature Forest[4]	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 is generally 80–140 years for biogeoclimatic group A[5] and 80–250 years for group B.[6]
Old-growth stage	
7 Old Forest[4]	Old, structurally complex stands composed 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 typical, as are patchy understories; understories may include tree species uncommon in the canopy, due to inherent limitations of these species under the given conditions; time since disturbance generally greater than 140 years for biogeoclimatic group A[5] and greater than 250 years for group B.[6]

[1] In the assessment of structural stage, structural features and age criteria should be considered together. Broadleaf stands will generally be younger than coniferous stands belonging to the same structural stage.

[2] Substages 1a, 1b and 2a–d should be used if photo interpretation is possible, otherwise, stage 1 and 2 should be used.

[3] Substages 3a and 3b may, for example, include very old krummholz less than 2 m tall and very old, low productivity stands (e.g., bog woodlands) less than 10 m tall, respectively. Stage 3, without additional substages, should be used for regenerating forest communities that are herb or shrub dominated, including shrub layers consisting of only 10–20% tree species, and undergoing normal succession toward climax forest (e.g., recent cut-over areas or burned areas).

[4] Structural stages 4–7 will typically be estimated from a combination of attributes based on forest inventory maps and aerial photography. In addition to structural stage designation, actual age for forested units can be estimated and included as an attribute in the database, if required.

[5] Biogeoclimatic Group A includes BWBSdk, BWBSmw, BWBSwk, BWBSvk, ESSFdc, ESSFdk, ESSFdv, ESSFxc, ICHdk, ICHdw, ICHmk1, ICHmk2, ICHmw3, MS (all subzones), SBPS (all subzones), SBSdh, SBSdk, SBSdw, SBSmc, SBSmh, SBSmk, SBSmm, SBSmw, SBSwk1 (on plateau), and SBSwk3.

[6] Biogeoclimatic Group B includes all other biogeoclimatic units (see Appendix C).

Structural stage modifiers (optional attribute) are used when required for further differentiation of structural stages 3 to 7. These modifiers describe five stand structure types based on the relative development of overstory, intermediate, and suppressed crown classes (Table 3.4, Figure 3.7).

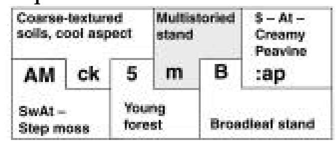


Table 3.4 Structural stage modifiers[1] and codes[2]

Modifier		Description
s	**single storied**	Closed forest stand dominated by the overstory crown class (dominant and co-dominant trees); intermediate and suppressed trees account for less than 20% of all crown classes combined[3]; advance regeneration in the understory is generally sparse.
t	**two storied**	Closed forest stand co-dominated by distinct overstory and intermediate crown classes; the suppressed crown class is lacking or accounts for less than 20% of all crown classes combined[3]; advance regeneration is variable.
m	**multistoried**	Closed forest stand with all crown classes well represented; each of the intermediate and suppressed classes account for greater than 20% of all crown classes combined[3]; advance regeneration is variable.
i	**irregular**	Forest stand with very open overstory and intermediate crown classes (totaling less than 30% cover), and well-developed suppressed crown class; advance regeneration is variable.
h	**shelterwood**	Forest stand with very open overstory (less than 20% cover) and well-developed suppressed crown class and/or advance regeneration in the understory; intermediate crown class is generally absent.

1 Adapted from Weetman *et al.* (1990). Stand structure types and crown classes are further described and illustrated in Figure 3.7.
2 Structural stage modifiers should be used as in the following examples: 5s for young forest stage with single-storied structure or 7m for old forest with multistoried structure. The only structural stage modifier, other than single storied, generally applicable to structural stage 3 is "h" (for shelterwood). This can be used to describe recently regenerated stands with a very open overstory (less than 20% cover of mature trees or vets) and a (usually dense) understory of seedlings and saplings.
3 Based on either basal area or percent cover estimates.

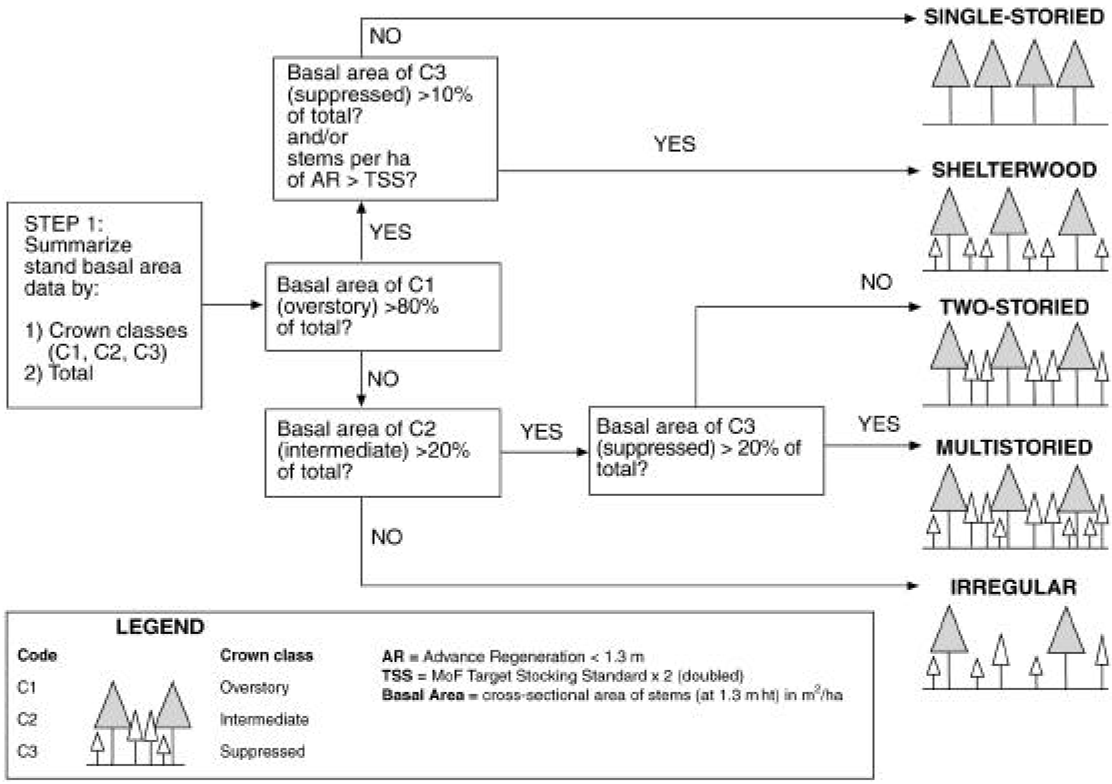


Figure 3.7 Structural stage modifiers

Stand composition modifiers (optional attribute) are used as required for further differentiation of structural stages 3 to 7. These modifiers differentiate coniferous, broadleaf, and mixed stands (Table 3.5).

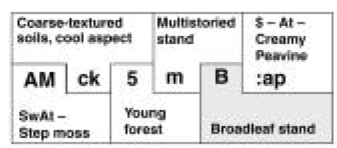


Table 3.5 Stand composition modifiers[1, 2] and codes

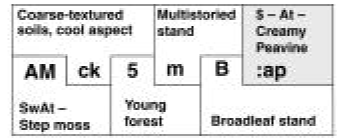
Modifier	Description
C coniferous	Greater than 3/4 of total tree layer cover[3] is coniferous
B broadleaf	Greater than 3/4 of total tree layer cover[3] is broadleaf
M mixed	Neither coniferous or broadleaf account for greater than 3/4 of total tree layer cover[3]

[1] Adapted from RIC, 1997a.

[2] Stand composition modifiers should be used as in the following examples: 6C for mature forest of coniferous composition, 7mM for old forest with multistoried structure and mixed composition, 3bC for tall shrub community dominated by coniferous saplings.

[3] Stand composition modifiers emphasize overstory and intermediate tree layers, since these are the most visible on aerial photographs.

Seral community types[1] (optional attribute)



Seral community types (Table 3.6) are an optional ecosystem attribute that should only be used in mapping where project objectives and **survey intensity level** warrant this level of detail. For instance, if seral floristic differences are relevant (as, for example, in the assessment of **forage species** or competing **vegetation complexes**) a floristic classification of seral community types may be required in a mapping project. A description of seral plant communities is useful for determining where the current **plant community** falls on the scale between early seral and **potential natural community** climax for any community type. (Province of BC, 1995b).

Given lack of data on seral ecosystems, there is not a current standard list of seral community types for the province. Therefore, classification and mapping of seral community types must be approved by the Regional Ecologist during a mapping project. This will help to ensure some degree of standardization and correlation of seral units as they are proposed. A list of currently used seral community types and their codes is being maintained with the *Provincial Site Series Mapping Codes and Typical Environmental Conditions* on the TEM website (see Appendix B). Seral community types are named using two or three typical or dominant species (e.g., trembling aspen–creamy peavine), and are given a two-letter lower-case code (e.g., ap).

Table 3.6 Example seral community types for the BWBSmw2

Seral Community Code	Seral Community Name (DeLong, 1988)
ap	At – creamy peavine
ak	At – kinnikinnick
as	At – soopolallie
al	At – Labrador tea
ab	At – black twinberry
ao	At – oak fern
ac	Ac – cow parsnip

3.2.4 Alternate methods for assigning site modifiers and structural stage

Site modifiers are usually estimated from air photographs. However, an alternative to interpreting these attributes is to model them from existing digital data sources. For example, **TRIM** data can be used to determine aspect modifiers and terrain attributes could be used to assign certain other site modifiers. Modelling is acceptable if it provides results similar to air photo interpretation.

1 We limit the term “seral” here to the developmental stages of an ecological succession not including the climax community (Lincoln *et al.*, 1982). We recognize that, in the ecological literature, climax communities are also technically considered part of the sere.

Similarly, structural stage, structural stage modifiers, and **stand composition modifiers** are usually estimated from air photos. Alternatively, the forest cover database (specifically the age, species composition, and stocking criteria) is a useful source of information for assigning these attributes. In fact, it should be possible, using this database in combination with some field verification, to model structural stage for a given study area and assign structural stage to ecosystem polygons using GIS programming **algorithms**. Modelling of a dynamic attribute such as structural stage may better facilitate future updates from the forest cover mapping. However, modelling requires expertise and software that may not be readily available to all mapping contractors. Where modelling of structural stage is used, it may be preferable for interpretations to keep it as a separate layer within the GIS.

3.2.5 Naming ecosystem units

Ecosystem units are named according to the site series name, site modifiers, and structural stage. For example, the ICHvk/01: CwHw–Devil's club–Lady fern unit, with the map code RD, would be given the ecosystem unit name "CwHw–Devil's club–Lady fern; typic." The same site series on cool aspect sites and in mature forest (e.g., RDk6) would be named "CwHw–Devil's club–Lady fern; cool aspect; mature forest."

3.3 Ecosystem Map Units

Ecosystem map units are either simple, containing one ecosystem unit, or compound, containing up to three ecosystem units (for which one or all of the three attributes: site series, site modifier, and structural stage differ one from the other) (see Figure 3.8). The proportion of ecosystem units is indicated with "**deciles**." Ecosystem map units may also have minor **inclusions** that are too small to map at the scale of the survey.

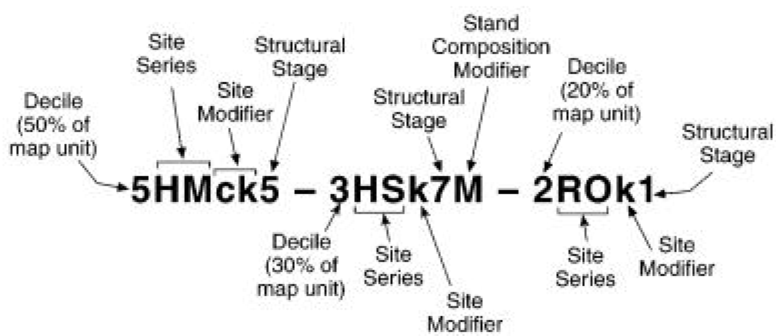


Figure 3.8 Compound map units

An ecosystem map unit should have a limited range of characteristics, so that it can be interpreted and treated uniformly (e.g., it should not contain highly contrasting ecosystem units unless one is of minor extent and cannot be feasibly mapped as a separate simple unit). The objectives of the survey will often determine which characteristics are important.

Only ecosystem units that occupy 20% or more of a polygon are typically indicated in the map label. Those that occupy less than 20% of the polygon (e.g., a small wetland) can be indicated in the map label if they are particularly significant for an interpretation. Another option is to indicate these ecosystem units in the database comments field or as an **on-site symbol**. The intent of this guideline is to minimize compound map units and encourage delineation of new polygons where there is considerable complexity.

The inclusion of three ecosystem units in a compound map unit should be done sparingly. Nevertheless, it is recognized that in some study areas with a complex distribution of ecosystems, ecosystem units are difficult to separate and compound map units cannot be avoided.

Minimum Polygon Size

A minimum polygon size of 0.5 cm^2 (e.g., 0.7×0.7 cm) is recommended. This polygon size corresponds to a land area of: 0.5 ha, at a scale of 1:10 000; 2.0 ha, at 1:20 000; and 12.5 ha, at 1:50 000.

3.4 Terrain and Soil Attributes

Conventions for displaying terrain and soil drainage symbology on air photographs and in the terrestrial ecosystem map database should follow Howes and Kenk (1997), RIC (1994), and the Canada Soil Survey Committee (1978) listed in Appendix B. The proportion of terrain components is indicated with deciles.

3.5 Polygon Boundaries

Figure 3.9 provides the standardized polygon boundary line weights—or, alternatively, colour boundaries—that should be used for final presentation of ecosystem mapping.

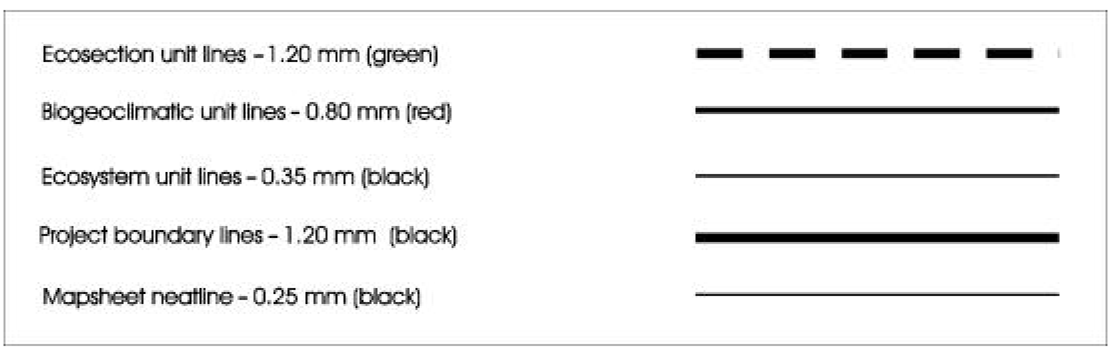


Figure 3.9 Standardized polygon boundary line weights

3.6 Options for Ecoregion/Biogeoclimatic Map Unit Symbols

On a map, the ecosection unit symbol should generally be presented above the biogeoclimatic unit symbol, with both enclosed by a circle (see Figure 3.2). A new symbol should be placed on the map whenever one or both of the two units change. Although this is the standard, alternative methods may work in special circumstances based on the approval of the project ecologist.

3.7 Options for Ecosystem Map Unit Symbols

With the use of GIS and a colour plotter, there are many alternatives for displaying the ecosystem unit components on a terrestrial ecosystem map. The standard is presented in Figure 3.9 above. The alternatives are generally dictated by the needs of the clients of the map.

For example, if forestry staff are familiar with the site series numbers presented in the Ministry of Forests regional guides, they can produce maps with the two-digit numbers rather than the two-character codes. However, not all map units are site series. In these cases, accepted site series could be given the two-digit code (e.g., 01 for the zonal ecosystem), while non-correlated, generalized, grouped, or other ecosystem units could keep their appropriate two-letter code. Since ecosystem units have both alphabetic and numeric codes, it is suggested that a separator be used to distinguish the components. This alternative could appear as follows and for this example, the components are separated by a period:

Simple unit:	**01.7**	Describes one site series and structural stage, with no site modifier
Compound unit:	**4.01.7–3.03.sw.5–3.RO.w.1**	Describes a combination of site series and other units

4.0 Polygon Data and Interpretations

The greatest value of ecosystem unit characterization and mapping is in providing interpretations for a variety of disciplines (for examples, see Klinka, 1976; Lindeburgh and Trowbridge, 1985; Lea *et al.*, 1990; Cichowski and Banner, 1993; and BC Ministry of Forests regional field guides) (Figure 4.1). The importance of interpretive mapping lies in the opportunities it gives users to evaluate the landbase for its land use values and sensitivities. The Forest Practices Code requires a number of land based interpretations related to operational and strategic level planning. Landscape unit planning, forest development planning and biodiversity requirements for maintaining forest ecosystem networks (including retention of old growth, the temporal and spatial distribution of cutblocks, and rare and endangered plant communities) are all examples of interpretations that can be accommodated by TEM.

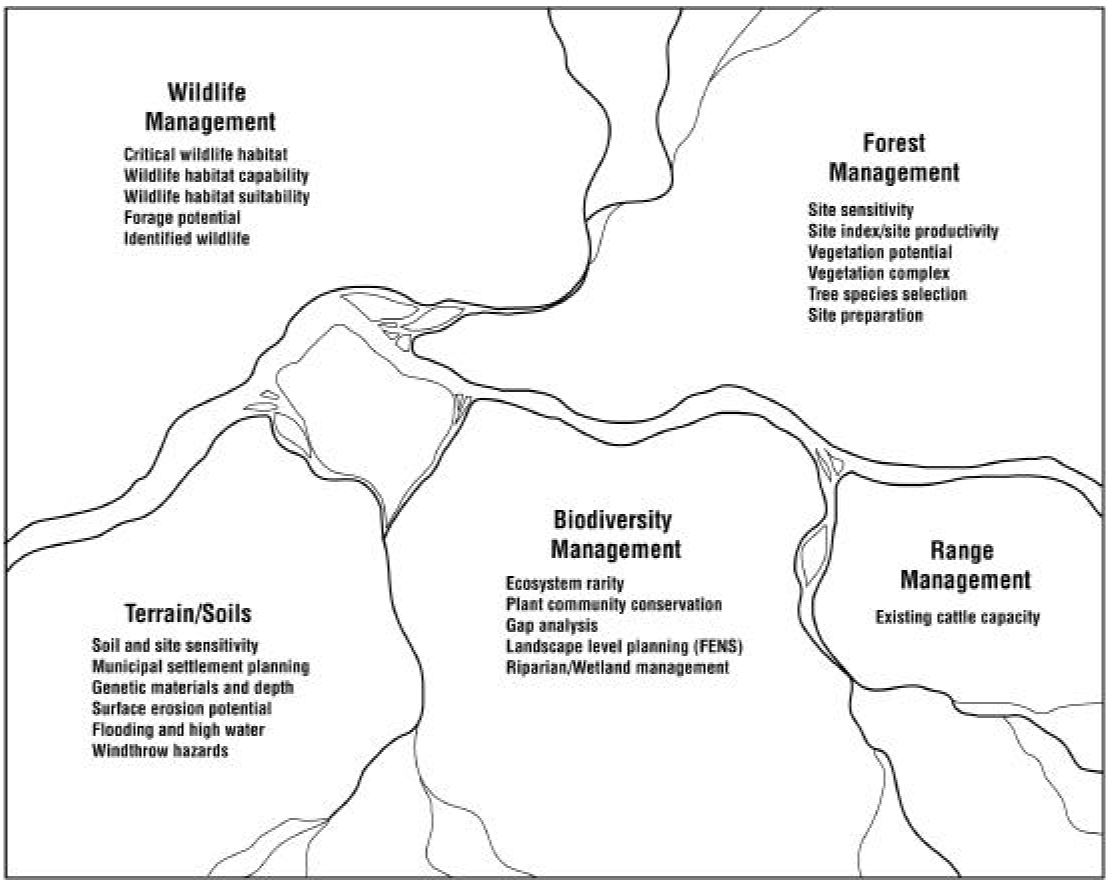


Figure 4.1 Examples of possible interpretations from ecosystem map

For each mapping project, a digital map with an associated polygon database must be produced. Some examples of polygon attributes included in the database are **polygon number**, site series, structural stage, and genetic material. The number of individual data attributes that could be recorded for each map polygon is very large, especially compared to the information actually portrayed in a map unit label. The interpretative capabilities of any given map are based on the amount of data associated with each mapped polygon. Through the use of GIS, ecosystem map units may be combined to form interpretative or treatment units, where they share similar characteristics with regard to a specific resource value or management interpretation. As well, ecosystem maps can be readily combined with other data sources (such as bedrock geology maps and soils mapping) to allow further resource interpretations.

To ensure standardization of baseline ecological information, minimum data standards (core polygon attributes) have been developed for those data attributes common to many interpretations (Table 4.1). Additional attributes may be required to make specific interpretations for a particular project. Based on discussions with potential ecosystem map users, interpretations and corresponding data attributes have also been identified and grouped into five broad subject areas: biodiversity management, terrain and soils management, forest management, range management and wildlife management. Table 4.2 provides examples of possible interpretations under each of these areas. Terrain stability mapping is not an interpretation from TEM mapping, but is a separate mapping procedure.

4.1 Core Polygon Data

The attributes listed in Table 4.1 must be recorded for each map polygon. These core attributes constitute the minimum information that must be included when 1:50 000 and larger scale ecological inventories are conducted in the province.[2] Core attributes are primarily interpreted attributes. Some, such as structural stage and a few site modifiers, can be modeled or derived from other sources. Others, such as **Project name** and ecosystem mapper are applied universally to the data file rather than interpreted for each polygon. Attributes such as ecosection and biogeoclimatic map unit designations need only be recorded once for each ecosystem map unit, while ecosystem and terrain attributes may be recorded up to three times for compound polygons.

