INVERMERE TIMBER SUPPLY AREA PREDICTIVE ECOSYSTEM MAPPING (PEM) FINAL PROJECT REPORT

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We appreciate being able to use Dr. Bob MacMillan's LMES terrain surrogate model and think that it provided an adequate and affordable substitute for traditional and more costly bioterrain mapping. The "Invermere Model" of PEM mapping is being applied to the Quesnel PEM project as an inexpensive alternative to other forms of raster based PEM mapping.

1.0 Introduction

1.1 History of the Project

Predictive Ecosystem Mapping (PEM) was tendered by Slocan Forest Products, Radium Division in February 2003 to be used in support of Timber Supply Review activities scheduled for the fall of 2003. Budget restrictions early in the 2003/2004 fiscal year resulted in the contract for PEM throughout the Invermere TSA to be split between the Timber Harvesting Landbase, funded through Slocan Forest Products, Radium Division, and the Non-Timber Harvesting Landbase, funded by the Ministry of Sustainable Resource Management, Nelson BC. As the Invermere PEM model was run throughout the TSA using a single process we felt that it was appropriate that the process and result be described within a single report, as the complete coverage was provided to both clients.

The primary, critical component of this project is that the PEM product is able to provide credible, spatially accurate, site series data to support a site index adjustment in the Invermere TSA. This coverage is appropriate for use with VRI or Forest Cover spatial and database information. Together they create a powerful combination of ecological and inventory attributes. A reconnaissance level PEM, prepared for MSRM for planning purposes and known as the “East Kootenay PEM” (Ketcheson et al, 2002) already existed for the Invermere TSA. This model was based on landscape shape and lacked traditional bioterrain mapping. Its accuracy was unknown, but it did provide an excellent starting point from which a more elaborate PEM model could be developed. The original “East Kootenay PEM” was created using existing spatial inventories and models and was not tested with spatially accurate field data. Existing site series data from the ISIS data base indicated that the original PEM was reasonably adept at finding circum-mesic sites, but lacked resolution in dry and wet areas. The Canal Flats PEM (Ketcheson et al, 2001) also occurs within the Invermere TSA and was developed with spatially accurate plot data, but lacked bioterrain mapping. This PEM model gave an excellent representation of the landscape with a very good correlation between randomly located plot data and the overall output of the PEM model. It did not have a formal assessment of accuracy and only overlaps with a portion of the Invermere TSA. However, both of these mapping projects provide a baseline from which improvements to the PEM model could be made.

A secondary, but also key, requirement of this project is that the PEM product supported other site series based interpretations, such as biodiversity (structural stage distribution) and critical wildlife habitats, which are directly of interest to the Invermere TSA in the future. The output from this product can be used directly for such interpretations, but those interpretations are not included within the scope of this project.

The PEM output is required to be produced and documented in a manner that meets the PEM Data Committee April 2000 Specifications for Digital Data Capture. It is also critical that the mapping be subjected to the appropriate accuracy and model goodness of fit assessments proposed in the *Protocol for Quality Assurance and Accuracy Assessment* *of Ecosystem Maps* proposed by Meidinger (2003). The mapping had to meet the specified levels of accuracy before being accepted for use in the SIBEC site index adjustment process. The assessment of accuracy was completed by an independent party and submitted to Slocan Forest Products and BC Ministry of Forests Research Branch for consideration. In order to maintain independence of the accuracy data we were not privy to the final accuracy assessment report, it has been submitted to the client and we were given the indication that the PEM model achieved the level of accuracy necessary for use in TSR activities.

New field data collection for this project met Provincial Standards as well as the needs of PEM model development and verification. Existing field data collected within the Invermere TSA was also used to augment model-building and verification processes.

The approach to terrain mapping within a tight time line and restricted budget is taken from the Canim Lake PEM project being undertaken by Weldwood, 100 Mile House (MacMillan et al., 2003). In this project there were considerable cost savings seen by using a simplified approach to bioterrain mapping that involves a combination of the *LMES* (Landmapper Environmental Solutions Inc.) landscape facet models and targeted depth and texture mapping. The final product met tests of accuracy using this approach to terrain delineation. However, this simplified approach to terrain delineation means that the client does not have the benefit of traditional bioterrain mapping (Howes and Kenk, 1997) throughout the project area.

What is key to this project is that the process and methods used have already demonstrated themselves to be applicable to the goal of adjustment of the forest estate model analysis unit. It is critical that the PEM project works in concert with that effort.

1.2 Location

The Invermere TSA PEM project area is located in the south east corner of British Columbia (see Figure 1), and occupies an area of approximately 1,113,513 ha. It is located within the dry and moist climatic zones with precipitation increasing from south to north (Braumandl and Curran, 1992).

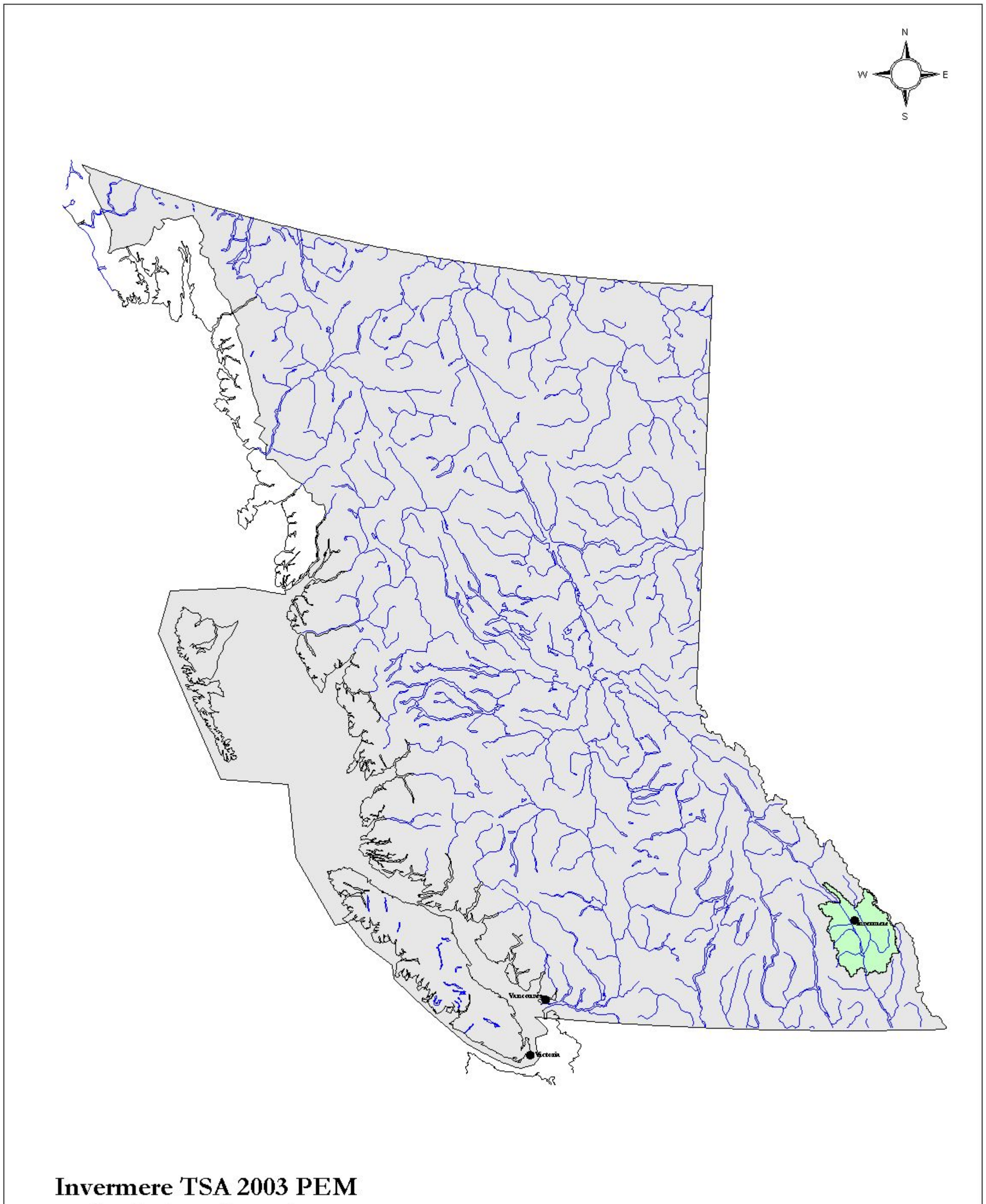


Figure 1. Invermere TSA PEM location within south east British Columbia

Mapping was completed using newly updated and defined subzones recently completed by Braumandl and Dykstra (2003) and approved for use by Dennis Lloyd, Research Ecologist, BC Ministry of Forests, Kamloops. The Invermere TSA is located within the following 1:20,000 TRIM map sheets as illustrated in Figure 2:

082F.079	082J.014	082J.063	082K.040	082K.099
082F.080	082J.015	082J.064	082K.047	082N.007
082F.089	082J.021	082J.071	082K.048	082N.008
082F.090	082J.022	082J.072	082K.049	082N.009
082F.098	082J.023	082J.073	082K.050	082N.016
082F.099	082J.024	082J.074	082K.057	082N.017
082F.100	082J.025	082J.081	082K.058	082N.018
082G.071	082J.031	082J.082	082K.059	082O.001
082G.072	082J.032	082J.083	082K.060	082O.002
082G.081	082J.033	082J.091	082K.067	
082G.082	082J.034	082J.092	082K.068	
082G.083	082J.035	082J.093	082K.069	
082G.084	082J.041	082K.008	082K.070	
082G.091	082J.042	082K.009	082K.076	
082G.092	082J.043	082K.010	082K.077	
082G.093	082J.044	082K.018	082K.078	
082G.094	082J.045	082K.019	082K.079	
082J.001	082J.051	082K.020	082K.080	
082J.002	082J.052	082K.028	082K.086	
082J.003	082J.053	082K.029	082K.087	
082J.004	082J.054	082K.030	082K.088	
082J.011	082J.055	082K.037	082K.089	
082J.012	082J.061	082K.038	082K.090	
082J.013	082J.062	082K.039	082K.098	

Figure 2. Invermere TSA 1:20,000 TRIM Map Sheet Coverage

1.3 Ecosection and BEC setting

The Invermere TSA is classified using two hierarchies. The ecoregion classification of Demarchi (1996) utilizes climate and physiography while the Biogeoclimatic Ecosystem Classification (BEC) (Braumandl and Curran, 1992) used by the BC Ministry of Forests, relies on vegetation to indicate site, soil and climatic features. The ecoregion classification (as shown in Figure 3) is used at quite broad levels (three subdivisions within the TSA), while the BEC system is used down to site series level (in excess of eighty units within the project area).