4.2 Polygon Data for Additional Interpretations

Ecosystem mapping projects often focus on specific topics such as wildlife habitat **suitability** or forest site productivity. Ecological interpretations for such projects may require information about attributes not on the core attribute list. For example, information about **tree crown closure**, stand composition modifiers, and **site disturbance** may be required to rate habitat **capability** and suitability for certain wildlife species. These attributes would therefore have to be included in the database so that the ecosystem map could be interpreted adequately. A different data set (including soil and **humus form** attributes) would be required to determine forest **site sensitivity**.

Additional attributes that may be useful to enhance specific interpretations are presented in Table 4.2. The attributes are listed below the column heading for each particular type of interpretation. For example, detailed interpretations for **site productivity** may require information about some, or all, of the additional attributes listed under that column heading. **Wildlife suitability** and capability interpretive mapping will require a separate set of data attributes, and each species may even require different attributes. In most cases, more than one management

2 A standardized coding format for core polygon data should follow “Standards for Digital Terrestrial Ecosystem Mapping (TEM) Data Capture in British Columbia.”

interpretation will be required to meet a project's objectives. Careful planning at the outset will ensure that all necessary data attributes are collected to meet these requirements.

The lists presented in Table 4.2 provide guidelines only. An initial step in every mapping project should be to determine the desired uses of an ecological map and the interpretations required. Data attributes for specific projects should be worked out with the client and other users at the early project planning stages. Ecological mappers can choose to collect (in conjunction with the core polygon information) data for an entire subject area (e.g., forest management), or only data associated with a specific interpretation (e.g., forest site sensitivity). The data requirements should always be determined by the scope and objectives of the project.

Table 4.2 shows only a sample of potential management interpretations. The attributes included are based on our existing knowledge and understanding of ecosystem complexities. Required data attributes may also vary by region, locality, or, in the case of wildlife, by the particular species of interest. Other forestry interpretations not listed here might be pest susceptibility or potential growth-limiting factors for individual tree species. As mentioned above, selected wildlife species or species groups may also necessitate the collecting of data attributes not listed (e.g., arboreal lichen abundance, a significant forage requirement for caribou in certain areas). Other attributes and interpretations will undoubtedly be considered as we increase our knowledge of biodiversity and ecosystem dynamics.

Table 4.1 Core polygon attributes required for terrestrial ecosystem mapping

Project- or Mapsheet-Specific Attributes – repeated for all polygons

Project name
Ecosystem mapper
Terrain mapper
Survey intensity level

Polygon-Specific Attributes – unique for each polygon

Record one of each of the following elements or classes per polygon:

Mapsheet number
Polygon number
Data source
Ecosection unit
Biogeoclimatic unit (zone and subzone; variant and phase required if present)
Geomorphological processes (when present)
Soil drainages

Record up to three ecosystem and/or terrain units per polygon (see Figure 3.8):

Ecosystem attributes

- Decile
- Site series
- Site modifier(s)
- Structural stage

Terrain attributes

- Decile
- Terrain texture (optional but should be done where possible; record up to three for each component)
- Surficial material (record one for each component; could include a surficial subtype)
- Qualifiers (when present, record one for each component)
- Surface expression (record up to three for each component)

Table 4.2 Possible Terrestrial Ecosystem Mapping interpretations and the associated attributes

GENERALIZED INTERPRETATIONS	Ecosystem Representation	Plant Community Conservation	Ecosystem Rarity	Gap Analysis	Landscape planning (FENS)	Riparian & Wetland Management	Soil & Site Sensitivity	Municipal Settlement Planning	Genetic Materials & Depth	Surface Erosion Potential	Flooding & High Water	Windthrow Hazard	Recreation	Site Sensitivity	Site Index/Productivity	Vegetation Potential	Vegetation Complex	Site Preparation	Tree Species Selection	Existing Cattle Capacity	Critical Wildlife Habitat	Wildlife Capability	Wildlife Suitability	Identified Wildlife	Forage Potential
SUBJECT AREAS	Biodiversity						Terrain/Soils							Forestry						Range	Wildlife				
OPTIONAL ATTRIBUTES																									
Anthropogenic Sites'				✓	✓	✓							✓										✓	✓	
Area of Polygon	✓	✓	✓	✓	✓					✓			✓								✓	✓	✓		
Bedrock Type*					✓								✓	✓	✓								✓		
Coarse Fragments >2mm							✓			✓		✓		✓	✓	✓		✓	✓						
Coarse Woody Debris													✓					✓	✓	✓	✓	✓	✓	✓	
Composition of Leading species by Layer			✓		✓											✓	✓		✓	✓	✓			✓	
Depth of Forest Floor										✓				✓	✓	✓	✓	✓	✓						
Depth to Root Restricting Layer							✓			✓	✓	✓		✓	✓	✓	✓	✓	✓						
Depth to Water Table			✓			✓				✓	✓	✓	✓	✓	✓			✓	✓						
Ecosystem Condition	✓		✓										✓								✓				
Ecosystem Defensibility			✓										✓								✓			✓	
Ecosystem Viability			✓										✓								✓			✓	
Elevation							✓								✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Flooding Regime*			✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
Forage Species													✓								✓	✓	✓	✓	✓
Humus Form							✓							✓	✓	✓	✓	✓	✓						
Hydrogeomorphology		✓	✓	✓	✓	✓					✓			✓						✓					
Hydrologic Classification*				✓	✓		✓																		
Land Cover Classification (VRI)*													✓	✓											
Microsites (Avalanche, Cliffs, Wetlands)			✓	✓	✓			✓					✓	✓							✓	✓	✓	✓	
Moisture Regime														✓	✓	✓	✓	✓	✓	✓					
Nutrient Regime							✓							✓	✓	✓	✓	✓	✓	✓					
Partial Cover Flag (3)		✓	✓				✓			✓			✓	✓	✓		✓	✓	✓			✓	✓		✓
Plant Community	✓	✓	✓	✓	✓	✓							✓			✓	✓		✓	✓	✓	✓	✓	✓	✓
Polygon Adjacency				✓	✓								✓								✓	✓	✓	✓	
Seral Community Type													✓			✓	✓			✓	✓		✓	✓	✓
Shrub Crown Closure																✓	✓				✓		✓	✓	✓
Site Disturbance		✓	✓			✓							✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Slope										✓				✓				✓		✓		✓	✓		
Slope (Meso) Position											✓							✓		✓					
Soil Bulk Density (1)(2)							✓			✓		✓		✓	✓				✓						

5.0 Map Legends

A map legend provides a summarized description of all map unit components and map symbols, together with other supporting information including survey objectives, survey intensity, location, field sampling, other data sources, aerial photograph reference numbers, and map credits.

The recommended type of legend for terrestrial ecosystem maps has an open format and involves a list of ecosystem units and symbols that may be mapped as simple or compound map units. A large number of unique map units can potentially result from this **open legend** format. Mitchell *et al.*, (1989) present further details on open and **closed legend** formats.

As a minimum, the items described in Table 5.1 should be included in all ecosystem map legends. Figure 5.1 presents an example. The specific layout and the amount of space allocated to each category may vary by project, and other categories may be added as required (e.g., interpretive information for ecosystem units). It is important to keep in mind that the map legend should contain only summary information that is generally expanded in the report (called an "**expanded legend**") accompanying the map.

Most agencies have specific requirements as to what must be in the expanded legend. Generally, an expanded legend will contain descriptive information for each mapped ecosystem. This includes the site series name, all related coding, a description of typical environmental characteristics, and the features that characterize atypical site series as identified by the site modifiers. The expanded legend will also describe the vegetation related to structural stages and any important associated features. Presentation of the information can be in a variety of formats. Examples of expanded legends can be found on the TEM website (see Appendix B).

Table 5.1 Minimum data to be included on map legends

Item	Minimum Requirements	Comments
1. Title	Include: • Study area name • Map sheet number/s (NTS, BCGS) • Map scale • Date	Example: Ecosystem Units of the Date Creek Research Area, Prince Rupert Forest Region, portion of map sheet 93M 009 (1:20 000), February 1992
2. Introduction	Include: • Objectives of the mapping project (including interpretations to be supported by the map) • Study area • Mapping standards (include reference to this document and survey intensity level)	Sampling followed Survey Intensity Level 4 (RIC 1995).
3. Map Label Format	Provide example labels of ecosection, biogeoclimatic, and ecosystem units components, clearly indicated.	

Item	Minimum Requirements	Comments
4. Map Boundaries	Provide examples of all line types used to delineate polygons (see section 3.5), including study area boundary and sample plot locations.	
5. Ecoregion Units	List all applicable ecosections or ecoregions and their codes.	
6. Biogeo-climatic Units	List all applicable biogeoclimatic units and their codes.	
7. Site Units	Provide a description of site units, including site series names, two-letter codes and site series numbers, typical situations and moisture regime, assumed site modifiers and mapped site modifiers.	Detailed descriptions of site units should be provided in a separate report.
8. Site Modifiers	List mapped site modifier and code.	Only modifiers used in the mapping project need to be listed.
9. Structural Stages and Modifiers	List structural stages, structural stage modifiers and codes.	List and describe all structural stages, including the age criteria specific to each biogeoclimatic subzone (see Table 3.3.)
10. Data Sources	Include lists of all data sources in the project: • aerial photos (year, scale, all photo numbers, colour or black and white) • all previously available data and maps, such as forest cover, satellite imagery, base maps, etc. • percent polygons and/or ha per inspection checked • number and type of samples	
11. Credits	Include: • names of all mappers and field personnel • name of project supervisor • names of correlators and reviewers • co-ordinating and funding agencies • GIS personnel	
12. Citation	Provide the citation as it should be referenced in other reports.	

TERRESTRIAL ECOSYSTEM MAPPING OF THE PURCELL WILDERNESS CONSERVANCY
Map sheets 82K/038, 039, 040, 048, 049, 050
Scale 1:20 000
December 1998

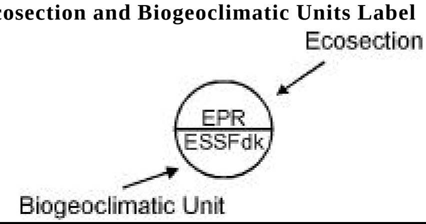
Introduction

This project provides detailed ecosystem mapping of the southeast corner of the Purcell Wilderness Conservancy, located in southeast British Columbia, east of Kootenay Lake.

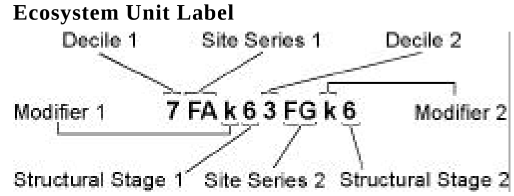
Wildlife capability and suitability mapping will be produced for grizzly bear, elk, and mountain goat. Recreation opportunity and sensitivity mapping will also be completed. Detailed ecosystem mapping will provide the frame-work for appropriate resource management for these, and other wildlife species occurring within the management zone.

Mapping was completed following the methods as outlined in Standard for Terrestrial Ecosystem Mapping in British Columbia (RIC, 1998). Fieldwork was completed in August of 1998 using survey intensity level 4.

Ecosection and Biogeoclimatic Units Label



Ecosystem Unit Label



Map Boundaries

Ecosection	▬ ▬ ▬ ▬	Study area boundary	▬▬▬▬
Biogeoclimatic Unit	────	Plot location symbol	◆
Ecosystem Unit	────		

Ecosections:

EPR: Eastern Purcell Mountains

Biogeoclimatic Units

AT	Alpine Tundra Zone
ESSFdk	Dry Cool Engelmann Spruce Subalpine Fir
ESSFdkp	Dry Cool Engelmann Spruce Subalpine Fir Parkland

Site Modifiers

Code	Criteria	Code	Criteria
c	coarse-textured soils	m	medium-textured soils
d	deep soils (> 100 cm to bedrock)	p	peaty material
f	fine-textured soils	s	shallow soils (20-100 cm to bedrock)
j	gentle slope (slope <25%)	v	very shallow (< 20 cm to bedrock)
k	cool aspect (285°–135°, slope >25%)	w	warm aspect (135°–285°, slope >25%)

Structural Stage

Code	Structural Stage
1	Sparse/Bryoid
2	Herb
2d	Dwarf Shrub
3	Shrub/Herb
3a	Low Shrub
3b	Tall Shrub
4	Pole/Sapling
5	Young Forest (generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions.)
6	Mature Forest (ESSFdk is Group A, 80-140 yrs).
7	Old Forest (ESSFdk is Group A, >140 yrs).

Stand Composition

Code	Description
C	coniferous
B	broadleaf
M	mixed

Structural Stage Modifiers

s	single-storied
t	two-storied
m	multistoried
i	irregular
h	shelterwood

Figure 5.1 Example of Map Legend

Ecosystem Units

AT Alpine Tundra Zone

Map Code	Site Series #	Site Series Name[1]	Assumed Modifiers	Typical Conditions	Moisture Regime	Mapped Modifiers
AW	00	White mountain avens–Snow willow	j	gentle to moderate slopes	mesic	k, s, w
HP	00	Heather–Woolly pussytoes	j	gentle to moderate slopes	submesic	c, s, w
SP	00	Black alpine sedge–Woolly pussytoes	j	moderate slopes, receiving sites	subhygric	k, w

ESSFdk Dry Cool Engelmann Spruce Subalpine Fir

Map Code	Site Series #	Site Series Name[1]	Assumed Modifiers	Typical Conditions	Moisture Regime	Mapped Modifiers
DM	02	Fd–Douglas maple–Soopolallie	d, m, w	significant slope, warm aspect, deep med-textured soils	xeric – subxeric	s
FA	01	Bl–Azalea–Foamflower	d, j, m	gentle slope, deep, med-textured soils	mesic	c, f, k, s
FG	03	Bl–Azalea–Grouseberry	d, j, m	gentle, deep, med-textured, non-calcareous soils	subxeric–mesic	c, k, v
FH	06	Bl–Azalea–Horsetail	d, j, m	gentle to level slope, receiving sites, deep med-textured soils	subhygric–hygric	c, f
FM	05	Bl–Azalea–Step moss	d, j, m	gentle, lower slope, moisture receiving, med-textured soils	subhygric	c, f, k
FS	04	Bl–Azalea–Soopolallie	d, j, m	gentle slope, deep, med-textured, calcareous soils	submesic–mesic	c
WS	07	Willow–Sedge	d, j, m	mineral wetland, deep med-textured soils	subhydric	f, p

ESSFdkp Dry Cool Engelmann Spruce Subalpine Fir Parkland

Map Code	Site Series #	Site Series Name[1]	Assumed Modifiers	Typical Conditions	Moisture Regime	Mapped Modifiers
FV	00	Subalpine-fir–Willow–Sitka valerian		steep slopes, snow avalanched	mesic–subhygric	j, k, w
HP	00	Heather–Woolly pussytoes	d, j, m	gentle slopes, deep med-textured soils	submesic	k, w
WC	00	Willow–Cinquefoil	j	gentle slopes, receiving sites	subhygric	k, w

[1] Includes unclassified ecosystem units

Data Sources

This mapping project is based on 1:20 000 black and white stereo aerial photography from Geographic Data BC taken in June of 1994. Base map is from Terrain Resource Inventory Mapping (TRIM) from Geographic Data BC Forest cover maps (1994) from the Ministry of Forests, Nelson Region. A total of 22% polygon inspection was achieved. 27 full plots 107 ground inspections and 400 visual checks were completed.

Credits

Mapped by Jill Forest and Jack Moss of Moss Mapping Limited, Pemberton, BC. Field data collection: Jill Forest, Jack Moss, Tom Hawthorne, Roberta Wolfe. Project supervisor: Roberta Wolfe. GIS personnel: Cynthia Smith. Correlation and Edit by: D.R. Brown and R.K. Bark, Resources Inventory Branch, Ministry of Environment, Lands & Parks, Victoria, BC. Funding provided by Forest Renewal British Columbia (FRBC), the Ministry of Environment, Lands & Parks, Nelson Region, and SPRUCE TREES, Kootenay Division.

Citation

Forest, J. & J. Moss. 1998. Ecosystem Mapping of the Purcell Wilderness Conservancy. Prepared for BC Environment, Nelson Region, in partnership with FRBC and SPRUCE TREES, Kootenay Div. 6, 1:20 000 Maps.

Figure 5.1 Example of Map Legend (cont.)

6.0 Mapping and Field Survey Procedures

Outlined here are the major steps required to develop an ecosystem map, from the project planning stage to production of the final map (Figure 6.1). Clearly understanding and adhering to all of these steps is critical to ensure the final map and interpretative products meet the project objectives, fulfill the needs of clients, and conform to provincial standards.

6.1 Project Planning

Project planning is the most important step in a mapping and inventory project. It sets the scene for the entire mapping project from defining objectives for the study and ensuring the involvement of all necessary individuals and clients, to determining what map and interpretative products are needed and deciding how those will be achieved.

6.1.1 Defining objectives and developing a working plan

The following guidelines can help the mapper develop a work plan for a mapping project:

- Define the purpose and objectives of the project.
- Determine the products required by clients (e.g., maps, interpretations, reports, legends, database, summary statistics, etc.).
- Plot study area boundaries on an overview map.
- Determine the scale and survey intensity level to use.
- Develop sampling plan.
- Determine the attributes to be collected and mapped.
- Determine project personnel, budgets, and scheduling of fieldwork and product completion.
- Determine GIS/digital requirements.
- Follow provincial standards set out for data collection, classification, mapping and presentation.

Objectives of a mapping project should be determined through co-ordination and consultation with clients, regional and provincial co-ordinators, and the mapping team. The objectives of an ecosystem mapping project need to be clearly defined and documented, to ensure they address the specific needs of the clients and meet provincial mapping standards. Well-defined objectives serve as benchmarks for contract managers and mapping personnel.

Once survey objectives are defined, a decision about scale of mapping and survey intensity must be made. Both must ensure that a balance is achieved between the desired map product and available budget. Section 6.3.1 provides some guidelines for determining appropriate survey intensity levels for ecosystem mapping.

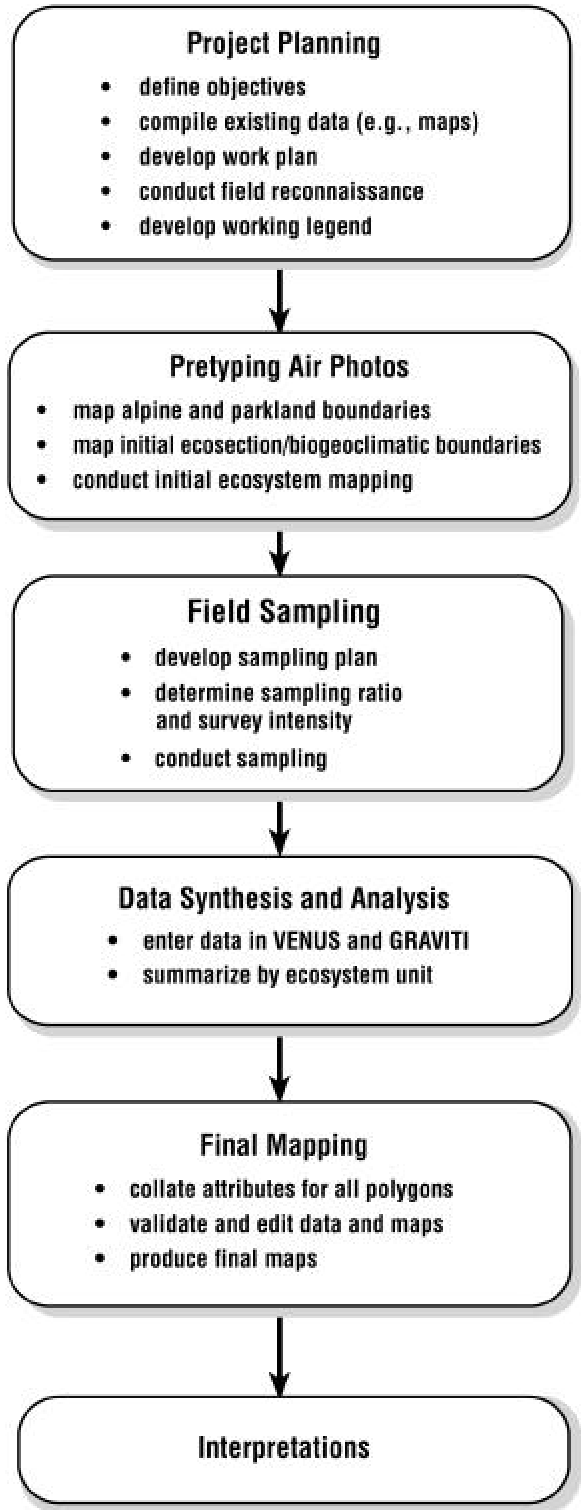


Figure 6.1 Summary of mapping and field survey procedures

6.1.2 Compiling existing data

The following guidelines can help the mapper compile existing data for a study area:

- Determine what resource information and maps exist for the study area and adjacent areas, and assess their utility.
- Determine the appropriate base map to use (keeping in mind that TRIM is the preferred base where available).
- Review available aerial photography and obtain photographs that provide the appropriate scale, coverage, and quality.
- Review ecosystem classification and data relevant to the study area, including its ecoregion and biogeoclimatic classification (using appropriate regional field guides).
- Contact the Ministry of Forests Regional Ecologist for assistance in understanding the distinguishing characteristics between biogeoclimatic units and similar site series, and in understanding how well defined the ecosystem classification is for the study area.