Ecoregions are large regional-sized, ecological land units that have similar macroclimate, physiography, vegetation and wildlife potential. Five levels of Ecoregion Classification are recognized including Ecodomain, Ecodivision, Ecoprovince, Ecoregion and Ecosection. Following the ecological land classification hierarchy set forth by Demarchi (1996), the Invermere TSA is located within the Humid Temperate Ecodomain, the Humid Continental Highlands Ecodivision, and the Southern Interior Mountains Ecoprovince. Within the Ecoprovince, it is further divided into the following Ecoregions: the Northern Columbia Mountains, the Western Continental Ranges and the Southern Rocky Mountain Trench.

Ecosections are subregional units within ecoregions that are similar in climate, landforms, bedrock geology, soils, and plant and animal distributions. The Invermere TSA is located within the following three ecosections as described by Demarchi (1996):

The Northern Columbia Mountains Ecoregion

The Eastern Purcell Mountains (EPM) Ecosection is a mountainous area with high valleys. It is located leeward of the Purcell Ranges in the southwest part of the region and lies within a distinct rainshadow.

The Western Continental Ranges Ecoregion

The Southern Park Ranges (SPK) Ecosection is located in the Rockies from north of the Elk Valley to the Blaeberry Valley. It is a rugged mountainous area that is dissected by long rivers, forming moderately wide valleys.

The Southern Rocky Mountain Trench Ecoregion

The East Kootenay Trench (EKT) Ecosection is a broad, flat glacial plain with a distinctive rainshadow that lies in the southern portion of the Rocky Mountain Trench from Donald to the USA border.

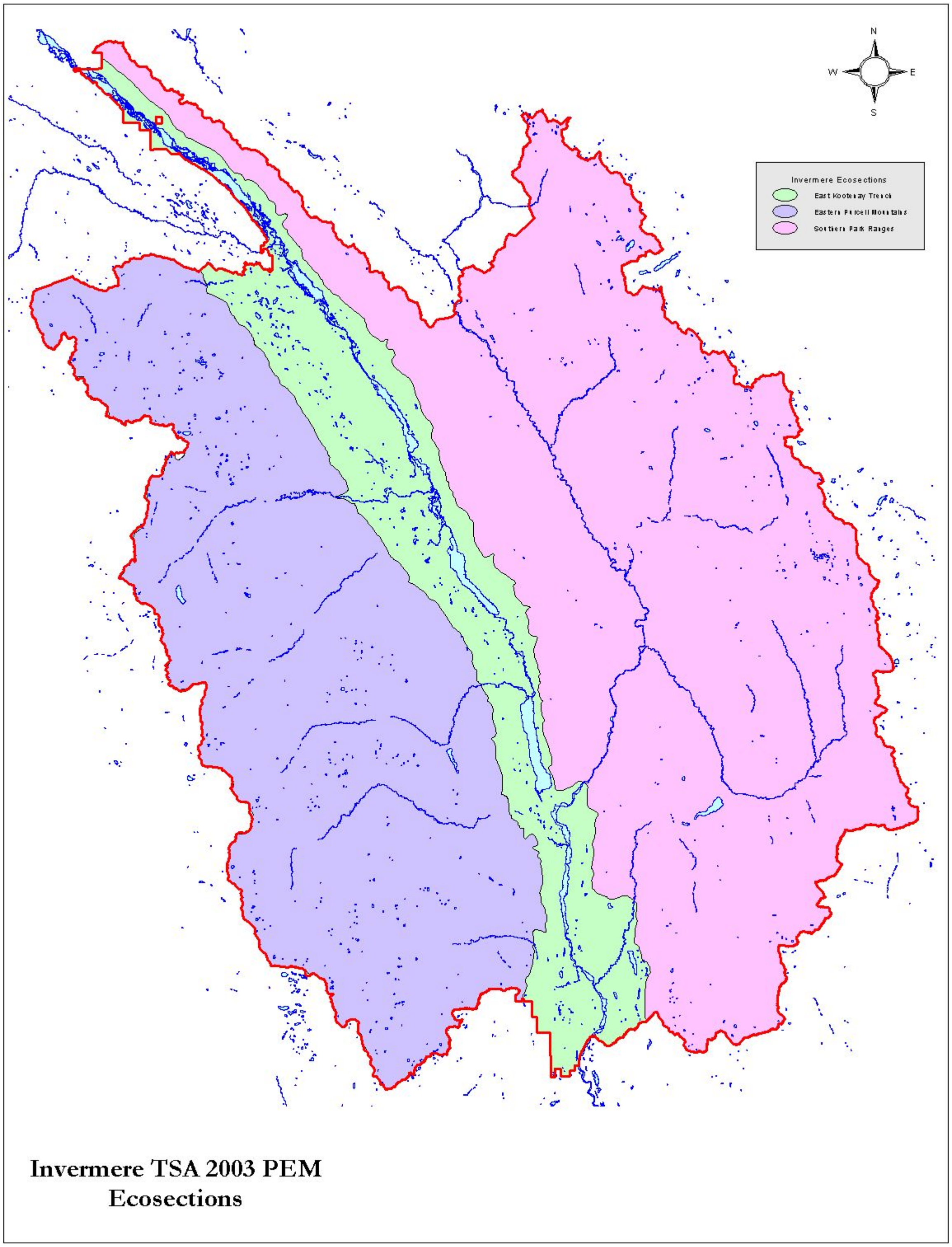


Figure 3. The Ecosections of the Invermere TSA

Biogeoclimatic Zones, Subzones and Variants occur within each Ecosection and are classified using the Ministry of Forests Biogeoclimatic Ecosystem Classification (BEC) system (Braumandl and Curran, 1992). These units represent groups of ecosystems under the influence of the same regional climate. The Invermere TSA spans the Dry, Moist and Wet Climatic Regions and contains twelve biogeoclimatic subzones and variants (see Figure 4) that are briefly described below.

Dry Subzones

1) PPdh2 - The Kootenay Dry Hot Ponderosa Pine Variant occurs in the southern part of the East Kootenay Trench generally between 700 and 950m in elevation. Very hot, very dry summers and mild winters with very light snowfall characterize this zone. Zonal sites support open stands of Ponderosa pine and Douglas-fir (Braumandl and Curran, 1992). Common species in the understorey include bluebunch wheatgrass, saskatoon, prairie rose, and rosy pussytoes. There has been extensive fire, grazing, and logging disturbance within this variant.

2) IDFdm2 - The Kootenay Dry, Mild Interior Douglas-fir Variant occurs along the East Kootenay trench generally between 800 and 1200 m in elevation on warm aspects and between 800 and 1100 m on cool aspects. Hot, very dry summers and cool winters with very light snowfall characterize this variant (Braumandl and Curran, 1992). Mature zonal sites support stands of Douglas-fir; however, due to frequent wildfires, mixed seral stands of Douglas-fir, western larch and lodgepole pine are more common.

3) IDFdm2N - This new unit replaces the IDFdm2 located north of Brisco. It is similar to the IDFdm2, although Braumandl and Dykstra (2003) report is to be “apparently more productive” and exhibits differing successional sequences more dominated by trembling aspen and paper birch.

4) IDFxk - Undifferentiated Interior Douglas-fir (Windermere Lake) Unit occurs along Windermere and Columbia Lakes between 800 and 900m primarily on warm aspects. Hot, very dry summers and cool winters with very light snowfall characterize this zone. Mature zonal sites support open stands of only Douglas-fir while other tree species are rare. Bluebunch wheatgrass and junegrass are the dominant understorey species. Marcoux (1997) has developed site series for this subzone in consultation with the regional ecologist.

5) MSdk -The Dry Cool Montane Spruce Subzone occurs along the East Kootenay trench. It is found above the IDFdm2 generally between 1200 and 1650 m elevation on warm aspects and between 1100 and 1550 m elevation on cool aspects. Warm, dry summers and cold winters with light snowfall characterize this zone (Braumandl and Curran, 1992). Mature zonal sites support stands of hybrid white spruce and subalpine fir with minor amounts of Douglas-fir. Due to widespread wildfires, extensive stands of lodgepole pine exist today.

6) ESSFdk1 - The Dry Cool Engelmann Spruce Subalpine Fir Subzone occurs along the East Kootenay trench. It is found above the MSdk generally between approx. 1650 and 2050 m elevation on warm aspects and between 1550 and 1920 m on cool aspects. This zone is characterized by cool, moist summers and very cold winters with moderately heavy snowfall (Braumandl and Curran, 1992). Mature zonal sites support stands of subalpine fir and Engelmann spruce.

7) ESSFdk2 – The Parson Dry Mild Engelmann Spruce – Subalpine Fir Variant occurs in the northeastern corner of the Invermere TSA from about 1600 to 2000 m on warm aspects and from 1500 to 1950 m on cool aspects. This zone was previously mapped as the ESSFwm but is characterized by a drier climate than the ESSFwm and a warmer, moister climate than the ESSFdk. Mature zonal sites support stands of subalpine fir and Engelmann spruce. Site series units were developed from field data by Kernaghan et al (1999), as this subzone is not described in Braumandl and Curran (1992). The fire cycle is much longer than in the ESSFdk, especially on cool aspect slopes.

8) ESSFdku - The Upper Dry Cool Engelmann Spruce Subalpine Fir Subzone occurs between 2050 and 2300 m elevation on warm aspects and between 1920 and 2380 m on cool aspects. It is located above the ESSFdk1 and ESSFdk2 on the highest forested slopes of the Rocky and Purcell Mountains. This zone is characterized by cool, dry summers and very cold winters with heavy snowfall. Mature zonal sites support stands of subalpine fir, Engelmann spruce and alpine larch. Late lying snow and frost pocketing create a mosaic of forest and permanent meadows. This subzone is not documented in Braumandl and Curran (1992) and has been described by Kernaghan et al (1997, 1998).

Moist Subzones

9) ICHmk1 - The Kootenay Moist Cool Interior Cedar - Hemlock Variant occurs in the central part of the Invermere TSA. This variant is characterized by warm, moist summers and cool winters with light snowfall (Braumandl and Curran 1992). Mature zonal sites support stands of western redcedar, hybrid white spruce and subalpine fir; however, due to frequent wildfires and mountain pine beetle outbreaks, these are rare. Mixed seral stands of lodgepole pine and Douglas-fir are more common.

10) ESSFwm – The Wet Mild Engelmann Spruce – Subalpine Fir Subzone occurs in an isolated small area in the northeastern corner of the Invermere TSA at approximately 1650 to 2000m on warm aspects and from 1500 to 2000m on cool aspects. This subzone is characterized by cool, moist summers and cold, wet winters with moderately heavy snowfall. Climax zonal sites have stands of Engelmann spruce and subalpine fir. The understorey vegetation is dominated by false azalea with oak fern being widespread on zonal sites. Long fire cycles have produced many old growth stands and few seral stands.