After an area has been selected for ecosystem mapping, all relevant map and point source data must be compiled. This should include information on vegetation ecology, climate, forest cover, **Vegetation Resource Inventory** (if available), bedrock and surficial geology, soils, hydrology, satellite imagery, topography, and other resource information required to serve the objectives of the project. Appendix B outlines the common data sources available and where they may be obtained.

Aerial photographs, of the kind and scale specified in the work plan, must be obtained. It is preferable to have photographs that are equal to, or larger than, the scale at which the final map will be presented. Data points should be transferred from previous ecological sampling to the alternate (non-typed) aerial photographs. Adjacent mapping projects of similar methodology and scale should be reviewed and, if appropriate, the borders matched between the two study areas. Satellite imagery can provide additional overview information of the types of landscapes and general vegetation cover present in the study area.

6.1.3 Conducting field reconnaissance

A field reconnaissance is essential to begin establishing relationships between aerial photograph features and ecosystem characteristics on the ground. Field reconnaissance should be carried out after all relevant information has been collated and aerial photos have been obtained. Field reconnaissance gives the mapper time to develop a preliminary understanding of:

- ecosystem (site series) distribution and observable landscape features in the study area (e.g., microclimate effects, soils, bedrock geology, surficial geology, vegetation succession, disturbance history);
- biogeoclimatic and ecoregion relationships in the study area;
- relationships between aerial photograph features and ground features; and
- access and logistics for field sampling.

The reconnaissance is also an opportunity for obtaining information on ecological classification and sampling requirements and planning the tentative location of sampling transects. Some aerial photo **pre-typing** is necessary before field reconnaissance (see section 6.2).

The project objectives and working plan may have to be adjusted depending on the complexity initially observed. It is important that the entire mapping team take part in the initial reconnaissance so that members can correlate observations of **ecological processes** in the study area. Even in remote areas where access is difficult and costly, field reconnaissance is recommended.

6.1.4 Developing the working legend

The following guidelines can help the mapper create a **working legend**:

- Develop an initial list of ecosystem units (site series, site modifiers, structural stages, etc.) present or expected in a study area, and identify their relationships to topographic and terrain features in the area.
- Complete landscape sketches, portraying ecosystem and landform relationships, to help develop mapping concepts and ensure consistency in mapping.
- Initiate discussions with Regional Ecologists regarding existing ecological classification and defining new units for study area.

Field reconnaissance and pre-typing provide the basis for development of the working legend. Once the field reconnaissance has been completed, a tentative legend can be established, linking ecosystem units to recognizable terrain, landscape, and biological characteristics. These include such terrain and landscape attributes as surficial material and surface expression, soil drainage, **soil depth**, **slope**, aspect, and **slope position**, and such biological characteristics as overstory tree species and stand density. The working legend should list all ecosystem units that are expected to occur in the study area, and should include codes and names (Table 6.1).

Table 6.1 Example working legend for mapping ecosystem units

ECOSECTION	BIOGEOCLIMATIC UNIT	BIOTERRAIN				ECOSYSTEM UNIT
		Landscape Position	Surficial Material	Soil Depth/Texture/Drainage		
SOB	*BGxh1*	Level areas	Floodplain			CD
Southern Okanogan Basin	Okanagan Very Dry Hot Bunchgrass		Terrace	Coarse-textured		AN SWc PA
				Medium-textured		SW
				Fine-textured		SWf
			Organic			*not defined*
		Moderate Slopes	Moraine	Average Moisture	Fine-textured	SWf
					Medium-textured	SW
					Coarse-textured	SWc
				Moist		PR
			Colluvium	Deep		SW
				Shallow		WS
				Very Shallow		WSv
			Glaciofluvial	Coarse-textured		SWc
				Medium-textured		SW
			Glaciofluvial	Deep		ANw
				Shallow		WSw
			Colluvial	Deep		SWw
		Steep Southerly Slopes		Shallow		WSw
			Moraine	Shallow		WSw
				Deep		SWw
				Shallow		WSw
		Steep Northerly Aspect	Colluvial			SWk SWck PWk PWck
			Glaciofluvial			ANk SWck
			Moraine			SWk

6.2 Pre-typing of Aerial Photographs

Production of an ecosystem map begins with the pre-typing of aerial photographs. The procedure, which should involve all members of a mapping team, is the first step in helping the team understand the ecosystem/terrain/topography relationships within the study area. Some pre-typing should be completed before field reconnaissance, to clarify relationships between photo and ground features (see sections 6.1.3 and 6.1.4). The remaining aerial photos should be typed before field sampling begins. Where mapping that follows the same standards and scale has been previously completed on adjacent areas, the aerial photos from that project should be obtained and border-matched with the new typing.

6.2.1 Conducting initial ecoregion/biogeoclimatic mapping

Existing ecoregion and biogeoclimatic maps and reports should be consulted during the pre-typing stage, and the latest biogeoclimatic line work should be redrawn at the project map scale, using elevational models and obvious east–west or north–south boundaries. Regional Ecologists should be consulted to ensure that up-to-date information is being used. Because it is often very difficult to accurately delineate ecoregion and biogeoclimatic unit boundaries on aerial photos, the final mapping of most of these boundaries is usually done after field work is complete.

At the pre-typing stage, Alpine Tundra and subalpine parkland boundaries and approximate boundaries for the other biogeoclimatic units are mapped on aerial photos. The Alpine Tundra and subalpine parkland lines should be drawn before ecosystem map units are delineated. This provides an initial boundary from which the other ecosystem map units can then be drawn. Other biogeoclimatic map unit boundaries can be drawn either on the typed or non-typed photos, using a different colour than the ecosystem map units. These boundaries will need to be confirmed in the field and finalized after fieldwork.

Delineating Alpine Tundra zone

By definition, the Alpine Tundra zone has alpine vegetation on zonal sites. The Alpine Tundra zone boundary is usually the upper elevation of discontinuous forest (parkland, including **krummholz**) or in the case of the Spruce–Willow–Birch (SWB) zone, the upper elevational limit of extensive deciduous scrub (which is considered to be subalpine vegetation). The alpine boundary will have to be generalized at a consistent elevation (varying with aspect), because **cliffs**, rock outcrops, and avalanche chutes often dissect the alpine/subalpine transition (e.g., shrubby avalanche chutes are common in wetter subalpine forested subzones). Trees in krummholz form (prostrate or low in stature) may occur in the alpine zone, but they are of very low cover. Some larger krummholz patches may occur in sheltered, non-zonal sites. The placement of the Alpine Tundra zone boundary is shown in Figure 6.2. Glaciers are considered to be in the biogeoclimatic zone that is expected at that elevation (e.g., glaciers often extend into the subalpine and lower elevations).

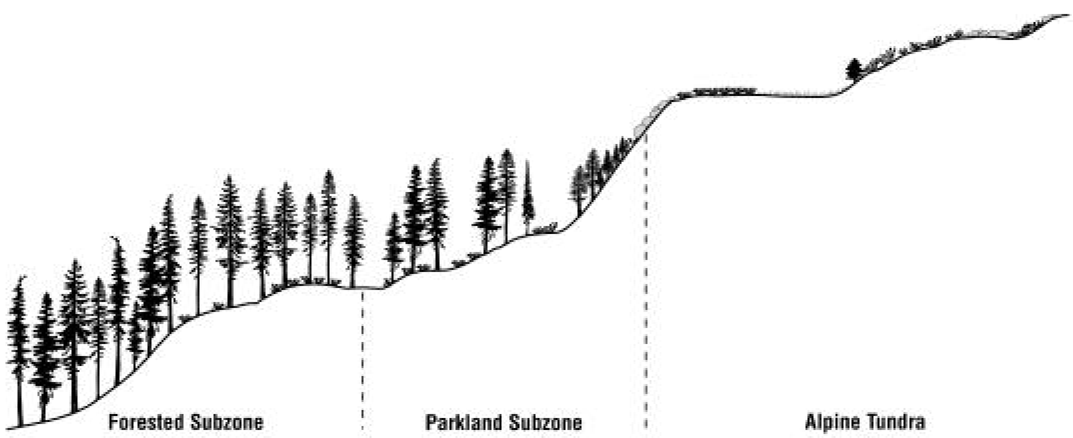


Figure 6.2 Delineation of Alpine Tundra and parkland subzone

Delineating subalpine parkland

Where possible, parkland subzones of the Mountain Hemlock and Engelmann Spruce–Subalpine Fir and scrub subzones of the Spruce–Willow–Birch zones should be mapped. They are recognized as a distinct elevational transition from closed or continuous forest to the treeless Alpine Tundra. Parkland is characterized by forest clumps interspersed with open subalpine meadows, shrub thickets, and krummholz (Figure 6.2). However, parkland varies in the proportion of treed patches versus open vegetation. It is often discontinuous and intermixed with rock outcrops, cliffs, or talus. Recognition of a distinct parkland subzone is most obvious in gently rising plateau areas or rounded mountains of relatively gentle relief (e.g., the Quesnel Highlands). As with alpine, the parkland boundary will have to be generalized at a consistent elevation.

In some areas, especially steep-sided coastal valleys, it is difficult to map subalpine parkland subzones as continuous elevational bands. Parkland in these areas is very narrow and discontinuous, and often dominated by sparsely vegetated ecosystems. In these cases, the entire subalpine subzone would be mapped as forested. Parkland-like ecosystems could then be delineated within the forested subzone as ecosystem units. For example, the biogeoclimatic unit could be designated as MHmm1 (implying that it is a forested unit), but much of the area mapped is sparsely vegetated rock, cliffs, and talus interspersed with patches of forest and heath. In such areas, tree growth is limited more by substrate (steep terrain and lack of soil) than by climate.

Even where a parkland subzone is mapped, parkland-like ecosystems may also occur in the forested subzone below, in areas (such as cirque basins) that receive cold air drainage, or in areas that have long snow duration and wet soils. These non-forested meadow and shrub communities, interspersed with forest patches, should be mapped as parkland-like ecosystem units within the forested subzone; the parkland subzone boundary should not be brought down in elevation to include these ecosystems.

6.2.2 Conducting initial ecosystem mapping

Terrestrial ecosystem mapping integrates vegetation, terrain (surficial geology), and soil features, both in terms of delineation criteria and database attributes. This "bioterrain" approach results in map units that portray ecosystem units (site series, site modifiers and structural stages) with their associated terrain attributes (genetic material, surface expression, **qualifiers**, geomorphological process, soil drainage).

The interpretative value that results from this bioterrain approach to ecosystem mapping is greatly increased over that of a pure vegetation, soils or terrain map. Since many terrain and landscape features correlate well with ecosystem properties, ecosystem polygons are delineated on aerial photos using a combination of recognizable permanent terrain and landscape features, biological characteristics, and inferences related to significant changes in the landscape (Figure 6.3). Refer to Table 6.2 for further explanation of delineation criteria. The resulting ecosystem map units can be developed in various ways, depending on the experience of the mappers, but polygon delineation is most effectively carried out using an interdisciplinary approach.

In order to develop a common understanding of ecosystem/terrain/landscape relationships, it is essential that the mapping team, usually composed of a vegetation ecologist and terrain/soil specialist, work together on representative photographs. Delineation can then be carried out by either specialist, in a consistent manner, as long as feedback occurs throughout the rest of the pre-typing process.

A useful approach to the initial pre-typing of photographs is to mentally divide the study area into broad landscape areas that have similar, repeatable map units and relationships (Figure 6.4). These areas can be determined from the working legend and consideration of ecosystem/site relationships in broad landscapes such as alpine, mountain slopes, valley floors, plateaus and plains. This frames the mapping process before more detailed terrain and vegetation features are considered.

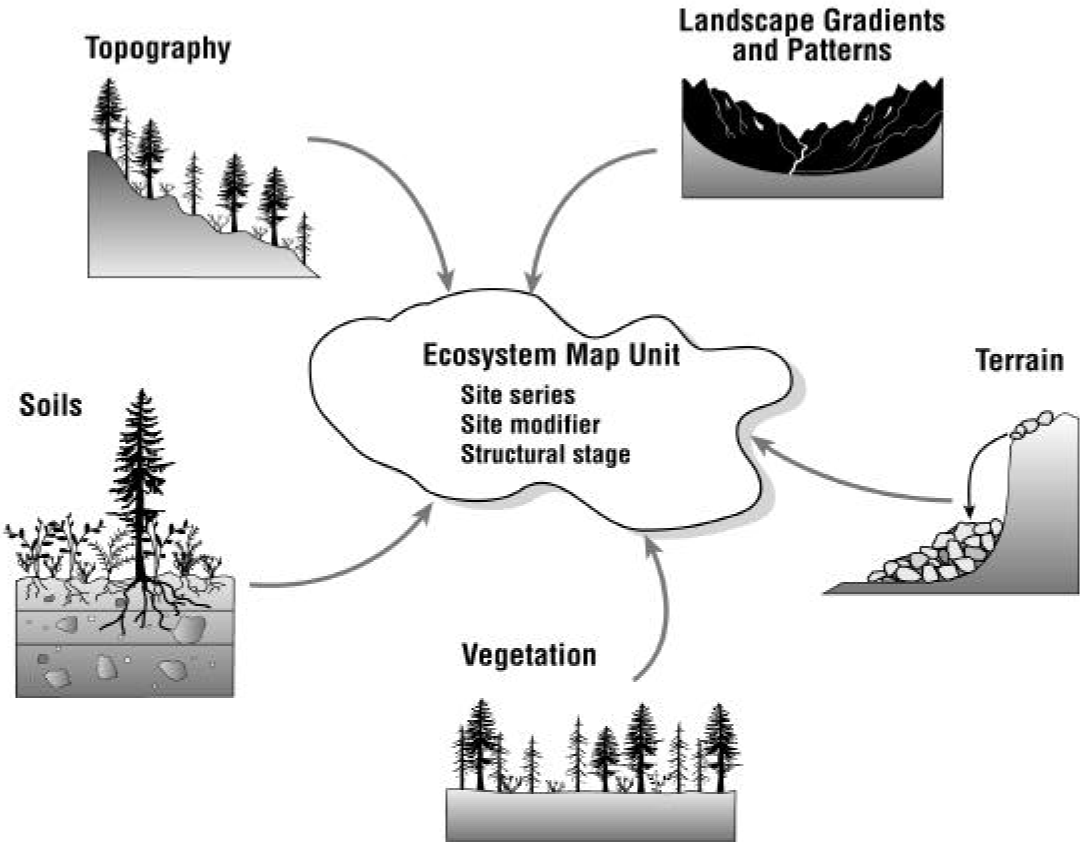


Figure 6.3 Integrated delineation criteria for developing Ecosystem Map Unit polygons.

Table 6.2 outlines the main criteria that should be used to delineate ecological polygons and assign core ecosystem and terrain attributes for ecosystem map units. Note that individual polygon attributes (e.g., site series, structural stage) are interpreted from one to many physical or biological criteria (e.g., slope position, vegetation composition and structure) that are either directly observable on the photo (e.g., slope position) or inferred from visual photo features or characteristics (e.g., vegetation composition and structure are inferred from tone, texture, colour, shape, pattern). The assessment of any one attribute is thus an integrated process, whereby many criteria are being observed and processed simultaneously in order to predict the attribute. Depending on the survey intensity level, a portion of the polygons will eventually have their attributes confirmed through ground sampling.

An attempt should be made to consider all of the criteria from Table 6.2. As mappers gain greater experience, this will become second nature. Other useful aids to aerial photo interpretation are the *Vegetation Resources Inventory Photo Interpretation Procedures Manual* (RIC 1997c), Howes and Kenk (1997), and Keser (1982).

Photo criteria can be integrated in many different ways, depending on the experience and background of the mapper. Some ecosystem or terrain boundaries, such as the edge of a floodplain or terrace, may be sharp (or “hard”) and clearly defined; other boundaries may be gradational (or “soft”). The latter can be determined by combining attributes of the ecosystems themselves with presumed terrain unit boundary features. The question of whether to lump or split polygons (e.g., to add or omit a boundary) is largely a matter of judgment, scale of mapping, and project objectives. Thus, if two or more experienced mappers were to independently map the same area, some boundary positions would correspond exactly, some would be fairly similar, and some would differ markedly. For example, a mature, coniferous forest on an active floodplain in the SBS biogeoclimatic zone, representing a Spruce–Horsetail site series, would be delineated in likely the same way by different mappers. However, the extent of the same site series occurring on subdued morainal terrain in the SBS might only be detected through a mapper recognizing subtle differences in species composition, crown closure, stand age, structure, and landscape characteristics. Interpretations of these criteria would vary among mappers as would polygon delineations.

The mapping team must work out how it will approach these less well-defined areas, to ensure a consistent approach to mapping is used. Where possible, the mappers should first delineate the hard terrain boundaries (these, in most cases, will coincide with ecosystem boundaries). Soft terrain boundaries can then be located either where there are subtle changes in the physical conditions that influence ecosystems (such as surface expression, soil drainage, and geomorphological processes) or where there is a vegetation change suggesting a change in ecosystem unit.

During the pre-typing phase, mappers should label map units with initial terrain and soil drainage symbols (using deciles) following Howes and Kenk (1997). They should also indicate ecosystem attributes (e.g., one to three ecosystem units) for a considerable portion of the project area. However, if they are limited by time or a lack of familiarity with the ecosystems in the map area, some mappers may only pre-type polygons with terrain labels. When this approach is taken, it is recommended that some attempt to label ecosystem map units for a portion of the study area be completed before field sampling, so that relationships of ecosystems to terrain attributes can be assessed in the field. The preferred system is to start with field reconnaissance so that initial ecosystem map units can be assigned to most polygons at the pre-typing stage.

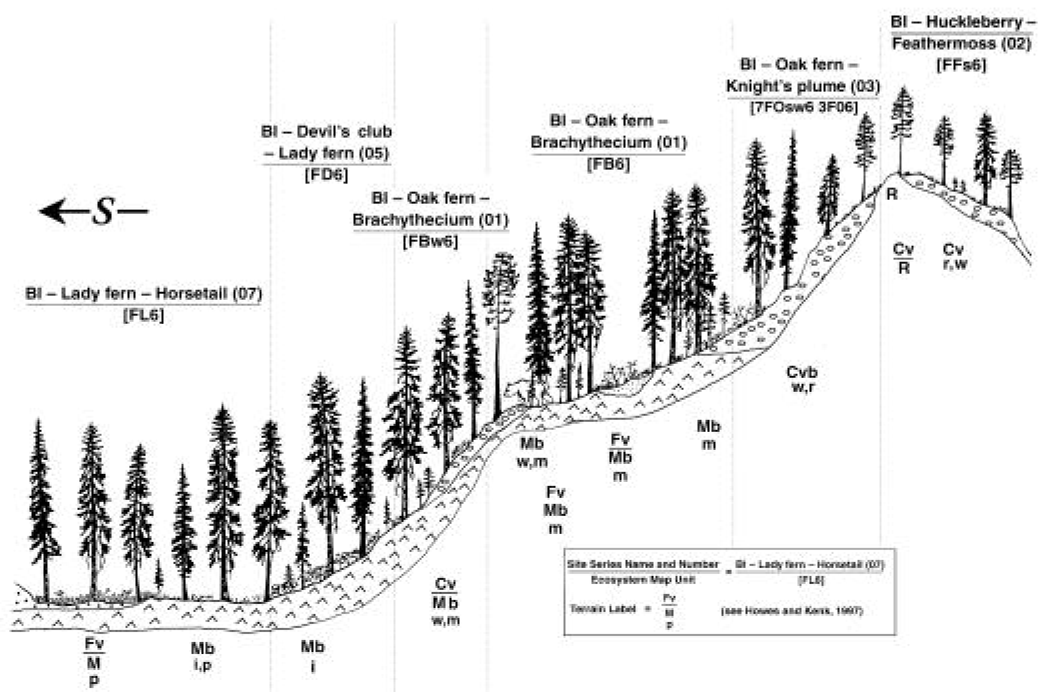


Figure 6.4 A landscape profile for the ESSFwk1.

Table 6.2 Criteria for delineating ecosystem map units on aerial photographs[1]

Criteria	Observable Feature/ Photo Characteristic	Applicable Mapped Attribute
Vegetation		
Tree species composition	Tone, texture, colour, size, shape, shadow	Site series[2], structural stage (seral community type)
Understory or non-forested vegetation composition or characteristics	Tone, texture, colour,	Site series, structural stage (seral community type)
Canopy characteristics (including crown closure)	Tone, texture, colour, shape, shadow, size, pattern (open, closed, layered, clumpy)	Site series, structural stage (seral community type)
Height of stand (relative productivity)	Texture, size, pattern, tone, density	Site series, structural stage (seral community type)
Topography		
Landscape position and shape	Shape and three dimensional characteristics	Site series, site modifier, soil drainage
Aspect	Shape, three dimensional characteristics and direction	Site series, site modifier
Slope	Shape and three dimensional characteristics	Site series, site modifier, soil drainage
Drainage pattern	Shape, pattern and three dimensional characteristics	Site series, site modifier, soil drainage
Terrain		
Landform/parent material including surface expression, qualifiers, terrain texture (e.g., active processes)	Topographic position, observable drainage and terrain patterns, shape, topography, tone, colour (disturbance)	Inferred terrain texture, genetic material, surface expression, qualifiers, site series, site modifier, soil drainage
Geomorphological process	Patterns	Geomorphological process, site series, site modifier
Soils		
Soil drainage	Tone, drainage patterns, topography	Soil drainage, site series, site modifier
Soil depth	Colour, tone, texture, topography	Soil drainage, site series, site modifier
Gradients/Patterns		
Relationship to other map units	Pattern, juxtaposition, size and edges	Various
Adjacent map units	Pattern, juxtaposition, shape and edges	Various
Polygon shape and orientation	Pattern, juxtaposition, shape, edges and direction	Various

1 Refer to *Vegetation Resources Inventory Photo Interpretation Procedures Manual* (RIC, 1997c) for more information on interpreting physical and biological attributes from aerial photographs.
2 Criteria used for site series assessment are by default also used for assessment of soil moisture and nutrient regimes, but these are not core attributes.