11) ESSFwmu - The Upper Wet Mild Engelmann Spruce - Subalpine Fir Subzone occurs above the ESSFwc1 on the highest forested slopes with small openings. It is found between about 2000 and 2200m. Provisional site series are based on units developed by Kernaghan et al (1999). Cool, moist summers and very cold winters with heavy snowfall characterize this subzone. Mature zonal sites support stands of subalpine fir, Engelmann spruce and alpine larch. Understorey vegetation is often dominated by mountain-heathers. Late lying snow, avalanching, colluvial action, thin soils and frost pocketing create a mosaic of closed forest, scree slopes, avalanche tracks, and permanent meadows.

12) ATun - Alpine Tundra Undifferentiated zone occurs above elevations from 2200 m in the north to 2600 m in the south. It encompasses the high, treeless peaks of the Purcells, Selkirks and Rockies. This zone is characterized by short, cool and moist summers and very cold winters with heavy snowfall. Much of the subzone is non-vegetated. Mountain-avens, mountain-heathers and arctic willow with no conifers characterize zonal vegetated sites.

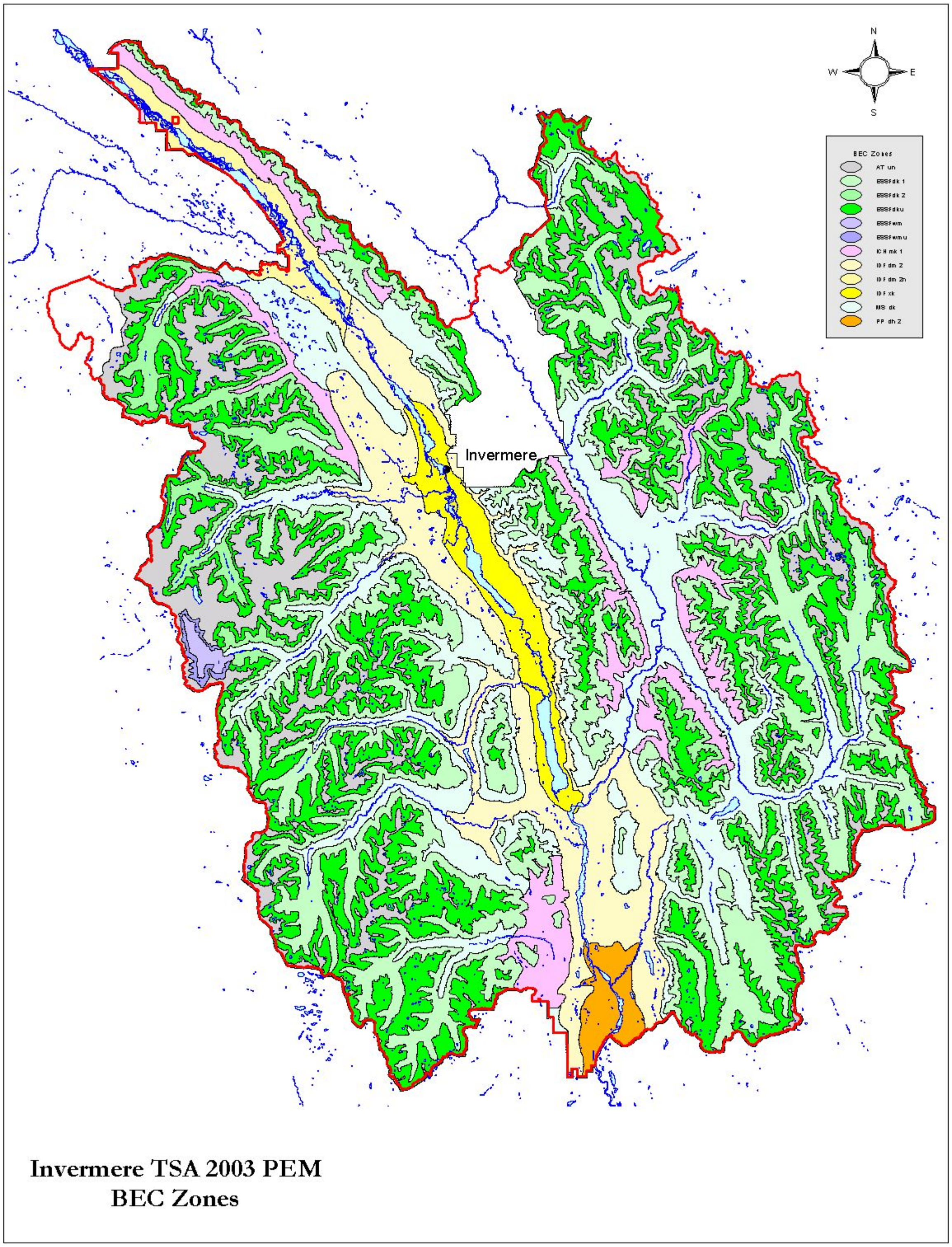


Figure 4. Biogeoclimatic Subzones of the Invermere TSA

2.0 Methods

2.1 An Overview of the PEM Process

An overview of the PEM model used for the the Invermere TSA PEM is depicted in Figure 5. The PEM model starts with spatial inventories from TRIM in a raster format using a 25 x 25 meter pixel, as well as rasterized forest cover and satellite imagery. The TRIM topographic data and hydrology was manipulated within the LMES model to produce “landscape facets” which provided a surrogate for traditional bioterrain mapping. Bioterrain mapping was replaced with targeted materials mapping which delineated areas of rock, thin soils, coarse textured terraces and non-forested wetlands. The landscape facets were subdivided into slope and aspect classes. See Section 2.2 for a detailed description of landscape facets. Table 1 lists the landscape facet, slope and aspect classes used in the first run of the PEM model. Table 2 outlines the rule sets used to modify the output of the initial run of the PEM model based on the targeted materials mapping. For example, if an area is designated as a planar midslope by the landscape facet model, but falls within a targeted terrain polygon that indicated that the site is on a mix of thin materials and bedrock, the site series allocated to the planar midslope is adjusted to reflect the drier conditions found on the mix of thin materials and bedrock. The detailed rule sets for each BEC variant that dictate site series adjustments based on targeted materials mapping can be found in Appendix VII.

The Invermere PEM model consists of four stages where the landscape facet, aspect and slope derived raster result is modified by spatial attributes from targeted terrain, which is essentially depth and materials mapping for sites with rock and thin materials, or coarse textured terraces. The result is then vectorized to create polygons which represent the modeled landscape facets subdivided by slope and aspect classes. The site series represented within these polygons were then reported as proportions within of site series by polygon.

At each step in the PEM model spatially explicit field data is compared to the output of the model. If the fit of the model to the field data is poor, then the knowledge bases are modified to improve the result of the PEM model. Knowledge bases can be found in Appendix II and the final results of model fit to field data can be found in Section 3.2.

Table 1. TRIM Derived Inputs for the Invermere PEM Model First Run

LANDSCAPE FACET	ASPECT CLASS	SLOPE CLASS
Sharp Crest	W - Warm (135 to 285 degrees)	1. 0 to 10% slope
Level Crest	K - Cool (286 to 134 degrees)	2. >10 to 25% slope
Upper Shedding Shoulder		3. >25 to 50% slope
Upper Swale		4. >50 to 80% slope
Planar Midslope		5. >80% slope
Divergent Midslope		
Convergent Midslope		
Midslope Terrace		
Midslope Swale		
Toe Slope		
Foot Slope		
Toe Slope Swale		
Lower Slope Mound		
Level Slower Slope		
Lower Slope Swale		
Riparian		
TRIM wetlands		

Table 2. Targeted Materials Mapping and Forest Cover Data Used to Modify the Results of the First Run of the Invermere PEM Model

Materials Code (see Table 3 for definitions)	**Aspect Class** (see Table 1 for definitions)	**Forest Cover Attribute**
R	W	Fd leading species
R1	K	
R2		
R3		
D		
TD		
TM		