During pre-typing, structural stages may be interpreted from aerial photographs or taken from other sources such as forest cover (or Vegetation Resource Inventory) maps, or a combination of these two methods. The best approach should be determined by the date that the aerial photographs were taken and by whether major disturbances have occurred since then.

The mapper should use judgment in delineating small polygons and should limit the complexity of polygon symbols, so that the mapping on the photos remains neat and legible. Photo interpretation is a skill that improves only with much practice, particularly in combination with ground truthing to calibrate the eyes. The mapper needs to develop a mental model of how all the pieces of information relate to the ecosystems that actually occur on the ground (Figure 6.3). This model will have to be "recalibrated" for each new study area, as well as for each biogeoclimatic unit within a study area. These relationships are developed throughout all stages of the project, from initial reconnaissance, and pre-typing, through field sampling and on to final typing and labelling.

6.3 Field Sampling

Sampling is required to confirm ecosystem and terrain map unit designations and boundaries, to collect data for ecosystem descriptions in reports, and to develop or refine the classification of ecosystem units. Sample types can be of varying detail, depending on their purpose. The intensity of sampling should be related to project objectives and funding. Sample transects and plots provide site-specific information on the distribution and characteristics of plant communities, landforms/parent materials, soils, and on the interrelationships among these ecosystem components. This information can then be used to interpret ecosystem relationships in the areas or polygons not sampled.

Determining sample intensity, sample detail, and location of transects and sample points is discussed in this section.

6.3.1 Establishing survey intensity

Survey intensity is a measure of sampling density and can be characterized either as the percentage of polygons that have been field inspected, or as the actual density of field inspections on an area basis (hectares per field inspection). Table 6.3 defines six survey intensity levels for ecosystem mapping and some of the factors to consider when planning a mapping project. Table 6.4 translates each of the survey intensity/map scale combinations into actual field inspection densities (hectares per field inspection). The table can be used to estimate how many field inspections would be required for study areas of various sizes, to meet each of the survey intensity level requirements. Basing field sampling requirements on minimum density values rather than polygon inspection percentages is recommended, because the total number of polygons is usually not known until after field sampling.

Table 6.3 Survey intensity levels for ecosystem mapping

Survey Intensity Level	Percentage of Polygon Inspections	Ratio of Full Plots: Ground Insp.: Visual Checks[1]	Suggested Scales (K =1000)	Area Covered by 0.5 cm^2	Range of Study Area (ha)	Interpretation Examples
1	**76–100%**	2 : 15 : 83	1:5 K to 1:10 K	0.25–0.5 ha	20–500	Site specific silviculture prescription; **soil sensitivity** to erosion, **soil compaction**, etc.
2	**51–75%**	3 : 17 : 80	1:10 K to 1:20 K	0.5–2 ha	100–10 000	Silviculture planning; **tree species selection**.
3	**26–50%**	5 : 20 : 75	1:10 K to 1:50 K	0.5–12.5 ha	5 000–50 000	Vegetation potential; forest productivity; habitat enhancement prescriptions.
4[2]	**15 – 25%**	5 : 20 : 75	1:20 K to 1:50 K	2–12.5 ha	10 000–500 000	Forestry, wildlife capability; ecosystem representation; general forest productivity; local resource planning; landscape management planning.
5[3]	**5–14%**	5 : 20 : 75	1:20 K to 1:50 K	2–12.5 ha	10 000–1 000 000	Forestry, wildlife capability; ecosystem representation; general forest productivity; local resource planning; landscape management planning.
R[3,4]	**0–4%**	0 : 25 : 75	1:20 K to 1:50 K	12.5–306 ha	50 000–1 000 000 +	Regional planning; broad landscape management planning.

[1] Inspection ratios are guidelines; actual project ratio should be set by project ecologists responsible for administering project.
[2] Survey intensity level recommended for most mapping. This provides a reasonable balance of cost and reliability.
[3] Survey intensity level recommended when Level 4 is too costly and lower reliability is acceptable.
[4] Level R (reconnaissance) ecosystem mapping should only be conducted by ecologists who have considerable field experience in the ecosystems of the study area.

Table 6.4 Field inspection density for selected survey intensity/map scale combinations

Survey intensity level[1]	Hectares per inspection 1:5000 (940 ha/sheet)	1:10 000 (3800 ha/sheet)	1:20 000 (15 100 ha/sheet)	1:50 000 (60 400 ha/sheet[2])
1	0.9–1.2	3.8–5	15–19	91–120
2	1.3–1.8	5.1–9	20–29	121–178
3	1.9–3.7	8–14	30–59	182–350
4	3.8–6.3	15–25	60–100	364–607
5	6.4–19	26–76	101–302	650–1820
R	18–94+	77–370+	303–1500+	2275–9100+

1 Values are guidelines only and are based on an average polygon size of 3–4 cm^2. Mapsheet areas and hectares per field inspection are based on an average map size; actual values will vary somewhat, depending on latitude.
2 Based on new 1:50 000 mapsheets (blocks of four 1:20 000 maps)

The survey intensity used in the preparation of an ecosystem map should be determined by project objectives and the proposed use of the map. If the map is to be used for making specific management decisions about portions of land (e.g., soil sensitivity to harvesting equipment, **site preparation** options, **tree species selection**), then the map needs to be very reliable. Increased reliability is usually achieved through a higher survey intensity and selection of a larger map scale. However, both of these factors increase the cost of the mapping project. If the map is to be used only for general land planning, then a lower survey intensity is appropriate and mapping can be done at a smaller scale. A low survey intensity does not necessarily mean that a map will be less reliable, although this is generally the case. Other factors influencing reliability are ecosystem complexity, relationship of ecological variation to readily identifiable aerial photo attributes, and surveyor knowledge and experience.

For example, in balancing cost and reliability of ecosystem mapping for landscape planning and **wildlife capability**/suitability, it is recommended that most mapping be conducted at level 4. The appropriate scale would be 1:20 000 or 1:50 000, depending on the complexity of ecosystems and the requirement for accuracy. At 1:20 000, this translates into a minimum of one inspection per 100 ha. If a lower cost and reliability is acceptable to the user, ecosystem mapping at level 5 or level R could be conducted.

Survey intensity level is not always related to scale; any intensity level can be conducted at any scale. However, smaller scale maps are generally used for land management planning and the higher costs of a more intense survey level are not usually warranted for broad management planning. Table 6.3 includes scale as a guide only to determine intensity level.

Another consideration in selecting mapping scale is the scale of the aerial photographs and other imagery to be used. The final map scale should not be significantly larger than the photo scale, as it will be difficult (maybe even impossible) to recognize and delineate small ecosystems on the photos that should be delineated at the map scale.

6.3.2 Designing a sampling plan

A sampling plan is critical for focusing field work during brief sampling periods, and helps ensure that sampling occurs where it should. Field work is costly but important. Well-planned field sampling is more cost-effective and productive and results in more reliable map products.

In preparing a sampling plan, the mapper should consider the following elements for the study area:

- Size of study area
- Topography
- Previous ecological sampling (number, type, and location)
- Existing information (e.g., biogeoclimatic units, site series classification, adjacent ecosystem mapping, geology, terrain, and soils)
- Additional data collection requirements for samples (e.g., wildlife, coarse woody debris, mensuration, range) and polygon database attributes
- Interpretations to be produced from the mapping
- Survey intensity level
- Sampling ratio of full plots, ground inspections, and visual checks
- Possibility for "new" site units
- Access (using topographic, forest **recreation**, forest cover, and forest development maps, recent aerial photos, latest access information from Ministry of Forests District Office)
- Questions from pre-typing or development of working legend
- Knowledge level and experience of field crews and mappers in the ecosystems of the area.

The sampling plan needs to integrate this known information to design field transects and demarcate potential sample plot locations. This will ensure that the project objectives are met, plots and inspections are well distributed and focused on objectives, and enough information will be compiled to finalize the pre-typing of the aerial photos.

A useful procedure to developing a sampling plan is to assess how all the above elements might affect the number and location of plots and inspections, and then start compiling the information on a set of maps at a smaller scale than the final mapping is to be (e.g., 1:50 000 or 1:100 000). All known information that can be displayed at the map scale should be mapped (e.g., ecosection boundaries, biogeoclimatic subzone/variant boundaries, roads, helicopter access points, bedrock geology, areas of "uncommon" structural stages or site conditions, existing plots). From this summary and evaluation, development of the sampling plan can begin.

Various sampling designs are possible for confirming and refining the pre-typing of polygons (see Forbes *et al.*, 1982; Gillison and Brewer, 1985; Valentine, 1986; Mitchell *et al.*, 1989). However, the most commonly used method of sampling in ecosystem mapping projects is the establishment of field inspections along transects. The transects can be randomly located, but are more often selected to cover the greatest number and variety of polygons in the least amount of field time. Sample points can be established systematically, at set distances along a transect, but are generally established subjectively.

Clear objectives for all field inspections should be articulated in the sampling plan. Some inspections may be to sample homogeneous areas for descriptive purposes, others to assess polygon boundaries, or assess ecosystem unit proportions within polygons. Because of their cost, detailed plots and ground inspections should focus on uniform sites within polygons and avoid transitional areas. Sampling at slope, moisture, or soil boundaries makes it very difficult to ascertain ecological determining factors, unless numerous plots are established systematically across the gradient. Visual checks can be planned to assess boundaries, confirm questionable areas from photo interpretation, or do whatever is necessary to confirm ecosystem designations and to meet project objectives. Again, it is best to have some focus for all plot inspections so that field crews are clear about their sampling objectives.

Sampling is required to characterize common and widespread ecosystem units, as well as those units that occur infrequently, such as wetlands and **riparian ecosystems**. Sampling intensity may consider the relative confidence in local biogeoclimatic mapping or focus on site series that are difficult to identify at the pre-typing phase. Intensive sampling may be done in ecosystems that are considered more valuable or more sensitive than others. For example, in a range mapping project, more sampling may have to be done in productive grassland communities and in forests with open canopies and higher forage values. Similarly, for wildlife studies, areas that are known winter ranges or are important for biological diversity (such as riparian ecosystems) may require more intensive sampling.

Using the set of maps with the compilation of resource information, and with the objectives of each of the sample types clearly articulated, the mapper should then plan where the transects will be located. It is important to keep in mind that the sampling plan is only a plan—improvisation in the field will be required, as some transects may not sample as planned or access may be restricted (e.g., by road washouts, bad weather). Therefore, more transects than required should be planned. Flexibility is the key. A tally sheet should be designed to keep track of what is sampled and what is still needed, and all information should be communicated to crews to ensure they know what is required.

After the sampling plan is developed, it should be reviewed by the Regional Ecologist or project ecologist to confirm that it meets the project objectives. The information (e.g., transects, required inspections) should then be transferred to the non-typed set of field photos to make it easier to use in the field. A well-thought-out sampling design will greatly increase field efficiency.

6.3.3 Conducting field inspections and plot sampling

Field inspections are of three types: full plot, ground inspection, and visual check. Together they are usually carried out in a 5:20:75 proportion, respectively (see Table 6.3). Full plots and ground inspections are done at specific locations (point samples), guided by the sample plan. Ground inspections are less detailed than full plots and visual checks are less detailed than ground inspections. Visual checks may be completed either at specific sampling points or for a boundary or an entire polygon.

Full plots

Full plots, recorded on the Ecosystem Field Form (FS882 [1-7]), provide the most detailed ecological data for a point sample and are intended for classification of site series, confirmation or classification of biogeoclimatic units, and development of ecosystem unit descriptions and summary statistics. Whether samples are selective or designed systematically along a transect, the boundaries of the actual sample plot should encompass a homogeneous ecosystem in terms of soil and vegetation properties. This ensures that the descriptive parameters and statistics recorded for individual ecosystems will be meaningful, and the characteristics of ecosystem units synthesized from the data accurate (Daubenmire, 1968; Mueller-Dombois and Ellenberg, 1974).

A plot is a point sample and can only be considered representative of an entire polygon if that polygon is very uniform and of one ecosystem. In large or heterogeneous polygons, where two or more ecosystem units occur, the surveyor could sample one ecosystem in detail and then do ground inspections or visual checks in the others. Plot size should usually be 400 m^2 in forested communities, but smaller plot sizes (100 m^2) may be appropriate in uniform, species-poor, non-forested habitats such as occurs in some wetlands, grasslands, or alpine areas. Plots may be circular (11.3 m radius), square (20×20 m), or rectangular (e.g., 10×40 m). Circular plots are generally easier to lay out using a plot radius cord and flagging a few trees to mark the circumference. However, a plot with dense understory of tall shrubs or trees can impede vision and may be easier to mark in a rectangular shape. Plot shape may vary to ensure that the plot encompasses a homogeneous unit.

Data collection procedures for full plots should follow the *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Forests and BC Ministry of Environment, 1998a). That guide updates some sections of Luttmerding *et al.* (1990) and is in a field guide format. Data describing the site, soil, vegetation, and mensuration or other required fields must be recorded on the Ecosystem Field Forms (FS882). Minimum data requirements for ecosystem mapping projects are shown in Table 6.5. For some projects, additional fields will have to be completed to acquire the necessary data for interpretations.

As full plots account for only a small proportion of the inspections and are the most costly to establish, they need to be carefully selected. The sampling plan should clearly set criteria for establishment of these plots (e.g., one sample of each site series, two in each zonal site series to confirm biogeoclimatic units, three or more in a new site series).

Table 6.5 Minimum data collection requirements for Ecosystem Field Forms (FS882)

Site Form

1. Date (Y/D/M)
2. **Plot number**
3. Project Identification
4. Surveyor(s)
5. General location (should be specific enough to find plot again easily)
6. Forest region
7. Mapsheet
8. **UTM** (zone, easting and northing) or latitude and longitude
9. Air photo no. (incl. Flight line)
10. Co-ordinates (X and Y)
11. Site diagram
12. Plot representing
13. Biogeoclimatic unit
14. Site series
15. Ecosection
16. Moisture regime
17. Nutrient regime
18. Successional status
19. Structural stage
20. Realm/class (for wetlands only)
21. Site disturbance
22. Elevation
23. Slope
24. Aspect
25. Meso slope position
26. Surface topography
27. Exposure type (if applicable)
28. Surface substrates (organic matter, decaying wood, bedrock, rocks, mineral soil, water)

Soil Form

1. Plot number
2. Surveyor(s)
3. Bedrock (at least to general level, where significant to site)
4. **Coarse fragment lithology** (at least to general level)
5. Terrain texture, surficial material, surface expression, geomorphological process
6. **Soil classification** (to subgroup)
7. Humus form (at least to group)
8. **Hydrogeomorphic** unit (at least to system)
9. Rooting depth
10. Rooting zone particle size
11. **Root restricting type** and depth (if applicable)
12. **Water source** (if applicable)
13. **Seepage depth** (if applicable)
14. Drainage
15. **Flooding regime** (if applicable)

Organic horizons/layers; for each:
- horizon/layer code and depth
- mycelial abundance
- fecal abundance
- von Post (for organic soils)

Mineral horizons/layers; for each:
horizon/layer code and depth
- colour (when required for diagnostic purposes)
- colour aspect (when colour entered)
- soil texture (< 2 mm fraction)
- % coarse fragments (gravel, cobbles, stones, and total)
- comments (especially mottles)

Profile diagram
Notes

Vegetation Form

1. Surveyor(s)
2. Plot Number
3. Species list “complete” or “partial”
4. % cover by layer (A, B, C, D)
5. Species by layer
6. % cover for each species by layer and sublayers
7. Notes

Mensuration Form

1. Surveyor(s)
2. Plot number
3. For three largest diameter trees of dominant tree species (if stands meet SIBEC standards)
   - tree number
     species code
     dbh
     height calculations
   - height to dbh
     total height
     Breast height age
     suppression
   - pathological indicators
     damage
     site series

The standards indicate that about 5% of sample plots should be full plots (see Table 6.3). This number is a guideline and the number required for a project depends on the survey intensity level and the assessment of a few criteria for the area. The following questions should be asked:

- Is there an existing site series classification?
- How well does the existing classification fit the project area?
- Do biogeoclimatic boundaries require extensive revision?
- How many existing full plots are there?
- What descriptive data is needed for a report?
- Is there a possibility of new site series or biogeoclimatic units being identified?

The project ecologist responsible for administering the project should assess the full sample requirements before the sampling plan is developed and/or a contract let for the project. Another criterion that is important in determining the number of full plots is the surveyor's knowledge and experience in the study area. With contract mapping, however, this is generally not known until after the bidding.

Full plots are essential for describing new ecosystems (site series). To be added to the provincial vegetation classification, the new data must first be evaluated by the Regional Ecologist in the area, and then compared with other site series. Therefore, the full plot data need to be carefully collected according to the standards outlined in *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Forests and BC Ministry of Environment, 1998a) with a complete species list, all species confirmed, and good soils and site data. An adequate number of samples is also required, preferably five or more (minimum of three) for each new site series. It is very important that the appropriate Regional Ecologist be consulted and new site series names and labels be approved before the map is finalized.

Ground inspections

Ground inspections are abbreviated plots from which data are recorded to confirm the identification of the ecosystem unit or polygon designation, or determine polygon boundaries. They also provide some data for characterizing ecosystem attributes (e.g., abbreviated species lists can be used to characterize structural stages). These plots should make up about 20% of inspections at most survey intensity levels (see Table 6.3) (about one inspection per 375 ha for level 4, 1:20 000 mapping). Data should be recorded on the Ground Inspection Form (GIF). Minimum data requirements for ground inspections are listed in Table 6.6.

Ground inspections are point samples. Although plot size and shape are the same as for full plots, for speed of recording, plot boundaries are rarely marked. The data collected should be sufficient to confirm the ecosystem unit: site series, site modifiers, and structural stage. Dominant and indicator plant species should be recorded. These are generally all species on the main substrate above approximately 3–5% cover (so-called "dominants") and those species listed in the vegetation tables of the Ministry of Forests field guides (indicator species). Although a soil description need not be completed, data required on terrain classification, humus form, rooting zone texture, seepage water, and root-restricting depth, and so on, means that a small soil pit must be excavated.

Ground inspections are likely to be the main form of sampling for wetlands, alpine, and other non-forested ecosystems. Ground inspection forms completed on these ecosystems need to include notes on type of wetland or alpine ecosystem, so that this information can be used in mapping. In wetlands, for example, an indication as to whether the ecosystem is a marsh, swamp, fen, bog, etc., is essential. In alpine areas, an indication of site conditions like talus slope, wind-swept ridge, meadow, etc., is useful.

Table 6.6 Minimum data collection requirements for ground inspections

1. G (Ground) vs V (Visual)
2. **Air photo number**
3. Date
4. Project ID
5. Surveyor(s)
6. Mapsheet
7. Plot no.
8. Polygon no.
9. Lat./Long. or UTM
10. Aspect
11. Elevation
12. Slope
13. Soil moisture regime
14. **Soil nutrient regime**
15. Meso slope position
16. Drainage – mineral or organic soils
17. Mineral or organic soil texture
18. Surface organic horizon thickness
19. Humus form (to order level)
20. Depth to and type of restricting layer (if applicable)
21. Coarse fragment content
22. Terrain texture, surficial material, surface expression, and geomorphological processes
23. BCG unit
24. Ecosection
25. Site series
26. Site modifiers
27. Structural stage
28. Crown closure
29. Total % cover by stratum
30. Dominant/indicator plant species
31. % cover of dominant/indicator species
32. Complete or partial
33. Notes

Visual checks

Visual checks are the least detailed and also the predominant form of field inspection. They should account for approximately 75% of inspections (about one inspection per 100 ha at level 4, 1:20 000 mapping), and can take the form of notes on photos or maps, notes in a field book, notes recorded on tape, or polygon summaries on Ground Inspection Forms. These checks are intended to be quick inspections for mapping purposes and can include one or more of the following: confirm site series, site modifiers, structural stage, terrain attributes, **soil textures** and soil depths, briefly describe vegetation, assess biogeoclimatic mapping, record ecosystem or terrain component percentages, evaluate polygon boundaries, or note special features. They do not have to be entered in a database, but should be summarized in spreadsheet format for ease of use and presentation to project administrators or correlators.

Visual checks can be conducted on the ground, from the air (helicopter), or from viewscapes. Emphasis should be on the ground as **air calls** and viewscapes are limited in the types of information which can be confirmed. Map reliability is most likely to be improved if more ground is covered during field work.

Visual checks can also be used to supplement full plot or ground inspection data. They also can be used to provide information for ecosystems adjacent to areas that were sampled with a more complete inspection. For example, they could be used to characterize the series of wetland communities around a small pond or depression.

6.4 Data Synthesis and Analysis

After field work is complete, vegetation and environment data are tabulated and analyzed, and ecosystem units are finalized for the study area. Vegetation and environment data from full plots is computer coded in the VENUS (Vegetation and Environment NexUS) program (BC Ministry of Forests and BC Ministry of Environment, 1997). The ground inspection data needs to be entered into a set database format, or entered using the GRAVITI (Ground And Visual Inspection TEM Interface) data entry program (BC Ministry of Forests and BC Ministry of Environment, 1998b). Data from visual checks can be entered in a spreadsheet or database or using GRAVITI. Templates for data entry in an Excel spreadsheet or a dBase format database (dBase and Foxpro) that import into GRAVITI are available from the BC Ministry of Forests, Research Branch, in Victoria.

After data has been entered, tables summarizing vegetation or environment data may be required for classification or review purposes. VENUS will produce some basic tables for data from full plots, or more sophisticated (e.g., hierarchical) tables can be prepared by exporting the data to VTAB (Kayahara, 1992; Britton *et al*., 1995). Vegetation and environment summary tables should be produced for each ecosystem unit. Copies of the VENUS, VTAB, and GRAVITI data entry and analysis software are also available from the Ministry of Forests (see Appendix B).

Microsoft Windows-based VENUS is the standard for entering data for vegetation analysis. Other vegetation analysis programs, such as TWINSPAN and DECORANA (Hill, 1979a and b), ORDIFLEX (Gauch, 1977), CERO (Ceska and Roemer, 1971), SYNTAX (Podani, 1994), and PC ORD (McCune and Mefford, 1995), may also be used to analyze and summarize plot data, depending on the quantity of data and the objectives of the project.

6.5 Final Mapping

Before final photo typing and map labelling, all relevant information should be at hand, including pre-typed air photos, field data, and other existing maps for the area (e.g., ecosection, biogeoclimatic, forest cover, terrain, soils, bedrock geology, topographic, and satellite imagery). Typing should be corrected based on field surveys and the synthesis of field inspection data. Bioterrain and ecosystem map unit lines completed during pre-typing should be adjusted on the photos after field work is completed.

Biogeoclimatic boundaries should already have been refined to project scale from Ministry of Forests maps (1:500 000 to 1:100 000 scales) during pre-typing, assessed during field sampling, and if significant changes are anticipated, discussed with the Regional Ecologist. The boundaries may then be further refined, using sampling and observations along ground transects, as well as other sources of information such as **forest cover maps**. Special attention should be paid to data from zonal sites (Meidinger and Pojar, 1991), and vegetation and soil characteristics should be compared against subzone/variant descriptions in regional field guides. Distribution of other ecosystems can also be useful in refining biogeoclimatic boundaries. Overstory forest species can help guide the placement of subzone boundaries for certain subzones (e.g., ICH vs. ESSF).Where ground information is lacking, subzone/variant lines may be extrapolated from known elevational boundaries elsewhere in the study area.

Because transitions from one biogeoclimatic unit to another are often gradual, adjustments to biogeoclimatic map unit boundaries to make them follow ecosystem map unit boundaries should only be made if the lines are nearly coincident. Any proposed change to existing biogeoclimatic boundaries must be approved beforehand by the appropriate Ministry of Forests, Regional Ecologist.

Adjusting ecosection boundaries to follow biogeoclimatic boundaries and ecosystem map unit boundaries can also be done during this final stage of mapping. Ecosection boundaries are not distinct, especially at medium and large scales of mapping. Such generalization of ecosection boundaries to follow biogeoclimatic and ecosystem map unit boundaries must be done to prevent the creation of polygon slivers.

Final labelling and attributing of ecosystem unit polygons is completed through the re-evaluation of polygons on the photos (including the bioterrain information) and examination of field data and other sources of information (e.g., forest cover maps may be helpful in determining structural stage). An ecosystem unit polygon may contain up to three ecosystem units and the percentage of the polygon occupied by each component is estimated. Refer to Section 3.0 for more detail on these mapping standards.

Where ecosystem mapping has been completed on adjacent mapsheets, border matching should be carried out during this final mapping stage.

During the final photo typing, the attributes for the polygon database should be assessed and entered. The recommended approach is to first transfer the photo typing to the base map, and then to assign polygon numbers and labels and create the attribute file. This approach is preferred because the topographic information on the base map allows for better integration of biogeoclimatic and ecosystem unit boundaries. Base maps also provide a broader landscape view of the study area, allowing for better delineation of biogeoclimatic boundaries than can be done on individual air photos. Attribute data is entered using ecosystem and terrain database formats available on the TEM website (see Appendix B) and should be provided digitally in ArcInfo compatible format. This database will then contain all the data required for producing the final map and any interpretive map products. The database should be reviewed to ensure it is error-free. Common problems are missing information, deciles not adding up to 10, and incorrect codes. An input program with validation routines will soon be available.

An alternate approach is to record polygon data in an attribute file before photo typing has been transferred to a base map. In this approach, the air photo number and a tentative polygon number must be assigned to each polygon. This should only be used for small project areas, occurring within one biogeoclimatic unit.

Once polygon labelling and attribute coding is completed, a thorough edit of the database and map against the original air photo polygons is essential. A digital map and attribute file should be produced as a final product. Digitizing may be done directly from air photos or from the plotted mylar map. A final edit of the digital map against the plotted map and/or air photos is also necessary.

The final map legend should be produced according to the standards described in Section 5.0. The content of an expanded legend is client-driven, but should be specified at the outset of a project to ensure the appropriate data is collected.

6.6 Interpretive Mapping

The polygon attribute files should contain a complete set of core attributes (Table 4.1) plus any project-specific attributes. The full capability of the ecosystem maps is realized when all the data is compiled in GIS. Users can produce maps colour-themed for any number of purposes, as well as outputting summary statistics.

Interpretive maps can be in many forms (see Table 4.2). They may simply be maps combining specific attributes to display broader management units, or they may be the result of an algorithm combining many attributes in the database. Examples of interpretive products include maps with any of the following themes:

- terrain attributes
- dominant site series
- structural stages
- crown closure
- uncommon ecosystems less than a specified area
- ecosystem unit and slope class
- wildlife capability or suitability for selected species
- site productivity

Two example algorithms are presented, one for the site productivity of the Dog Creek project area (Table 6.7); and one for habitat suitability for Mountain Goats (Table 6.8). The resulting maps are presented in Figure 6.5 and Figure 6.6.

The information in Table 6.7 is used with the attribute database to determine an area-weighted site index average for each polygon that results from an overlay of the ecosystem map with the forest cover map. The site index value for the dominant tree species in each resulting ecosystem/forest cover polygon is determined from the ratings table. Polygons with the same site index class are then grouped together for the final map.

Table 6.7 Ratings table for site productivity of Dog Creek TEM project

IDF dk3	**Site Series**	**Tree Species**		
Code	**Name**	**Fd**	**Pl**	**Sx**
LP	FdPl – Pinegrass – Feathermoss	15	18	
DK	Fd – Juniper – Kinnikinnick	12	12	
DJ	Fd – Juniper – Peltigera	12	15	
DW	Fd – Bluebunch wheatgrass – Needlegrass	12		
DM	Fd – Feathermoss – Step moss	15	15	
DP	Fd – Pinegrass – Aster	15	15	
SR	SxwFd – Prickly rose – Sedge	18	18	18
SS	SxwFd – Prickly rose – Sarsaparilla	18	18	18

SH	Sxw – Horsetail – Glow moss	18	15

Notes: Values for tree species in table are site index @ age 50 (breast height age).
Assumptions for site productivity interpretation: SIBEC table results (BC Ministry of Forests, 1997) apply to study area
site productivity for a polygon is determined by site series and leading tree species combination site index classes will adequately represent the variability

In developing most interpretations, the mapper has two requirements: a "ratings" table, where the values for selected attributes (e.g., site series) are tabulated; and a set of assumptions. For the "site productivity for forestry" interpretation, Table 6.7 is the ratings table. The assumptions for the analysis are appended to the table.

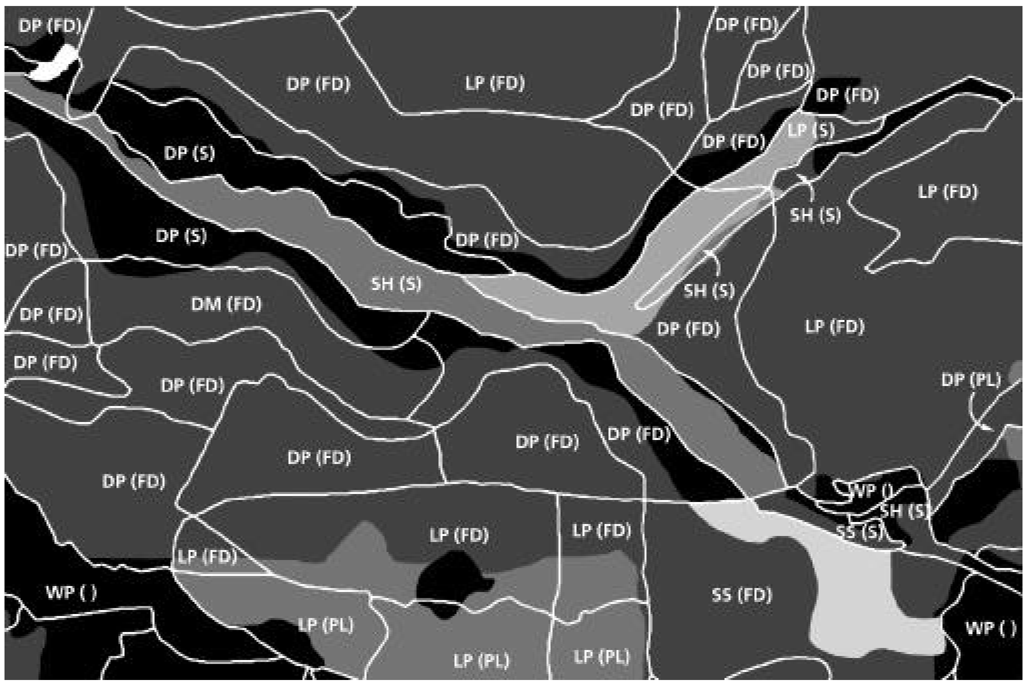


Figure 6.5 Site productivity interpretive map for portion of Dog Creek TEM project

The “Mountain Goat suitability” interpretive map is shown in Figure 6.6 The ratings table and assumptions are presented in Table 6.8.

Table 6.8   Ratings table for Mountain Goat suitability

ECO_SEC	BEC_ZONE	BEC_SUBZON	BEC_VRT	BEC_PHASE	SITE_S	SITE_M	STRCT_S	STRCT_M	SERAL	MORAM_LI_G_FD	MORAM_LI_G_SH
SAH	AT				TA	k	1			6	3
SAH	AT				TA	w	1			6	3
SAH	AT				SH		2			3	3
SAH	AT				SH	k	2			3	3
SAH	AT				SH	w	2			2	3
SAH	AT				AW		2			2	2
SAH	ESSF	wk	2		AC		2			4	5
SAH	ESSF	wk	2		AC	k	2			4	5
SAH	ESSF	wk	2		AC	w	2			3	5
SAH	ESSF	wk	2		AT		2			4	6
SAH	ESSF	wk	2		LA					6	6
SAH	ESSF	wk	2		FO		2			2	6
SAH	ESSF	wk	2		FO		3			3	6
SAH	ESSF	wk	2		FO		4			4	6
SAH	ESSF	wk	2		FO		5			4	6
SAH	ESSF	wk	2		FO		6			4	6
SAH	ESSF	wk	2		FO	k	7			4	6
SAH	ESSF	wk	2		FO	w	2			2	6
...several rows omitted...											
SAH	SBS	vk			RB		2			3	6
SAH	SBS	vk			RB	n	2			0	0
SAH	SBS	vk			RH		6			4	6
SAH	SBS	vk			RI					6	6
SAH	SBS	vk			RO	s				3	2
SAH	SBS	vk			RT	n				0	0
SAH	SBS	vk			SD		2			3	6
SAH	SBS	vk			SF		2			3	6
SAH	SBS	vk			SF		3			3	6
SAH	SBS	vk			SF		6			4	6
SAH	SBS	vk			SF	f	2			3	6
SAH	SBS	vk			SF	f	3			3	6
SAH	SBS	vk			SF	f	4			3	6
SAH	SBS	vk			SF	f	6			3	6
SAH	SBS	vk			SS		2			3	6

Notes: Habitat suitability in Figure 6.6 was determined by calculating a weighted average of food and security within each polygon.
Security habitat was weighted 4:1 over feeding habitat.
Subsequently, all polygons with security ratings less than moderately high were assigned a suitability rating of nil.

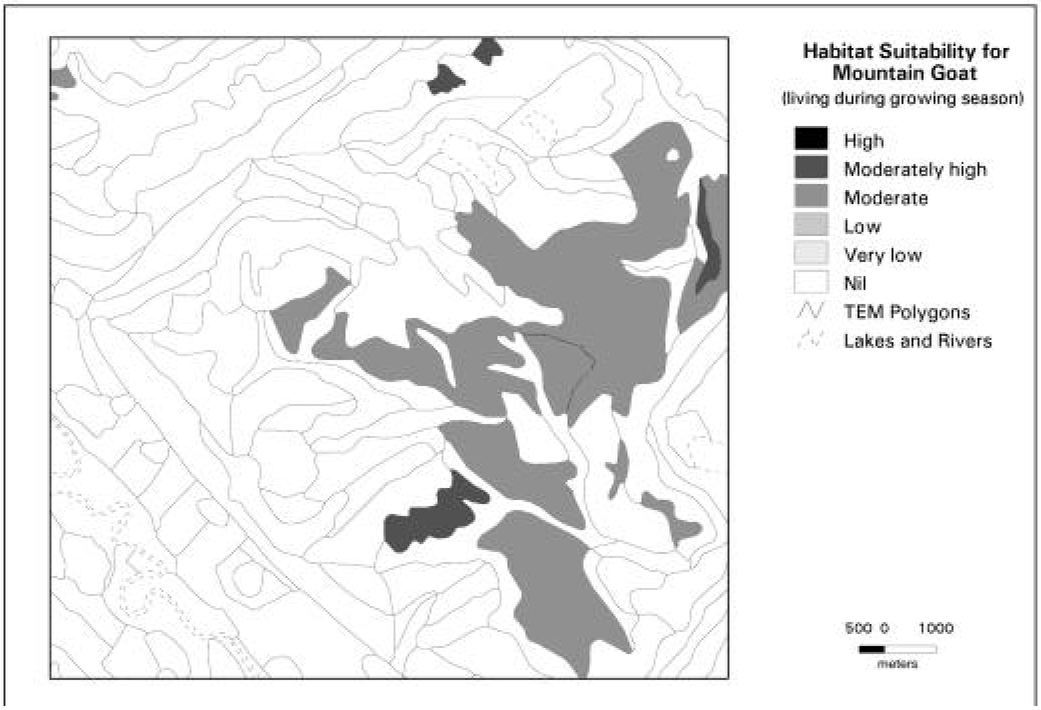


Figure 6.6 Habitat suitability interpretive map for Mountain Goat

6.7 Quality Assurance, Correlation, and Map Reliability

Quality and reliability of the ecosystem maps and associated databases are extremely important in TEM. Maps are costly and time-consuming to produce, and users expect them to be well produced and reliable. Time taken during mapping, sampling, data entry, and compilation will result in a map product and database that will benefit the client and many users in future years. Principles and procedures to ensure high quality mapping are presented in this section.

6.7.1 Quality assurance and correlation

This report provides standards to ensure that all ecosystem mapping in the province follows the same methods and is compatible from project to project, using the same ecosystem unit characterization and symbology. Similarly, the *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Forests and BC Ministry of Environment, 1998a) provides data collection standards for sampling site, soils, vegetation, trees and wildlife habitat. For assistance in applying mapping and sampling standards, the BC Ministry of Forests' Regional and Research Branch Ecologists and BC Environment's Provincial Correlators with the Resources Inventory Branch should also be consulted.

The goals of the TEM correlation process are to: 1) improve TEM mapping by giving the mappers technical support before, during, and after the field season, providing them with comments on interim products, and offering them constructive criticism; 2) furnish a critical evaluation and quality assurance function to ensure that the RIC standards for TEM are promoted and enforced; and 3) provide a feedback mechanism for the continued evaluation, improvement, and evolution of TEM.

For each project, a project ecologist should be identified to ensure that project members are mapping consistently and meeting quality standards. Periodic reviews are required to evaluate the sampling plan, pre-typing, field data collection, final mapping process, map legends, and reports describing the ecosystem units that are mapped. The project ecologist should use the expertise of Regional and Provincial Ecologists, terrain specialists of the BC Ministry of Forests and BC Environment, and project clients, to ensure timely and on-going review. Reviews conducted throughout the mapping process are more likely to result in quality products for the least cost. Where interpretive maps and databases are being produced, they should also be reviewed by appropriate specialists.

If mapping is done under contract, the agreement should outline the review requirements for each deliverable of TEM. Those requirements can be summarized as follows:

1. Sampling plan. The sampling plan, including working legend (based on existing information), should be reviewed for the timing of field sampling; consideration of access (hike-in/road/helicopter) and relative costs; strategy for sampling ecosystems, structural stages, parent materials; etc.
2. Preliminary mapping (pre-typing). A preliminary set of photos should be reviewed before fieldwork, to assess ecosystem unit and/or bioterrain delineations and provide feedback to the mappers. This step includes an assessment of alpine and parkland biogeoclimatic boundaries (if these units occur in the area) as they are important to subsequent delineations.
3. Field sampling. Correlation during field sampling allows for assessment of field sampling procedures (e.g., plots in appropriate locations, forms completed correctly and accurately); and determination of whether site series are identified and mapped and whether biogeoclimatic units are mapped reasonably at the larger scale.
4. New site series. If new site series are recognized, they will require approval by the Regional Ecologist. In order to review this stage, the ecologist should be supplied with all appropriate field data, vegetation and environment tables by sites series, and brief notes justifying any proposed new site series.
5. Biogeoclimatic boundaries. The linework should be reviewed before final mapping, as these lines are critical to subsequent ecosystem mapping and sampling.
6. Draft ecosystem map. A review of an early draft of the ecosystem map and databases may identify errors or inconsistencies that are more easily corrected than at the end of the project. At this time, all aspects of the mapping should be reviewed. This means determining that ecosystem unit symbology, designations, proportions, and total of proportions are correct; use of “non-vegetated” or “anthropogenic” types is appropriate; each polygon is closed and properly matched to photo borders; site modifiers are used where appropriate; and linework, map legend, GIS spatial data, databases, and attributes follow standards. Final terrain attributes will also be reviewed, and when bioterrain is the initial base mapping for ecosystem, it should be evaluated prior to completion of ecosystem mapping.

7. Final mapping. This is the last opportunity to review the TEM project. A final review of photo interpretation, mapping, and databases, (as in item 6), should be conducted before acceptance. This should be a less rigorous review than that of the draft map, to confirm that recommendations have been incorporated.
8. Final report. If produced, the report should be reviewed to ensure it is accurate and consistent with the map, standards for labelling, etc. All projects with a wildlife component require an expanded legend.

To ensure a quick and efficient review, all necessary project materials should be provided to the reviewer.

6.7.2 Map reliability

An assessment of map reliability is an evaluation of how accurately the map and legend represent the landscape. Both qualitative and quantitative assessments of map reliability are useful.

Qualitative assessment

The map and the process of preparing the map are qualitatively assessed during the correlation procedure outlined in Section 6.7.1. In addition, there may be specific field-based qualitative reliability assessments after mapping. These trips would entail comparing map delineations and labels with what is observed on the ground. The differences between a qualitative assessment and the quantitative assessment outlined below are in aspects such as selection of sample points and compilation of results. The qualitative approach may still be systematic and focused, but does not rely, for example, on selecting random polygons or plotting transects within polygons. Rather, its emphasis is on assessing as many polygons as possible within the time frame available, using whatever access is possible (e.g., road transects, visual observations, helicopter hovers). The compiled results are used to assess whether the map is reliable for the intended interpretations and can be used to focus a subsequent quantitative assessment.

Quantitative assessment

A sample of map polygons should be assessed in the field by the mapping project supervisor or correlator. The objective of this assessment is to provide some statistics on the accuracy of the polygon designations and to “audit” the mapping project. The process of assessing map reliability quantitatively is discussed in Steers and Hajak (1979), Wang (1982), Forbes *et al.* (1982), Valentine (1986), and Gopal and Woodcock (1994). Although a standard procedure has not yet been developed, the following principles should be followed in any assessment:

1. Identify aspects of the project that require a quantitative assessment. It may be a general assessment of all ecosystem unit components, or a focus on specific problems identified from the qualitative assessment. For example, the focus may be site modifier designations, the assessment of ecosystem unit proportions, the placement of polygon boundaries, or the mapping of one or two site series.

2. Identify specific attributes to be assessed at each ground sample to be audited (e.g., site series, site modifier, structural stage, or ecosystem unit proportion) and determine the allowable variation from the measured value. This will usually involve setting an assessment scale where "almost" right answers get intermediate values. For example: if absolutely wrong, a value of 1 might be applied; if understandable, but wrong, a value of 2; if a reasonable result, a value of 3; if a good answer, a value of 4; and if absolutely right, a value of 5.

3. Randomly select a sample of polygons. This can be done for the total map or for a stratified sample of polygons addressing the "problem" being assessed. The maximum size of the subset of polygons depends on the size of the population, the issues being addressed, and the resources available. However, it should not be less than 30 polygons. Depending on the focus of the assessment, an efficient field procedure might involve randomly selecting a set of polygons and deciding *a priori* to sample the surrounding two to three polygons at the same time.

4. Plot line transects. Within each polygon, a transect that will cross all significant landscape features should be plotted. Mark 10–20 sample sites at a fixed interval along the transect. Again, an effective field procedure would be to plot the transect through the cluster of polygons to allow for efficient travel.

5. Sample along each transect. Each sample site should be assessed using the ground-truthing attributes selected above.

6. Analyze the data and generate statistics. The data for each polygon should be assessed and the observed values compiled into a value that can be compared to the mapped value. The polygon can then be evaluated and scored, using the chosen assessment scale.

Other useful procedures for assessment are to assess other polygons (of the same population) by helicopter hover or photo interpretation. The results of these assessments can also be used in the analysis of the problem or project.