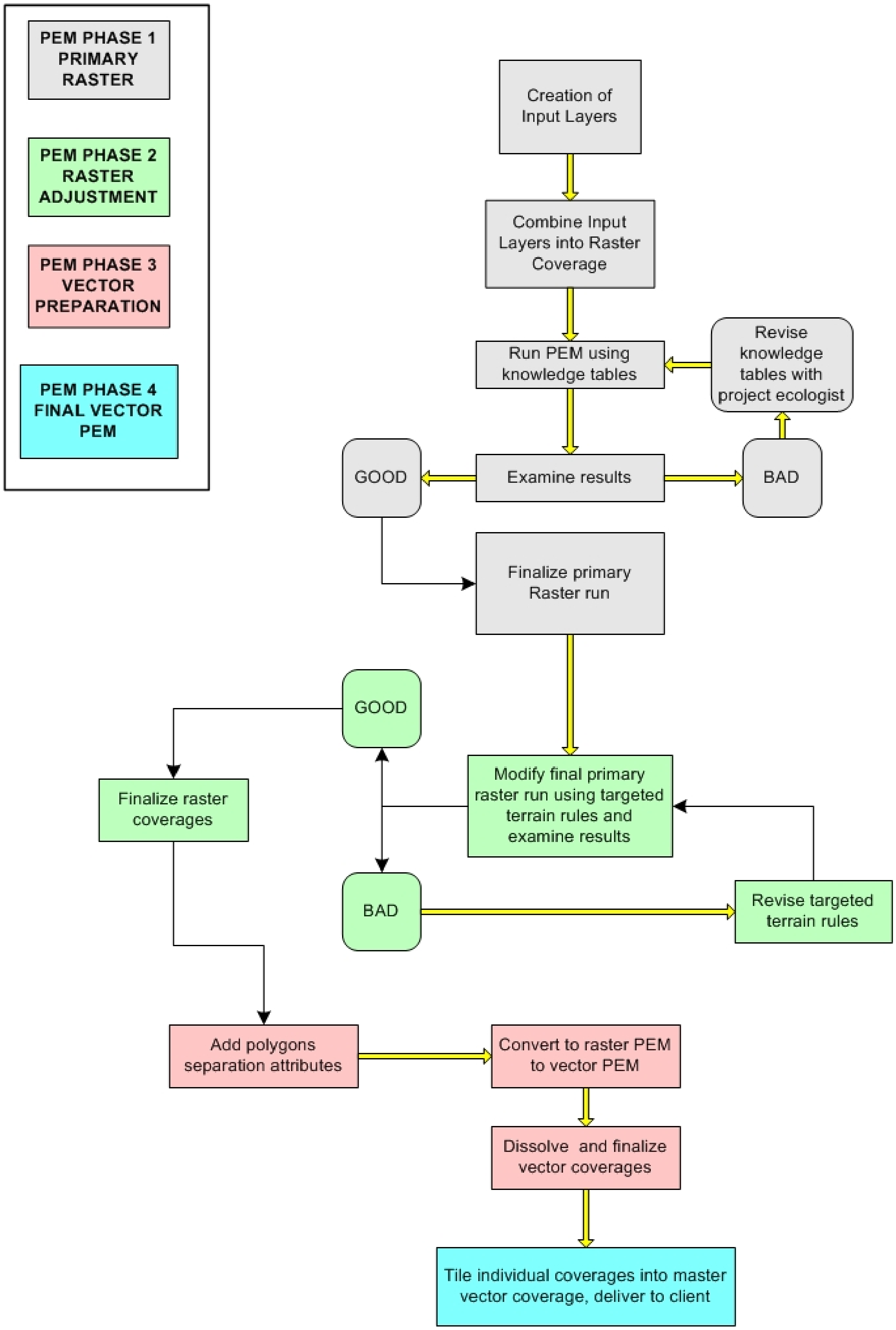


Figure 5. Invermere TSA PEM Model Overview

2.2 Landscape Facet Model

Given tight time lines and budgets associated with this project we proposed to undertake an automated approach to bioterrain mapping that is based on a combination of both air photo interpretation and the *LMES (Landmapper Environmental Solutions Inc.)* landscape facet model. Initially the landscape was classified in a 25 x 25 meter raster format into facets reflecting the landscape shape and position features that terrain mappers traditionally air photo interpreted. These include slope position, slope class, aspect, and hydrologic flow class.

2.2.1 LMES Automated Landform Model

LMES has been developing new procedures and a computer toolkit for landform analysis and classification for the past 10 years. The applicability of these procedures for Predictive Ecosystem Mapping was recently demonstrated in a PEM pilot project conducted in the Cariboo Forest Region of BC (MacMillan, 2002). The LMES procedures and toolkit analyze digital elevation data, and other relevant digital data sets, to automatically partition landscapes into fundamental geomorphic-hydrologic spatial entities. These spatial entities were used as the basic landscape shape categories within the Invermere PEM model. The model uses automated procedures that directly predict site series for each defined spatial entity when subdivided by aspect and slope class. Table 1 and Section 2.2.1.2 report the landscape facet categories used in the Invermere PEM model.

2.2.1.1 Landform Facet Generation

Landform facets represent segmentations of the overall landscape into smaller units that are designed to be less variable than the landscape as a whole. Each landform facet is designed to express a more narrow range of external characteristics defined according to morphology (shape), relative landform position (context), exposure (aspect) and relative drainage condition (wetness). The assumption is made that landform facets also possess a more restricted range of internal characteristics (soil texture, depth, mineralogy) than the landscape as a whole.

In the *LMES* approach, the only input layer required to define landform facets is a raster, or grid, Digital Elevation Model (DEM) derived from TRIM data.

The main steps followed in processing DEM data to compute landform facets are as follows.

Step 1. Obtain a seamless DEM and process it to smooth and to reduce obvious errors.

In general, we have found that optimum smoothing is achieved by using 3 passes of a mean filter with window sizes of 3x3, 3x3 and 5x5, in that order.

Step 2. Process the DEM data to compute cell to cell flow topology.

The *LMES* programs use the flow direction calculations later for computing a number of terrain indices. One set of important indices consists of a variety of measures of relative landform position. Many of these measures of landform position are computed by tracing along flow paths from every cell in a DEM until the flow path reaches one of several important kinds of cells.

Step 3. Compute a series of terrain derivatives and morphological and hydrological indices using the cleaned and filtered DEM data and the flow topology data.

The *LMES* process computes a number of fairly common derivatives including slope percent, aspect, and profile and plan curvature. It also computes a version of the wetness index, or compound topographic index (Quinn et al., 1991) in this step. These are used to determine relative landform position and are invaluable in establishing landform context which is a key consideration in the subsequent landform classification procedures.

Step 4. Revise the existing *LMES* landform facet classifications for the project area.

Normally, the *LMES* program is run at this point using one of several predefined sets of classification rules. In the case of this proposed project landscape facet classification rules were reviewed and revised until they best reflected functional categories that would be the most useful to discriminate between Braumandl and Curran's (1992) site series classification.

Step 5. Apply the final, revised *LMES* landform facet classification to all DEM blocks defined for the project area.

LMES uses a custom in-house program to apply a set of rules to the DEM data and derivatives of DEM data to automatically classify a suite of defined landform classes.

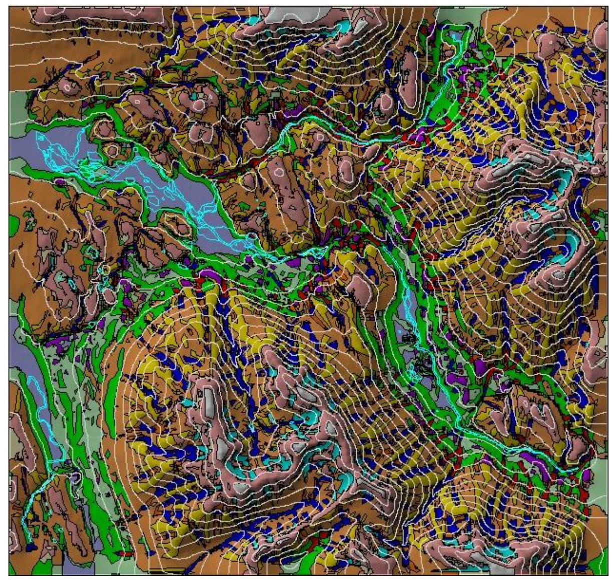
Step 6. Prepare final vector and raster output files for each of the DEM blocks defined for the project area.

Step 7. Archive all data files generated in the process of computing the *LMES* landform facet classifications for each of the DEM blocks defined for the project area.