As mapping is somewhat of an art, it is often difficult to determine whether a mapped attribute is clearly right or wrong. Therefore, a "fuzzy analysis" of the data is recommended. Gopal and Woodcock (1994) outline several options. For example, the so-called "RIGHT" function can be used if the objective is to determine the nature and distribution of errors. Other functions can determine magnitude or significance, source, or the nature of errors.

Determining a pass/fail grade requires setting certain minimum values. For example, using the RIGHT function, a minimum passing value might be set at 65% for each map category assessed and 75% overall. The proportion of polygons meeting the quantitative criteria will vary according to survey intensity level. At the lowest intensity level, perhaps only 60% of the polygons will pass, whereas at the highest level, most polygons should.

7.0 Summary of Methods and Standards

7.1 Summary

The Terrestrial Ecosystem Mapping methodology integrates the climatic, vegetative, and physical attributes of British Columbia's diverse ecosystems into one map product. The methodology emphasizes the relationship between topographic, terrain and soil features of the landscape, and the vegetation and vegetation development stages of each ecosystem unit. Recommended for ecosystem mapping at scales of 1:5000 to 1:50 000, the methodology describes standards for ecosystem unit development, symbology, sample types, mapping procedures, required data attributes, legends, and summaries of potential interpretive products.

In order to achieve consistency in the products of TEM mapping, this methodology has been prepared for and approved by the Resources Inventory Committee for use in British Columbia. The goal is to ensure the delivery of high quality, consistent map products through standards, correlation and quality assurance.

A three-level classification hierarchy of ecological units is embedded within the methodology. At the broadest level, both ecoregion and biogeoclimatic classifications are utilized. Site units and vegetation developmental units depict terrestrial ecosystems at a more detailed level. At these detailed levels, individually mapped polygons are described by ecosystem units, which are composed of site series, site modifiers and structural stage. Each polygon may contain up to three ecosystem units; the proportions of the units are indicated by deciles preceding each site series (see Figure 3.8).

Mapping terrestrial ecosystems is an integrative process where specialists from each of the major disciplines combine their expertise to capture the spatial representation of ecosystems in a project area. The approach to mapping begins with consideration of the existing classifications for the area (ecoregion, biogeoclimatic, and site), and their relationships to topography, terrain, and developmental patterns on the landscape. All related land information data and maps are collected and analyzed for their usefulness with the mapping. Once appropriate imagery is obtained, ecosystem map polygons are delineated.

Ecosystems are pre-typed on the photos, and subsequently checked in the field. Field sampling provides the information required to confirm biogeoclimatic unit boundaries, describe the site series as they occur within the study area, classify new ecosystems, and describe structural and vegetation characteristics of younger structural stages. To maximize the efficiency of the field crews, the methodology recommends developing a detailed sampling plan to guide field work. Field data are of three types: 1) full plots; 2) ground inspections; and 3) visual checks. For most terrestrial ecosystem projects these sampling types should follow the ratios outlined for survey intensity level 4 (see Table 6.3). However, in some cases and for special purposes, other survey intensity levels and sampling ratios may be used.

Ecosystem mapping provides spatial data for a multitude of ecological interpretations. Since the final map is digital, in a geographic information system, the attribute files can be accessed and models developed to display or summarize interpretive information. In addition, the polygon-based data can be integrated with other resource inventories to develop even more interpretations. As the TEM provincial database is developed, it will facilitate many aspects of natural resource management.

Ecosystem mapping in British Columbia has evolved from several similar but disparate methods to what is now called Terrestrial Ecosystem Mapping. TEM itself has undergone a rapid evolution in the past few years, but the intent now is to stabilize the methodology for several years. There will always be new ideas on various aspects of mapping ecosystems. The intent of this standard is not to stop development, but to control it so that a provincial database of ecosystem mapping can be developed and used for management interpretations wherever required in BC.

7.2 TEM Standards

The following table (Table 7.1) lists manuals, field forms, databases, and training courses pertinent to TEM projects. Most of these are available on the TEM website. Additional data sources related to TEM (e.g., air photos, terrain maps) are listed in Appendix B.

Table 7.1 TEM standards manuals, field forms, databases, and training courses

Standards	Description
Provincial Site Series Mapping Codes and Typical Environmental Conditions. (1997a) RIC, Ecosystems Working Group	Provides the two-letter codes for all provincial sites series and site series-like map units, as well as descriptions of typical conditions, typical site modifiers, and moisture regime. Formerly called Appendix J in the *Standards for Terrestrial Ecosystem Mapping in BC* (1995), this is now a stand-alone document. This Excel 4 file will be updated every few months as new units are defined; a notice of the update will be sent out via “ecomapper.”
Ecoregions and Ecosections of British Columbia. (1997). D. Demarchi	Provides the 1997 list and codes of ecoregions and ecosections.
Biogeoclimatic Units of British Columbia. (1997). D. Meidinger	Provides the 1997 codes and names for BGC levels from zone to variant.
Terrain Classification System for British Columbia, Version 2. (1997). D. Howes and E. Kenk	Provides the system for classification of surficial materials, landforms, and geological processes of BC This document has had minor revisions and updates from the 1988 version.
Field Manual for Describing Terrestrial Ecosystems. (BC Min. of For. and BC Min. of Env., 1998a).	A pocket-size field guide to filling out 1998 Ecosystem Field Forms (FS882 [1–7]). Printed on waterproof paper
Ecosystem Field Forms (FS882 [1–7]). (1998). Province of BC	These are the updated version of the 1996 FS882 forms. They are field guide size, and printed on waterproof paper. Forms included are: • Site – FS882 (1) • Soil – FS882 (2) • Vegetation – FS882 (3) • Mensuration – FS882 (4) • Wildlife habitat assessment – FS882 (5) • Tree attributes for wildlife – FS882 (6) • Coarse woody debris – FS882 (7)
Ground Inspection Forms (GIF) and	These forms are designed for ground inspections or visual

Coding (1998). RIC, Ecosystems Working Group	checks for sites or polygons.

Training Courses	Description
Introduction to Terrestrial Ecosystem Mapping Techniques.	This is a five-day course geared towards training individuals in all steps of producing terrestrial ecosystem maps. It presents the classification and methodological concepts outlined in this manual.
Describing Terrestrial Ecosystems in the Field.	This is a five-day course designed to train individuals in the field identification and coding standards of all components found on the Ecosystem Field Forms (FS882).
An Introduction to Biogeoclimatic Ecosystem Classification.	This is a two- to three-day course intended to familiarize individuals with the Biogeoclimatic Ecosystem Classification framework, while providing hands-on practice describing, identifying, and interpreting sites.

Databases	Description
Standards for Digital Terrestrial Ecosystem Mapping (TEM) Data Capture in British Columbia. (1998). RIC, Ecological Data Committee, Ecosystems Working Group.	This document sets out procedures and rules for capturing, storing, and distributing ecological data for the GIS and other database systems. Further edits will be made, based on user comments and review. (Includes terrain database information.)
VENUS (1997) Version 3.0, RIC, Ecosystems Working Group	This is a database and analysis package for field data (Ecosystem Field Form – FS882). It is called VENUS (Vegetation and Environmental data NexUS). The current version is 3.0 but the program could be subject to change. The TEM website should be consulted for the latest version. Please register that you are a VENUS user so that you can be contacted when the program is improved or updated.
GRAVITI (1998a). RIC, Ecosystems Working Group	This is a digital database format for recording, storing, and analyzing site and polygon information collected on the 1998 Ground Inspection Form (GIF).

Draft Procedures	Description
Terrain Supplement to Terrestrial Ecosystem Mapping (TEM) (1998) RIC, Ecosystems Working Group	This document will provide guidelines for ecosystem-terrain mapping. It is based on Appendix B of the *Standards for Terrestrial Ecosystem Mapping in BC* (RIC 1995). Now a stand-alone document.
Data Capture for Geographic Information System (GIS). RIC, Ecosystems Working Group	This program will provide data entry and validation routines for polygon data for terrestrial ecosystem mapping in GIS. Available in 1998.
Draft Procedures for Terrestrial Ecosystem Mapping. RIC, Ecosystems Working Group	Provides detailed procedures for terrestrial ecosystem mapping at scales of 1:5000–1:50 000

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Appendix A: Glossary

For legal and/or strict technical definitions, refer to the Forest Practices Code definitions and registered glossaries where applicable. The definitions below are mainly to provide readers with an understanding of the terms used in this manual. Glossary items appear in bold the first time they used in the test of this manual.

Aerial photograph: A photograph of the earth's surface taken from the air. It is usually a vertical view, and one of a series of photos taken from an aircraft flying a systematic pattern at a given altitude in order to obtain continuous photo coverage for mapping purposes (RIC, 1997c).

Air call: A site description usually made from a low-flying helicopter. The data may consist of one or more significant attributes confirming an observation. The information is recorded on a map or aerial photograph as a permanent record (BC Ministry of Forests, 1985).

Air photo number: The number recorded on each photo, assigning the flightline and the frame number.

Algorithm: A set of mathematical instructions or problem-solving procedures designed to provide answers to complex problems. It is used in modelling applications to portray the interrelationships between different sets of data (e.g., timber supply yield tables, wildlife habitat, or fire spread) (Dunster and Dunster, 1996). Also a series of commands that specifically assign habitat use values and hierarchies to ecosystem unit polygons, based on *assumptions, ratings* and *adjustments* for an animal species (RIC, 1998). An algorithm may also be a simple set of statements.

Alpine: Non-forest land that, owing to its elevation, is above the tree line. Alpine vegetation on zonal sites is dominated by low shrubs, herbs, bryophytes and lichens. Alpine is considered to be above the krummholz and parkland forest, although treeless by definition, rare stunted (krummholz) trees may occur. Much of the alpine will be non-vegetated, covered primarily by rock and ice (RIC, 1996).

Anthropogenic sites: Sites modified by human activities to the extent that their initial physical properties (e.g., structure, cohesion, consolidation) have been drastically altered. Includes, for example, spoil heaps, fill, waste water, and archaeological sites.

Area of polygon: The total area (ha^2) on the ground covered by a polygon boundary.

Aspect: The orientation of a slope by means of compass points; indicates whether the slope is exposed to the north, south, east, west, or any point between. Aspect is measured in degrees (Luttmerding *et al*., 1990).

Attribute: A characteristic required for describing or specifying some entity (Dunster and Dunster, 1996), that is associated with an ecosystem map unit.

Bedrock: The solid rock, usually older than Quaternary (except rock formed by the cooling of lava), underlying soil and the regolith or exposed at the surface (Agriculture Canada, 1976).

Bedrock type: A rock type from one of three bedrock groups, Sedimentary, Igneous, or Metamorphic. Examples of bedrock types are calcareous sandstone 'ks' or granite 'gr.' They are explained and listed in *Terrain Classification for British Columbia Version 2.0* (Howes and Kenk, 1997).

Biogeoclimatic phase: Accommodates the variation, resulting from local relief, in the regional climate of subzones and variants. Phases are useful in designating significant, extensive areas of ecosystems that are, for topographic or topo-edaphic reasons, atypical for the regional climate. Examples could be extensive areas of grassland occurring only on steep, south slopes in an otherwise forested subzone, or valley-bottom, frost-pocket areas in mountainous terrain. For example, ICHmc1a refers to the coastal (a) phase of the Nass (1) variant of the moist cold (mc) subzone of the Interior Cedar–Hemlock (ICH) zone. (Meidinger and Pojar, 1991).

Biogeoclimatic subzone: A more site specific level of the biogeoclimatic classification system than the biogeoclimatic zone. The subzone describes the zonal/or climax vegetation, and corresponding climate and soil. For example:

ESSFmm – Moist Mild Engelmann Spruce-Subalpine fir
ESSFdc – Dry Cold Engelmann Spruce-Subalpine fir
ESSFdcp – Dry Cold Parkland Engelmann Spruce–Subalpine Fir

Biogeoclimatic units: A general term referring to any level of Biogeoclimatic zones, subzones, variants or phases. Biogeoclimatic units are inferred from a system of ecological classification based on a floristic hierarchy of plant associations. The recognized units are a synthesis of climate, vegetation, and soil data. (Pojar *et al*., 1987).

Biogeoclimatic variant: A further subdivision of biogeoclimatic subzone reflecting further differences in regional climate. Variants are described as warmer, colder, drier, wetter, or snowier than the "typical" subzone (e.g., ESSFmm1–Moist Mild Raush Engelmann Spruce–Subalpine Fir).

Biogeoclimatic zone: Geographical areas having similar patterns of energy flow, vegetation and soils as a result of a broadly homogeneous macroclimate. Biogeoclimatic zones are comprised of biogeoclimatic subzones with similar zonal climax ecosystems. For example:

ESSF – Engelmann Spruce-Subalpine fir biogeoclimatic zone
BG – Bunchgrass biogeoclimatic zone
IDF – Interior Douglas-fir biogeoclimatic zone

Capability: Ability of the habitat, under optimal natural (seral) conditions to provide life requisites of a species, irrespective of its current conditions (RIC, 1997c).

Cliffs: Steep, vertical or overhanging rock faces. Cliffs provide the physical protection for wildlife and may concentrate a variety of reptiles, birds, and mammals into relatively small but stable environments (Sinnemann, 1992).

Climax ecosystem: The final and relatively stable stage in plant succession for a given environment where the species present perpetuate themselves in the absence of disturbance (BC Ministry of Forests, 1985).

Closed legend: A map where every single or combined symbol in a delineation corresponds to an entry in the legend is said to have a "closed" legend. The map delineations are grouped into a finite number of map units, each with a unique symbol (Mitchell, 1989).

Coarse fragments>2mm: Soil particles > 2 mm in size; they are classed as gravels, cobbles, or stones and are described by size, dominant type, and volume of each class in each soil horizon. Coarse fragments are defined as percent by volume (Luttmerding *et al*., 1990).

Coarse fragment lithology: The rock types that make up the coarse fraction, gravels, cobbles and stones, of the soils material. Lithologies include such types as argillite 'ar' or granite 'gr'.

Coarse woody debris: Refers to large (> 7.5 cm in diameter) dead and down woody material at various stages of decomposition, located above the soil, and not self-supporting. Trees and stumps are considered self-supporting. It is described by five decay classes, with 1 being the least deteriorated and 5 the most deteriorated (RIC, 1997a).

Composition of leading species: A list of dominant vegetation species, described as the total percent (%) cover of each species, in each vegetation layer. Vegetation layers are described and defined in *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Forests and BC Ministry of Environment, 1998a).

Critical wildlife habitat: Part or all of an ecosystem occupied by wildlife species, or a population of such species, that is recognized as essential for the maintenance and long-term survival of the population (Dunster and Dunster, 1996).

Data source: The source of the data used to determine map units. Describes how data that is mapped and/or described in databases has been collected. Data sources can be air photo interpretation, full plot inspections, ground inspections, visual checks, and previous sampling data or maps.

Decile: The proportion (in tenths), of a polygon covered by a particular ecosystem unit.

Depth of forest floor (LFH): The depth of the uppermost layer of organic soil (LFH) measured in centimeters until a mineral soil layer is reached. Describes the organic horizons developed primarily from the accumulation of leaves, twigs and woody materials with or without a minor component of mosses (Luttmerding *et al.*, 1990).

Depth to root restricting layer: The depth (cm) at which a soil layer or condition severely restricts root penetration. A root restricting layer results in no greater than “few” roots being present. Examples of root restricting layers include pans, cemented horizons, compact parent materials, chemical concentrations such as salts, bedrock, and saturated soil conditions (Luttmerding *et al*., 1990).

Depth to water table: The measured depth (cm) of the water table at the time of sampling, as indicated by the surface of the zone of saturation (Luttmerding *et al.*, 1990).

Dominant species: Those species of plants that have the highest cover values in an ecosystem and/or represent the majority of the biomass.

Ecological land classification and mapping: “A hierarchical, multi-factor approach to categorizing and delineating at different levels of resolution, areas of land having similar capabilities and potential for management. These areas of land are characterized by unique combinations of the physical environment, biological communities and human dimension” (Avers *et al*., 1993).

Ecological processes: The actions or events that link organisms and their environment, such as mutualism, successional development, nutrient cycling, carbon sequestration, primary productivity, and decay (Avers *et al*., 1993).

Ecoregion: Areas with major physiographic, minor macroclimatic, or oceanographic differences within each Ecoprovince (Demarchi, 1996). Ecoregions can be used to group biogeoclimatic or marine zones for the determination of historical and potential distribution of vegetation and wildlife.

Ecosection: Areas with minor physiographic and macroclimatic or oceanographic differences, defined at the sub-regional level (Demarchi, 1996).

Ecosystem (terrestrial): A volume of earth-space that is composed of non-living parts (climate, geologic materials, groundwater, and soils) and living or biotic parts, which are all constantly in a state of motion, transformation, and development. No size or scale is inferred. For the purposes of terrestrial ecosystem mapping, an ecosystem is characterized by a ‘plant community’ (a volume of relatively uniform vegetation) and the ‘soil polypedon’ (a volume of relatively uniform soil) upon which the plant community occurs (Pojar *et al*., 1987).

Ecosystem condition: Describes the extent of damage or alteration from the community’s optimal condition and character (regardless of structural stage). Consideration is given to the type and extent of human-induced disturbances or land use, presence of non-native plants, or any other factor that would result in loss of species or ecological function.

Ecosystem defensibility: Describes the extent to which the ecosystem occurrence can be protected from extrinsic human factors that might otherwise degrade or destroy it. Considers the surrounding land use and degree of fragmentation of surrounding landscape.

Ecosystem map unit: Map units represent mappable portions of the landscape (Valentine, 1986). They are established as a result of applying a classification to map polygons. Ecosystem map units include site series, site modifiers, and vegetation developmental units (structural stages and seral community). An ecosystem map unit contains either predominantly one mapping individual (simple map unit) or more than one (compound map unit). Each may contain a certain proportion of other ecosystem units that are unmappable at the scale of mapping (Valentine, 1986).

Ecosystem rarity: Provides a comparative measure of whether an ecosystem is uncommon or common in a given area (e.g., the number of occurrences of a specific ecosystem in a given project area).

Ecosystem unit: Classification units that are generally derived from the site series of biogeoclimatic ecosystem classification by further differentiating the units based on more specific site conditions (e.g., site modifiers), in order to define more homogeneous site units, and vegetation developmental units, in order to define more homogeneous structural stages.

Ecosystem viability: Describes the long-term prospects for continued existence of the community, considering the effects of surrounding land use and the immediate/near future threats to the site.

Elevation: The vertical distance from a datum, typically mean sea level, to a point or object on the Earth’s surface, measured in metres (Dunster and Dunster, 1996).

Existing cattle capacity: The ability of the land in its current state to support cattle (Mumford, 1997).

Expanded legend: An expanded legend is a report that will generally contain descriptive information for each mapped ecosystem. This includes the site series name, all related coding, a description of typical environmental characteristics, and the features that characterize atypical site series as identified by the site modifiers. The vegetation related to structural stages and any important associated features are also described. Presentation of the information can be in a variety of formats. Most agencies have specific requirements as to what must be in the expanded legend.

Flooding/high water: Flooding hazards relate to overflow by rivers, creeks, and streams. Interpretation aids in identification of areas that are prone to this type of flooding. High water relates to the fluctuating of the water table due to periodically high ground water tables and poorly drained catchments (Luttmerding *et al*., 1990).

Flooding regime: The immersion of substrate by water (saturated peats not covered by surface water are NOT considered flooded). Flooding regime on sites can vary in occurrence (annually to never) and in duration (winter flooding to diurnal flooding) (Mackenzie and Banner, 1998).

Forage potential: The potential amount of available forage (kg/ha) for a specific species on a particular site over a given amount of time.

Forage species: Important plant species used for forage by either domestic or native animal species; listed to show the presence and percent cover.

Forest cover map: Shows relatively homogeneous forest stands or cover types; produced by the BC Ministry of Forests and the forest industry from the interpretation of aerial photographs and information collected in field surveys. Information commonly displayed on forest cover maps includes tree species, height class, and age class. These maps are being replaced by Vegetation Resource Inventory (VRI) maps.

Full plot: Full plots, recorded on the Ecosystem Field Form (FS882), provide the most detailed ecological data for a point sample and are intended for classification of site series, confirmation or classification of biogeoclimatic units, and development of ecosystem unit descriptions and summary statistics.

Gap analysis: The analysis of ecological types that are not sufficiently protected or are not in conservation areas. Defines areas considered to be of significant biodiversity value in terms of plant, animal and habitat uniqueness, overall diversity, and species richness and rarity; estimates how much of these areas are protected; then ranks them and makes recommendations for ensuring a certain percentage of each type of area are protected. Gap analysis can be measured at a coarse filter or landscape level, or at a fine filter or ecosystem level.

Genetic materials: see surficial materials.

Geomorphological process: The natural mechanisms of weathering, erosion, and deposition that result in the modification of the surficial materials and landforms at the earth's surface (e.g., mass movement processes such as snow avalanches, slow mass movement, or rapid mass movements (Howes and Kenk, 1997).

Ground inspection: Ground inspections are abbreviated plots (either point or polygon samples) from which data are recorded to confirm the identification of the ecosystem unit. They also provide some data for characterizing ecosystem attributes (e.g., abbreviated species lists can be used to characterize structural stages). They should make up about 20% of inspections at most survey intensity levels. Data should be recorded on the Ground Inspection Form (GIF).

Humus form: The group of possible horizons (L, F, H and O) located above the soil surface which have formed from organic material, and/or soil fauna and may be intermixed with mineral soil. Describes the degree of decomposition and mineralization of soil organic material (Luttmerding *et al.*, 1990). The Orders include Mor, Moder and Mull; an example of a Group is Mormoder.

Hydrogeomorphic classification: A system that classifies the physical state of a wetland or riparian site by broad hydrological processes and concurrent geomorphological patterns (MacKenzie and Banner, 1998).

Hydrogeomorphology: The broad hydrological processes characterizing landscape units and ecosystems by water sources and hydrodynamics. Described by patterns of waterflow, water courses and connectivity in the landscape (RIC, 1997a).

Identified wildlife: Those species at risk that the Deputy Minister of Environment, Lands and Parks, or a person authorized by that Deputy Minister, and the chief forester, agree will be managed through a higher level plan, wildlife habitat area or general wildlife measure (Province of BC, 1995a).

Inclusions: Ecosystem units that represent, generally, less than 20% of the polygon or an area too small to delineate at the scale of mapping. Inclusions as small as 10% of the polygon may be mapped if they represent important elements required to achieve the project objective. In some cases inclusions may be represented by "on-site symbols."

Indicator species: A plant species that is closely correlated with a particular environmental condition or habitat/ecosystem type such that its presence or absence can be used as an indicator of environmental conditions.

Krummholz: Scrubby, stunted growth form of trees, often forming a characteristic zone at the lower edge of the alpine zone, just above the timberline in subalpine forests (Dunster and Dunster, 1996).

Land cover classification: A revision of the forest cover classification that incorporates non-forested components such as wetlands, uplands, alpine areas, estuaries, heath, and krummholz in its delineation of landscape units (RIC 1997a).

Landscape planning: Broad scale planning aimed at ensuring the continued maintenance and health of ecological systems in the landscape (e.g., Landscape Unit Planning, Forest Development Planning, Forest Ecosystem Networks, or Range Unit Plans, as defined in the Forest Practices Code.)

Map legend: For terrestrial ecosystem maps, the map legend is generally an open format which provides a summarized description of all map unit components and map symbols, together with other supporting information including survey objectives, survey intensity, location, field sampling, other data sources, aerial photograph reference numbers, and map credits. The specific layout and the amount of space allocated to each category may vary by project, and other categories may be added as required (e.g., interpretive information for ecosystem units).

Mapsheet number: The BCGS (British Columbia Geographic System) or NTS (National Topographic Series) location, identification for each mapsheet at all scales (e.g., 92F.057).

Microsite: Small but potentially important habitat features such as seepage areas, which are important to a number of wildlife species.

Mineral horizon: A soil horizon containing 17% or less organic carbon (about 30% organic matter) by weight. Mineral horizons may be one or all of A, B, and C horizons, and may have varying proportions of sand, silt, clay, coarse fragments, and organic matter. A soil horizon is approximately parallel to the land surface and has characteristics altered by processes of soil formation (Agriculture Canada Expert Committee on Soil Survey, 1987).

Moisture regime: Indicates, on a relative scale, the available moisture for plant growth in terms of the soil's ability to hold, lose, or receive water. Described as moisture classes from Very Xeric (0) to Hydric (8) (Luttmerding *et al*., 1990).

Municipal settlement planning: Soil and terrain characteristics that may affect municipal planning in terms of development, road building, hazard assessments, resource extraction, greenspaces, etc.

Nutrient regime: Indicates the available nutrient supply for plant growth on a site, relative to the supply on all surrounding sites. Nutrient regime is based on a number of environmental and biotic factors, and is described as classes from Oligotrophic (A) to Hypereutrophic (F) (Luttmerding *et al.*, 1990).

On-site symbol: Symbols that are graphic representations used to display linear, point or polygon features not portrayed by the ecosystem or terrain symbols. They may be manually or digitally created. Examples of features which might be displayed using on-site symbols are eskers, springs and cliffs (Howes and Kenk, 1997).

Open legend: A map has an open legend when the map delineations are not classified into map units. The legend serves to summarize the list of symbols that may be used singly or in combination on a map delineation. Map labels are flexible, depending on the component site units (Mitchell, 1989).

Organic horizons: Found in organic soils and commonly at the surface of mineral soils; they may occur at any depth beneath the surface in buried soils (river flooding, for example), or overlying geologic deposits. Organic horizons contain more than 17% organic C (approximately 30% organic matter) by weight. Two groups of these horizons are recognized: the O horizons (for wetlands) and the L, F, H horizons (for terrestrial humus forms) (Canada Soil Survey Committee, 1978).

Parkland: Subalpine area characterized by forest clumps interspersed with open subalpine meadows and shrub thickets. Vegetation cover may vary in the proportion of treed patches, meadows, and shrub thickets. The term parkland can also be used for lower elevation forest that are open due to restricted moisture availability, such as occurs in the Ponderosa Pine zone.

Partial Cover Flag: Indicates that the overlying material in the terrain component only partially covers the underlying material. Eolian veneer is an example.

Plant community: An assemblage of plants which occurs in areas of equivalent environmental conditions. Plant communities are characterized by certain species which are inconspicuous or unrepresented in other communities. Fundamentally, communities are the result of differing environmental tolerances of the various taxa which compromise the flora, and the heterogeneity of the environment (Daubenmire, 1968).

Plant community conservation: The preservation/conservation of examples of all possible natural plant communities at their climax state. It includes conservation of both common and restricted types of natural plant communities.

Plot number: A unique identifier recorded on field forms. The same number must be recorded on each field form component (e.g., Site, Soil, and Vegetation) and be located and referenced on a map and/or airphoto.

Polygon: Delineations that represent discrete areas on a map, bounded by a line. On an ecosystem map, polygons depicting ecosystem map units are nested within larger polygons containing the biogeoclimatic and ecoregion map units. Polygons depicting ecosystem units represent areas from less than one hectare to several hundred hectares, depending on the scale of mapping.

Polygon adjacency: A determination that provides a measure of how similar the habitats of adjacent polygons are. The relative closeness of one habitat to another can be important for particular species.

Polygon number: A unique identifier for each map polygon, and also serves to link the polygon to the associated database (e.g., 0001).

Potential natural community (PNC): The biotic community that would establish itself on an ecological site if all successional sequences were completed, without interference by humans, under the present environmental conditions. Natural disturbances are inherent in PNC development. The PNC may include acclimatized or naturalized non-native species (Range Term Glossary Committee, 1974). This term is not used by all agencies.

Polygon sliver: A small aerial feature commonly occurring along the borders of polygons following the overlay of two or more coverages.

Pre-typing: Tentative delineations mapped on aerial photographs using patterns in tone, texture, shadows and relief on the photos to distinguish physiographic features (slope, aspect, slope position), overstory vegetation, and parent materials. Map delineation boundaries should be established where changes occurring in air photo features correspond to changes in relevant site units (Mitchell, 1989).

Project name: Text characters to give a unique name to a project; used on field forms such as Ground Inspection Forms, and in databases. Usually appears in the top right corner of field forms used for the particular project (e.g., TEM_Beaver Cove).

Qualifiers: Provide additional information about the mode of geologic formation and/or the depositional environment of surficial materials and about the status of activity of geological processes. Two distinct types of qualifiers are: glacial qualifying descriptors (G), and activity-qualifying descriptors, which are either (A) active or (I) inactive (Howes and Kenk, 1997).

Recreation: The ecological assessment of the land's ability to support recreational activities (e.g., trail building, campsite locations, natural hazards, soil erosion).

Riparian classification: The systematic arrangement or groupings of riparian ecosystems based on established criteria (Mackenzie and Banner, 1998).

Riparian ecosystem: Terrestrial areas where the vegetation complex and microclimate conditions are products of the combined presence and influence of perennial and/or intermittent water, associated high water tables and soils that exhibit some wetness characteristics. Normally used to refer to the zone within which plants grow rooted in the water table of rivers, streams, lakes, ponds reservoirs springs marshes, seeps, bogs, and wet meadows (Dunster and Dunster, 1996). Ecosystems that occur next to streams and lakes and are influenced by flooding, sedimentation, erosion and/or subterranean irrigation (McKenzie, 1998).

Riparian/wetland management: Managing riparian and wetland ecosystems in order to ensure the maintenance and health of a diversity of viable riparian and/or wetland habitats within the landscape.

Root restricting type: See "Depth to root restricting type."

Scale: The degree of resolution at which ecological processes, structure, and changes across space and time are observed and measured (Avers, 1993). Common scales of terrestrial ecosystem mapping are 1:20 000 and 1:50 000.

Seepage depth: The depth, in a "soil pit," of temporary or permanent subsurface water, measured from the ground surface to water level, at the time of sampling.

Seral association: It is based on identification and prediction of the sequences of seral plant associations and structural/developmental stages that occur over time on a site in preclimax condition (Hamilton, 1988). The seral association describes the vegetation at the present time.

Seral community type: Generalized seral units dominated by a similar group of plant species, often in the upper strata (tree and/or shrub layers in the case of forest and shrub communities; shrub or herb layers, in the case of shrub steppe or grassland communities), but being more variable in understory composition than occurs in true seral associations.

Shrub crown closure: A measure of the area covered by the total shrub layer within a specified area and expressed as percentage.

Site association: Site associations are all ecosystems capable of producing vegetation belonging to the same plant association (or subassociation, in some cases) at climax. A site association is a group of ecosystems physically and biologically similar enough that they have or would have similar vegetation at climax (Meidinger and Pojar, 1991).

Site disturbance: Disruption to a site as a result of either natural events or human activities, such that the resulting vegetation and soil characteristics of the site differ from those expected at climax. Examples include fire, forest harvesting, wildlife browsing, and avalanching.

Site index/productivity: Describes the relative productivity of forest sites for growth of trees. Site index relationships are used to determine forest site productivity.

Site modifiers: Site modifiers are used to characterize site conditions more specifically where they differ significantly from the typical conditions described for a site series in the *Provincial Site Series Mapping Codes And Typical Environmental Conditions* (RIC, 1997b). A list of standard site modifiers has been developed and others may be added on a project specific basis. The standard list of site modifiers is based on topography, moisture, and/or soil factors. Up to two modifiers can be used per site series (e.g., HF**sw** indicates a HwCw–Falsebox–Feathermoss site series that is atypical in that it occurs on shallow soils and warm aspects).

Site preparation: Any planned measure to prepare a site for the favorable reception and satisfactory growth of naturally disseminated seed, sown seed, or planted seedlings.

Site sensitivity: see soil and site sensitivity.

Site series: Describes all land areas capable of producing the same late seral or climax plant community within a biogeoclimatic subzone or variant (Banner *et al*., 1993). Site series can usually be related to a specified range of soil moisture and nutrient regimes within a subzone or variant, but other factors, such as aspect or disturbance history may influence it as well. Site series form the basis of ecosystem units.

Slope: Recorded as a (%) percent gradient of the land (Province of BC, 1998).

Slope (meso) position: The position of a site relative to a local catchment area. Slope position ranges from crest or ridge positions to level ground (Province of BC, 1998).

Soil and site sensitivity: Describes the potential negative impacts that could affect an ecosystem in response to resource extraction, road building, or other human activities. Site sensitivities are categorized by the following (Province of BC, 1995b):

- Soil Compaction Hazard
- Mineral Soil Displacement Hazard
- Surface Erosion Hazard
- Mass Wasting Hazard
- Forest Floor Displacement Hazard

Soil bulk density: (also called apparent density) The mass of dry soil per unit of bulk volume. The bulk volume is determined before the soil is dried to constant weight at 105^{o}C (Canada Department of Agriculture, 1972).

Soil classification: The systematic arrangement of soils into categories on the basis of their similar characteristics, such as acidity, degree of slope, texture, structure, land use capability, etc. (Canada Department of Agriculture, 1972). Soil classification taxonomy follows the Canadian System of Soil Classification (Canada Soil Survey Committee, 1978).

Soil compaction: The process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per cubic foot (Soil Conservation Society of America, 1982). Soil compaction can be interpreted once soil texture, soil moisture, and soil class are known. This information is important to range, agriculture, forestry interpretations.

Soil depth: The depth (cm) of soil material that plant roots can penetrate readily to obtain water and plant nutrients; the depth (cm) to a layer that differs sufficiently from the overlying material in physical or chemical properties to prevent or seriously retard the growth of roots (e.g., Depth to Root Restricting Layer, Depth to Water Table, etc.) (Soil Conservation Society of America, 1982).

Soil drainage: “The rapidity and extent of water removal from the soil in relation to *additions*, especially by surface runoff and by percolation downwards through the soil” (RIC, 1994). Note: the soil drainage rating must consider the climatic regime to better estimate the ‘additions’ to the soil system. For example, in the Coastal Western Hemlock zone and other similar “wet” areas, rainfall and snowfall play a major role. As such, moderately well-drained and imperfectly drained classes are common. Soil drainage is not a permeability rating *per se*.

Soil infiltration rate: Determines the rate with which moisture is absorbed by a soil type. For example, a sandy soil has a very rapid infiltration rate, while a clay soil has a much slower infiltration rate.

Soil moisture holding capacity: Refers to the percentage of water by volume retained in the soil after it has been saturated and then allowed to drain for 24 hours (Wilde, 1958).

Soil perviousness: The degree to which the total volume of a soil, sediment, or rock is permeated with pores or cavities, generally expressed as a percentage of the whole volume unoccupied by solid particles (Soil Conservation Society of America, 1982).

Soil salinity: The amount of soluble salts in a soil, expressed in terms of percentage, parts per million, or other convenient ratios (Canada Department of Agriculture, 1972).

Soil nutrient regime: Indicates on a relative scale the available nutrient supply for plant growth (with emphasis on soil pH and the exchangeable cations Ca, Mg, Na, and K) The soil’s nutrient regime integrates many environmental and biotic parameters which, in combination, determine the actual amounts of available nutrients. It is a dynamic property, characterized by inputs and losses, with seasonal variations. The aim of the assessments is to derive an estimate of the available nutrient supply for a site which will characterize it relative to all other sites within the respective biogeoclimatic subzone or other biogeoclimatic unit (Luttmerding *et al*., 1990).

Soil texture: The relative proportions (%) of the various soil separates in a soil as described by the classes of soil texture (e.g., sand, silt, clay) (Canada Department of Agriculture, 1972). Soil textures are defined on a soil textural triangle and differ from the “terrain” texture classes.

Stand composition modifiers: Used to differentiate structural stages. Stand composition modifiers differentiate coniferous, broadleaf, and mixed stands.

Structural stage modifiers: Used to differentiate structural stages. Non-forested structural stage modifiers provide further differentiation based on life form and relative cover of individual state. Forested structural stage modifiers describe stand structure types based on the relative development of overstory, intermediate and suppressed, crown classes.

Structural stage: Describes the existing dominant stand appearance or physiognomy for a land area. Factors such as disturbance history, stand age, species composition and chance all influence structural stage. Structural stages range from non-vegetated to old forests. The additional modifiers of stand composition and stand structure can be used to further differentiate structural stage categories.

Suitability: The ability of the habitat in its current condition to provide the life requisites of a species (RIC, 1997c).

Surface erosion potential: The potential for detachment and movement of soil or rock fragments by water, wind, ice, or gravity. The land surface may be worn away by running water, wind, ice, or other geological agents, including such processes as gravitational creep.

Surface expression: The form and patterns of forms expressed by surficial material at the land surface. The three-dimensional shape of the material is equivalent to "landform" used in a non-genetic sense (e.g., ridges, plain) Surface expression also describes the manner in which unconsolidated surficial materials relate to the underlying unit (e.g., veneer, blanket, hummock and terrace) (Howes and Kenk, 1997).

Surficial (genetic/parent) material: The non-lithified, unconsolidated sediments occurring on the earth's surface. They are materials produced by weathering, biological accumulation, human, and volcanic activity. They include: residual materials weathered from rock *in situ*; transported materials composed of mineral, rock and organic fragments deposited by water, wind, ice, gravity, or any combination of these agents; accumulated materials of biological origin including human-made deposits; and unconsolidated pyroclastic sediments. **Depths of surficial material** are mainly designated by surface expression codes (see Surface Expression); 'b' blankets indicate materials greater than 1 metre; 'v' veneers indicate materials less 1 metre; and 'x' indicates very shallow materials (2–20 cm deep). In general surficial materials are of young geologic age and make up the parent material of most soils. (Howes and Kenk, 1997).

Survey intensity level: A measure of sampling density, expressed as a percentage of the map polygons that have been field inspected or as the number of hectares per field inspections.

Terrain texture: Describes the size, roundness and sorting of particles in unconsolidated clastic sediments, and the proportion and degree of decomposition of plant fibre in unconsolidated organic sediments. Specific clastic terms include blocks, boulders, cobbles, pebbles, sand, silt, and clay. Common clastic terms include mixed fragments, angular fragments, gravel, rubble, mud, and shells. Organic terms include fibric, mesic, or humic (Howes and Kenk, 1997).

Threatened/endangered species: A plant or animal species is classified as threatened if it is experiencing definite noncyclical decline throughout all or a major portion of its British Columbia ranges or has an extremely restricted distribution in a habitat with a high probability of environmental degradation. A plant or animal species is classified as endangered if it is an indigenous species that, on the basis of the best available scientific evidence, is indicated to be threatened with imminent extirpation or extinction. These species are identified as "red and blue listed" by the Ministry of Environment, Lands and Parks.

Tree crown closure: A measure of the area covered by the forest canopy, within a specified area and expressed as percentage.

Tree species selection: Tree species for regeneration of mapped unit. Based on biogeoclimatic and site unit along with specific site features.

TRIM (Terrain Resource Information Management): A base map produced, both in digital and hard copy form, for display at a scale of 1:20 000. Includes contour, water body, and other features for areas in British Columbia, including roads, pipelines and towns.

UTM (Universal Transverse Mercator): A grid present on most topographic maps and used for quantitative descriptions of locations (RIC, 1994).

Vegetation complex: Describes classes of post-disturbance vegetation communities. Twenty-two vegetation complexes are currently defined by Newton and Comeau (1990).

Vegetation potential: Describes the relative magnitude of the potential of a site to produce post-logging (or post-disturbance) vegetation that may, at high volumes, affect crop trees, as well as provide forage for cattle and wildlife and habitat for certain wildlife species.

Vegetation resource inventory (VRI) maps: A map showing relatively homogeneous forest stands or vegetation cover types, produced from the interpretation of aerial photos and information collected in field surveys, by the BC Ministry of Forests and the forest industry. Information commonly displayed on forest cover maps includes tree species, height class, age class, and land cover classes for non-forested units.

Visual check: Visual checks are the least detailed and also the predominant form of field inspection, accounting for approximately 75% of inspections, and can take the form of notes on photos or maps, notes in a field book, notes recorded on tape, or polygon summaries on Ground Inspection Forms. These checks are intended to be quick inspections for mapping purposes and can include one or more of the following: confirm site series, site modifiers or structural stage, terrain attributes, soil textures and soil depths, briefly describe vegetation, assess biogeoclimatic mapping, record ecosystem or terrain component percentages, evaluate polygon boundaries, or note special features. Visual checks can be either point or polygon samples.

Water source: The most influential source of water on a site (e.g., precipitation, groundwater and others), usually determined qualitatively (Province of BC, 1998).

Wetland: Semi-terrestrial sites where the water table is at, near, or above the soil surface and soils are water-saturated for a sufficient length of time that excess water and resulting low soil oxygen levels are principal determinants of vegetation and soils development. Wetlands must have either plant communities characterized by species that normally grow in soils water-saturated for a major portion of the growing season (“hydrophytes”), or soils with surface peat (“O”) horizons or gleyed mineral horizons (Bg or Cg) within 30 cm of the soil surface (Mackenzie, 1998).

Wetland classification: The systematic grouping or arrangement of wetland ecosystems based on established criteria (Mackenzie and Banner, 1998).

Wetland realm/class: Realm is the broadest level of distinction that delineates major biotic types, which reflect gross site differences in water abundance, quality, and source. The Class is an ecosystem classification unit describing sites that have broadly similar vegetation physiognomy, hydrology, and water quality (Mackenzie, 1998).

Wildlife capability: see Capability

Wildlife suitability: see Suitability

Wildlife trees: A standing live or dead tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife. Characteristics include large diameter and height for the site, current use by wildlife, declining or dead condition, value as a species, valuable location, and relative scarcity (Province of BC, 1995b).

Windthrow hazard: An assessment of terrain and soil limitations (drainage, texture, effective rooting depth, etc.) and the relationship to tree root stability. Ratings are based on soil limitations only and do not account for winds, stand composition, or other management practices.

Working legend: A tentative legend established once the field reconnaissance has been completed, linking ecosystem units to recognizable terrain, landscape, and biological characteristics, including such terrain and landscape attributes as surficial material and surface expression, soil drainage, soil depth, slope, aspect, and slope position, and such biological characteristics as overstory tree species and stand density. The working legend should list all ecosystem units that are expected to occur in the study area, and should include codes and names.

Zonal: Refers to the climatic climax plant community; that which best reflects the mesoclimate or regional climate of an area and is independent of local relief and soil parent material (Meidinger and Pojar, 1991).

Appendix B: Data Sources

A variety of **data sources** exist which can provide valuable information for all stages of an ecological mapping project including:

1. information prior to beginning any ecological mapping project.
2. information used during map production.
3. information incorporated into the ecological database.

Data sources such as air photographs, TRIM base maps, and biogeoclimatic maps, provide baseline data necessary to undertake and complete any level of mapping. The specific data sources which are needed, as well as the level of information needed from each of them is determined by:

1. the project objectives,
2. how the map data is to be used, and
3. the level of detail desired.

The following provides a general overview of data sources available for producing ecological maps, and where they maybe located.

TEM Website

The Terrestrial Ecosystem Mapping (TEM) website is currently under construction and will contain links to many of the data sources described in this Appendix. It will include updates to material related to TEM as well as a section for frequently asked questions. This site should be visited regularly in order to keep up to date with current TEM developments.

TEM website: http://www.env.gov.bc.ca/rib/wis/tem

Ecomapper

'Ecomapper' is a mailing list meant to provide a forum for discussion on issues and ideas related to implementing the Terrestrial Ecosystem Mapping (TEM) methodology in British Columbia and to answer questions from mappers. The list will forward all questions, comments, and replies to all subscribers.

All questions to the methodology committee will be answered, however some reasonable time period may be required to prepare a proper response. Feel free to use this list to discuss anything related to TEM.

To subscribe to this list, send an e-mail message to:

majordomo@lists.gov.bc.ca

with the following command in the body of the message and no signature:

subscribe ecomapping OR **subscribe ecomapping your-email@your-host.whatever**

where the your-email@your-host.whatever is an optional field containing the address which you are subscribed to the list with (e.g., jmapper@TEMnet.com).

If you would like to unsubscribe from this list, just send an e-mail message to:

majordomo@lists.gov.bc.ca

with the following command in the body of the message and no signature:

unsubscribe ecomapping OR **unsubscribe ecomapping your-email@your-host.whatever**

where the your-email@your-host.whatever is an optional field containing the address which you are subscribed to the list with. This optional field comes in handy when you are trying to unsubscribe from a different address than the one on the subscribers list.

To send a message to the list (all other subscribers), send mail to

ecomapping@lists.gov.bc.ca

If you have any additional questions about the list, please send a message to the list owners at

ecomapping-owner@lists.gov.bc.ca

Training

Training to prepare and interpret terrestrial ecosystem mapping is available through the BC Forestry Continuing Studies Network. Currently there is a five-day TEM course, Introduction to Terrestrial Ecosystem Mapping Techniques, which is geared towards training individuals in all steps of producing terrestrial ecosystem maps. It presents the classification and methodological concepts outlined in this manual. There is also a two-day TEM course, Deriving Interpretations from Ecosystem Maps, which is designed to show how ecosystem mapping can be used to develop interpretations for forestry, range, biodiversity, terrain, and wildlife management issues within the scope of the Forest Practices Code (FPC) requirements. It is intended for those individuals who administer, use, and interpret ecosystem mapping projects and products. Another five-day course, Describing Terrestrial Ecosystems in the Field, has been developed. It is designed to train individuals in the field identification and coding standards of all components found on the Ecosystem Field Forms (FS882), based on the 1998 standards.

A course on the Standards and Procedures for Wildlife Habitat Capability and Suitability Ratings will be piloted in the spring of 1998. It will be designed to train individuals in the standards and procedures for wildlife habitat capability and suitability ratings. This course will include use of the wildlife habitat assessment portion of the Ecosystem Field Form (FS882). Additional TEM related courses are also offered including Field Identification of Soil Properties and Classification, Understanding and Using Terrain Maps and An Introduction to Biogeoclimatic Ecosystem Classification. Please contact Kandy Akselson of the BC Forestry Continuing Studies Network, at (250) 365-7292 ext. 377 for further information regarding any of the above courses.

Aerial Photography and Remote Sensing Data

Aerial photographs can be purchased from Geographic Data BC at a variety of scales. It is the scale which determines the amount of detail the image provides, therefore it is not recommended that the scale of the photo be smaller than the scale of the mapping project. The variety of display choices range from black and white, colour, vertical, oblique, to orthophotos. Colour photos are the recommended choice if available.

Baseline thematic mapping depicts land use, ground cover and topographic features at 1:400K and 1:250K scale, based on satellite imagery interpretations. This information is useful for a general overview of a given study area but is not recommended for ecosystem mapping at much larger scales.

Ministry of Environment, Lands, and Parks
Geographic Data BC Branch
Customer Support
3rd. Fl., 1802 Douglas St.,
Victoria, BC
Canada, V8V 1X4
Tel: (250) 387-1441
Fax: (250) 356-3022

Bedrock Geology

Bedrock geology maps describing the various geologic eras in which the **bedrock types** were formed can be obtained from the Geologic Survey of Canada, and the British Columbia Geological Survey Branch. A one to one million Geologic Atlas compiled by Souther *et al.* (1979), Roddick *et al.* (1979), Tipper *et al.* (1979), Hutchison *et al.* (1979), and Price *et al.* (1977) provides a detailed and consistent overview of the bedrock types of British Columbia. Other sources of geologic data are the Geologic Survey of Canada 1981, 1982, 1985, and 1987 indices of geology reports and maps for British Columbia.

Ministry of Employment and Investment
Geological Survey Branch
PO Box 9320, Stn Prov Gov't
5th floor, 1810 Blanshard Street
Victoria, BC V8W 9N3
Tel: (250) 952-0429
Fax: (250) 952-0381

Natural Resources Canada
Geologic Survey of Canada
101 – 605 Robson Street
Vancouver, BC
Tel: (604) 666-0529
Fax: (604) 666-1337 (Sales)

Biogeoclimatic Zonation and Site Series

Biogeoclimatic maps for the six forest regions are available from the regional Ministry of Forests offices at the following scales: 1:500 000 for Prince Rupert, 1:250 000 for Prince George, Cariboo, Nelson, and Vancouver, and 1:100 000 for Kamloops. Digital copies of these maps are available through the Ministry of Forests Research Branch. There is also a 1:2 000 000 Provincial Biogeoclimatic Map available from Ministry of Forests Publications, (250) 387-6719.

The publication Ecosystems of British Columbia (Meidinger and Pojar, 1991) provides an overview of the biogeoclimatic classification system and which biogeoclimatic zones, subzones, and variants have been described to date. The 1997 list of codes and names for the BEC zones, subzones and variants is available on the Ministry of Environment, Lands, and Parks ftp site (address below). A word document titled, BEC97.doc. As well, each of the six Forest Regions have produced field guides for the identification and interpretation of site level ecosystems. These field guides can be obtained from Crown Publications.

All of the site units (ecosystem units) have been given two-letter codes, unique to each subzone and variant; as well as brief descriptions of the typical situations in which each unit occurs. A table listing all of the ecosystem units, including two-letter codes, typical situations, typical moisture regimes, and site modifiers is available on the Ministry of Environment, Lands and Parks ftp site. The excel table is called map_code.xls. It will be updated to include any new codes in the spring and fall of each year. A notice will be sent out on ecomapper once the table has been updated.

Ministry of Environment, Lands, and Parks ftp site:
IP address: 142.36.8.37
UserId: anonymous
Password: guest
or URL ftp://wldux2.env.gov.bc.ca/pub/TEM

The ftp directory is pub/TEM and the file names are BEC97.doc (Word 6.0) and map_code.xls (Excel 4.0).

or TEM website: http://www.env.gov.bc.ca/rib/wis/tem

Ministry of Forests
Research Branch
P.O. Box 9519, Stn Prov Gov't
Victoria, BC
Canada, V8W 9C2
Tel: (250) 387-6721
Fax: (250) 387-0046
Website: http://www.res.for.gov.bc.ca/

Crown Publications Inc.
521 Fort Street
Victoria, B.C V8W 1E7
Tel: (250) 386-4636
Fax: (250) 386-0221

E-mail: crown@pinc.com
Website: http://vvv.com/crownpub/

Ecoregions

The 1997 list of ecoregions and ecosections with appropriate codes can be found on the Ministry of Environment, Lands, and Parks ftp site. The word document is titled 97Ecoreg.doc.

Ecoregions have been mapped for the entire province at scales of 1:2 000 000 and 1:500 000. The 1:2 000 000 ecoregion map (available from the Ministry of Environment) exists as an overlay and can be used to accompany the 1:2 000 000 provincial biogeoclimatic map. The Prince Rupert (1:500 000) and Vancouver (1:250 000) biogeoclimatic maps include Ecoregion and Ecosection designations.

Ministry of Environment, Lands, and Parks ftp site:
IP address: 142.36.8.37
UserId: anonymous
Password: guest

or URL ftp://wldux2.env.gov.bc.ca/pub/TEM

The ftp directory is pub/TEM and the file name is 97Ecoreg.doc (Word 6.0).

Ministry of Environment, Lands and Parks
Resources Inventory Branch
Wildlife Inventory Section
P.O. Box 9344, Stn Prov Gov't
Victoria, BC V8W 9M1
Website: http://www.env.gov.bc.ca/rib/wis/tem

Soils

Most soil and soil/landform maps are produced at scales ranging from 1:20 000 to 1:50 000. These maps and reports are available from Geographic Data BC Information on soil surveys may also be obtained from Agriculture Canada. Some soils surveys have been digitized in either federal (CANSIS) or Provincial (CAPMAP) computerized soil information systems (Agriculture Canada 1990). These systems are no longer in use and conversion to modern GIS systems is underway in the BC Ministry of Agriculture, Food, and Fisheries.

Another series of maps were produced by the Canada Land Inventory (CLI) program between 1965 and 1990, based on reconnaissance and detailed soil surveys. Mapping themes included soil capability for agriculture, land capability for forestry, land capability for ungulates (wildlife), land capability for waterfowl, and land capability for recreation. Scales of mapping range between 1:20 000 and 1:250 000. Most titles are out of print but some may be available through Geographic Data BC or the Canada Map Office.

Ministry of Environment, Lands, and Parks
Geographic Data BC Branch
Customer Support
3rd. Fl., 1802 Douglas St.,

Victoria, BC
Canada, V8V 1X4
Tel: (250) 387-1441
Fax: (250) 356-3022
Website: http://www.env.gov.bc.ca/gdbc/

Ministry of Agriculture, Food, and Fisheries
Resource Planning Branch
2nd Floor, 808 Douglas Street
Victoria, BC V8W 9B4
Tel: (250) 387-0242
Fax: (250) 356-0044
Website: http://www.agf.gov.bc.ca/agric/resplan/bcsoils/soil.htm

– A catalogue showing available soil and soil/landform maps and reports.

Agriculture Canada
Land Resource Research Unit
6660 NW Marine Drive
Vancouver, BC V6T 1X2
Tel: (604) 224-4355
Fax: (604) 666-4994

– Most maps have been produced at 1:100 000 scale.
– CANSIS data maybe available.

Natural Resources Canada
The Canada Map Office
130 Bentley Rd.
Ottawa, Ontario K1A 0E9
Tel: 800-465-6277
Fax: 613-957-8861
E-mail address: info@geocan.nrcan.gc.ca
Website: http://maps.NRCan.gc.ca/cmo/dealers.html

Agriculture and Agri-Food Canada. 1998. The Canadian System of Soil Classification. 3rd ed. Publ. 1646. Ottawa 187 pp.

Contact: NRC Research Press, National Research Council Canada (613) 993-0151.

Surficial Geology (Terrain, Surficial Material, Landform)

The terrain classification system presently being used in British Columbia is the "Terrain Classification System for British Columbia," Howes and Kenk, Version 2.0 (1997). This publication contains definitions, descriptions, and diagnostic characteristics to aid in the photo-interpretation of landforms. The Terrain Geology Task Group, of the Earth Sciences Task Force of RIC has developed the Guidelines and Standards to Terrain Geology Mapping in British Columbia (RIC, Jan. 1996) which uses the classifications in Howes and Kenk, Version 2.0 (1997) and should be used in conjunction with that document. Combined, these documents should be viewed as the primary source of provincial terrain standards. If surficial information has already been mapped for a project area, it appropriateness will need to be assessed in relation to the objectives and standards of the current project.

Surficial Geology maps are available from a wide variety of sources and are described in an equally disparate manner, a few of which are listed below. A discussion of the descriptions and sources can be found in RIC Jan. 1996.

Ministry of Employment and Investment
Geological Survey Branch
PO Box 9320, Stn Prov Gov't
Victoria, BC V8W 9N3
Tel: (250) 952-0429
Fax: (250) 952-0381
Website: http://www.ei.gov.bc.ca/geosmin/mapinv/surfical.htm

– Historical bedrock information
– Digital Terrain and/or Soils and Landform maps available at 1:20 000, 1:50 000 1:100 000 and/or 1:250 000.

Natural Resources Canada
Geologic Survey of Canada
101 – 605 Robson Street
Vancouver, BC
Tel: (604) 666-0529
Fax: (604) 666-1337 (sales)

Crown Publications Inc.
521 Fort Street
Victoria, BC V8W 1E7
Tel: (250) 386-4636
Fax: (250) 386-0221
E-mail address: crown@pinc.com
Website: http://vvv.com/crownpub/

– Provides information on bedrock and surficial materials produced federally and provincially.
– An index of the reports and maps produced for BC is updated periodically

Topography

Topographic maps are available at a variety of scales (1:20 000, 1:50 000, 1:100 000, 1:250 000) for the province and are usually gridded using the NTS (National Topographical System) and the BCGS (British Columbia Geographic System). UTM and Latitude/ Longitude grids are usually included on these maps. For the purposes of Terrestrial Ecosystem Mapping, BCGS maps are preferred.

TRIM (Terrain Resource Information Mapping) maps and reports at 1:20 000 and Ministry of Environment maps at 1:250 000 can be ordered from Geographic Data BC. TRIM maps at 1:50 000 for selected areas are also available from the Ministry of Forests, Forest Practices

Branch. Where available, TRIM maps should be used as the standard for topographic information.

Ministry of Environment, Lands, and Parks
Geographic Data BC Branch
Customer Support
3rd. Fl., 1802 Douglas St.,
Victoria, BC
Canada, V8V 1X4
Tel: (250) 387-1441
Fax: (250) 356-3022
Website: http://www.env.gov.bc.ca/gdbc/

– 1:20000 TRIM maps available

Ministry of Forests
Forest Practices Branch
P.O. Box 9513, Stn. Prov. Gov't
Victoria, BC V8W 9C3
Tel: (250) 387-6656
Fax: (250) 387-6751

Crown Publications Inc.
521 Fort Street
Victoria, BC V8W 1E7
Tel: (250) 386-4636
Fax: (250) 386-0221
E-mail address: crown@pinc.com
Website: http://vvv.com/crownpub/

– 1:50 000 NTS maps available

Natural Resources Canada
The Canada Map Office
130 Bentley Rd.
Ottawa, Ontario K1A 0E9
Tel: 800-465-6277
Fax: 613-957-8861
E-mail address: info@geocan.nrcan.gc.ca
Website: http://maps.NRCan.gc.ca/cmo/dealers.html

Vegetation

Vegetation maps, including forest cover maps, are used to aid in the delineation of map units based on major vegetation and stand structure attributes. Vegetation maps have been produced in the past at a variety of scales by variety of sources, including the Ministry of Environment. Some of these maps may be available from Geographic Data BC. Further information on vegetation can be gathered from forest cover maps, such as tree species, stand age, and disturbance history. With the implementation of the new Ministry of Forests

Vegetation Resources Inventory, information on understory vegetation, structural stages, coarse woody debris, and snags will also be available.

Forest Cover Maps are available in hardcopy or digital form from Ministry of Forests. Forest Cover maps can also be accessed as digital files off of the BCSYS Network.

Ministry of Forests
Resources Inventory Branch
Digital Data Sales Distribution Centre
PO Box 9516, Stn Prov Gov't
Victoria, BC V8W 9C2
Tel: (250) 387-1314
Fax: (250) 387-5999
Website: http://www.for.gov.bc.ca/resinv/products/DigData/brochure.htm

– Forest Cover information is also available from the Ministry of Forests District offices.

Ministry of Forests, Resources Tenure and Engineering Branch
PO Box 9510, Stn Prov Gov't
Victoria, BC V8W 9C2
Tel: (250) 387-5291
Fax: (250) 387-6445
Website: http://www.for.gov.bc.ca/RTE/rtehome.htm

– Forest Atlas (1:20000 scale) provides spatial information regarding forest tenures, forestry and logging roads, trails, harvesting history, and gravel pits.

Database Formats

Ecosystem map database manuals, including formats for polygon database development and for GIS specifications have been developed by the Ministry of Environment, Lands, and Parks and are available on the ftp site. These manuals outline the standards and procedures for capturing, storing, and distributing ecological and terrain data for GIS as well as other database systems.

Currently there is a database and analysis package for field data available; it is called VENUS (Vegetation and Environmental data NexUS). The current version is 3.0 but the program could be subject to change so the TEM website should be consulted for the latest version of VENUS. Further information regarding the VENUS 3.0 or earlier versions of the VENUS data entry program and tabling software, can be obtained from:

Ministry of Forests ftp site:
IP address: 142.36.191.210
UserId: anonymous
Password: guest
The ftp directory is pub/VENUS

OR

URL address: ftp://cowichan.for.gov.bc.ca/pub/VENUS

OR

TEM website:
http://www.env.gov.bc.ca/rib/wis/tem

If you encounter problems downloading the program or entering data, or simply have questions regarding VENUS, please contact Greg Britton, Ecology Data Analyst, at the Research Branch, Ministry of Forests.

Tel:(250) 387-6717.
Fax: (250) 387-0046
e-mail address: Greg.Britton@gems8.gov.bc.ca

Resources Inventory Committee. 1997. Data Standards for Terrestrial Ecosystem Mapping in British Columbia. Resources Inventory Committee, Victoria, BC.

Contact: Ministry of Environment
TEM website: http://www.env.gov.bc.ca/rib/wis/tem

Data Forms

Guidelines for the field collection of ecological data has been well documented in the *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Forests and BC Ministry of Environment, 1998a). This document includes information, guidelines, and field forms (FS882) required for coarse woody debris and wildlife tree data collection, along with site, soil, vegetation, mensuration, and wildlife habitat data collection. There is also a revised field form for doing ground inspections, and visual checks. This form is called the Ground Inspection Form (GIF).

The above data collection guidelines and the associated field forms should be viewed as the standard for all ecological data collection in the field. Information about ordering these dataforms can be found on the TEM website.

Other Data Sources

The list of potential sources of data useful for ecological mapping is extensive. The above list comprises the recommended data sources for some of the primary data needs of ecological mapping projects.

Web browsers are also available which provide further information regarding the different map products and publications that are available, along with their sources.

These include:

Geographic Data BC Branch site at: http://www.env.gov.bc.ca/gdbc/

Land Data BC site at: http://www.landdata.gov.bc.ca/

Resources Inventory Committee at: http://www.for.gov.bc.ca/RIC

Appendix C: Natural Disturbance Types

Natural disturbance types (NDTs) as outlined in the Forest Practices Code Biodiversity Guidelines (1995) characterize areas with different natural disturbance regimes. Natural disturbance regimes include fire, wind, insects and disease. The following five natural disturbance regimes are recognized in the Forest Practices Code *Biodiversity Guidebook*:

NDT	**Definition**
NDT1	Ecosystems with rare stand-initiating events
NDT2	Ecosystems with infrequent stand-initiating events
NDT3	Ecosystem with frequent stand-initiating events
NDT4	Ecosystem with frequent stand-maintaining events
NDT5	Alpine Tundra and Subalpine Parkland ecosystems

All of the Biogeoclimatic subzones and variants recognized provincially have been classed into one of the above natural disturbance types. These natural disturbance types have been used in the Standard for Terrestrial Ecosystem Mapping to help define structural stages for mature and old forests. This document recognizes that because of their frequent stand initiating events, ecosystems falling under NDT3 should be considered mature and old sooner than all of the other NDTs. As outlined in Table 3.3, ecosystems falling within the Biogeoclimatic subzones/variants listed under NDT3 are recognized as being mature starting at 80–120 years, and old at greater than 140 years (100 years for BWBS). Other ecosystems within NDT1, NDT2, NDT 4 and NDT5 are considered mature starting at 80–120 years, and old greater than 250 years. For simplification the table below lists all subzone/variants recognized under NDT3, and calls them **Subzone Group A**. All subzone/variants recognized under NDT1, NDT2, NDT 4 and NDT5 are listed under**, Subzone Group B**.

GROUP A & B BIOGEOCLIMATIC ZONES IN BRITISH COLUMBIA

Zones	Group A Subzones: NDT1 (Old at greater than 140 years.)		Group B Subzones: NDT2, 3, 4, & 5 (Old at greater than 250 years.)	
BG			BGxh (all variants)	BGxw (all variants)
BWBS	BWBSdk (all variants)	BWBSvk		
	BWBSmw (all variants)	BWBSwk (all variants)		
CDF				CDFmm
CWH			CWHdm	CWHwm
			CWHds (all variants)	CWHws (all variants)
			CWHmm (all variants)	CWHvh (all variants)
			CWHms (all variants)	CWHvm (all variants)
			CWHwh (all variants)	CWHxm (all variants)
ESSF	ESSFdc (all variants)	ESSFdv	ESSFmc	ESSFwk (all variants)
	ESSFdk	ESSFxc	ESSFmk	ESSFwv
			ESSFmm (all variants)	ESSFvc
			ESSFmw	ESSFvv
			ESSFmv (all variants)	ESSFxv
			ESSFwm	All ESSF parkland variants
			ESSFwc (all variants)	
ICH	ICHdk	ICHmk2	ICHmm	ICHwc
	ICHdw	ICHmw3	ICHmc (all variants)	ICHwk (all variants)
	ICHmk1		ICHmk3	ICHvc
			ICHmw1	ICHvk (all variants)
			ICHmw2	ICHxw
IDF			IDFdk (all variants)	IDFxh (all variants)
			IDFdm (all variants)	IDFxm
			IDFmw (all variants)	IDFxw
			IDFww	
MH				MHmm (all variants)
				MHwh (all variants)
				All MH parkland variants
MS	MSdc	MSxk		
	MSdk	MSxv		
	MSdm (all variants)			
PP			PPdh (all variants)	PPxh (all variants)
SBPS	SBPSdc	SBPSmk		
	SBPSmc	SBPSxc		
SBS	SBSdh (all variants)	SBSmk (all variants)	SBSwk1 mountain	SBSvk
	SBSdk	SBSmm	SBSwk2	
	SBSdw (all variants)	SBSmw		
	SBSmc (all variants)	SBSwk1 plateau		
	SBSmh	SBSwk3		
SWB			SWBdk	SWBmks
			SWBmk	SWBvks
			SWBdks	