2.2.1.2 Landform

The objective of this derived landform is to model the moisture-holding capacity (or those features known to regulate the reception and retention of energy and water) of the land base, assuming similar soil and percent material properties throughout the study area (MacMillian 1998, Rowe 1996). The landform attributes to be used in the PEM will be derived from the TRIM gridded DEM based on *LMES*'s classification categories.The landform facets derived for the Invermere PEM model are made up of the following classes (as per MacMillan, 1998). They include:

- Sharp Crest
- Level Crest
- Upper Shedding Shoulder
- Upper Swale
- Planar Midslope
- Divergent Midslope
- Convergent Midslope
- Midslope Terrace
- Midslope Swale
- Toe Slope
- Foot Slope
- Toe Slope Swale
- Lower slope mound
- Lower slope swale
- Riparian



All spatial processing, analysis and modeling for this project will be carried out in a 25 x 25 meter raster format.

2.3 Generalized Materials Mapping

PEM models generally use only selected features of the bioterrain mapping within their knowledge bases to assist in the prediction of site series, these include very thin materials on rock, rock, wetlands and coarse textured glaciofluvial terraces. Our approach to terrain mapping targeted these features via on screen, direct to digital ortho-photo interpretation. Targeted terrain polygons were delineated using ortho-photos superimposed on TRIM topography and water in ARCVIEW 3.1 using the following mapping criteria.

Table 3. Targeted Materials Mapping Criteria.

Material Code	Description
R	100% bedrock or talus
R1	Up to 25% bedrock or talus and 75% shallow materials (veneers or very thin veneers)
R2	Between 25-50% bedrock or talus and 50% shallow materials (veneers or very thin veneers)
R3	Between 50- 75% bedrock and talus and the remainder shallow materials (veneers or very thin veneers)
D	100% shallow materials (veneers or very thin veneers)
TD	Coarse textured terrace
TM	Medium to fine textured terraces
W	Non-treed Wetlands

The materials mapping was completed throughout the Invermere TSA in both the Timber Harvesting Landbase and Non Timber Harvesting Landbase. This materials mapping formed a valuable PEM input layer used in conjunction with the LMES landscape facets as a surrogate for bioterrain mapping.

2.4 Invermere PEM Model Map Entities Knowledge Bases

The variables expressed in each of the above described spatial inventories are related to the site series classification via knowledge bases. The site series classification to be mapped is described in detail in Appendix IV and summarized in Tables 4 and 5. This classification was reviewed and approved for use by Dennis Lloyd, Research Ecologist, BC Ministry of Forests, Kamloops Region. A complete set of knowledge bases for all BEC variants of the Invermere PEM project can be found in Appendix II. An example of a PEM knowledge base can be found in Table 6.

Table 4. BEC Variants and Map Entities Mapped in the Invermere PEM Project

***** Site Series names in upper case are provisional names suggested by Dennis Lloyd, Research Ecologist, Kamloops Region.***

BEC Variant	Map Entity Code	Site Series Number	SiteSeriesName
AT	AW	01	DRY MEADOW**** Mountain-avens - Dwarf willow
AT	BP	03	MOIST MEADOW Black alpine sedge - Woolly pussytoes
AT	SL	02	EXPOSED RIDGE CREST Saxicolous lichen
AT	KR	04	KRUMHOLTZ
AT	WE	05	WETLAND
AT	AC	77	Avalanche chute
AT	AR	88	Avalanche runout zone
ESSFdk1	AC	77	Avalanche chute
ESSFdk1	AS	78	Trembling aspen - birch leaved spirea
ESSFdk1	AW	87	Sitka alder - willow
ESSFdk1	AR	88	Avalanche runout zone
ESSFdk1	FA	01	Bl - Azalea - Foamflower
ESSFdk1	DM	02	Fd - Douglas maple - Soopolallie
ESSFdk1	FG	03	Bl - Azalea - Grouseberry
ESSFdk1	FS	04	Bl - Azalea - Soopolallie
ESSFdk1	XF	03/04	Bl - Azalea – Grouseberry/ Bl - Azalea – Soopolallie map entity
ESSFdk1	FM	05	Bl - Azalea - Step moss
ESSFdk1	FH	06	Bl - Azalea - Horsetail
ESSFdk1	XM	05/06	Bl - Azalea - Step moss/ Bl - Azalea – Horsetail map entity
ESSFdk1	WS	07	Willow - Sedge
ESSFdku	AC	77	Avalanche chute
ESSFdku	AR	88	Avalanche runout zone
ESSFdku	AW	02	DRY MEADOW PLUS LOW KRUMHOLTZ Mountain-avens - Snow willow
ESSFdku	WE	07	WETLANDS
ESSFdku	DV	08	MOIST TO WET MEADOWS Subalpine daisy - Sitka valerian
ESSFdku	EM	01	SM-M FORESTS SeBl - White mountain-heather
ESSFdku	WF	03	SX TO SM FORESTS PaBl
ESSFdku	YW	04	DRY MEADOWS HEATHER Yellow mountain-heather - Woolly pussytoes
ESSFdku	LM	05	MESIC -SH forests
ESSFdku	FH	06	SH-H FORESTS Bl - Horsetail
ESSFdk2	AC	77	Avalanche Chute
ESSFdk2	AR	88	AVALANCHE RUNOUT ZONE
ESSFdk2	FG	02	Bl - Pa - Grouseberry
ESSFdk2	FH	04	Bl - False azalea - Horsetail
ESSFdk2	FP	01	Bl - Black huckleberry - Red-stemmed feathermoss
ESSFdk2	FS	05	Bl - Sedge - Sphagnum
ESSFdk2	FV	03	Bl - Rhododendron - Black huckleberry
ESSFdk2	WE	06	WETLANDS
ESSFwm	FA	01	Bl - Azalea - Arnica

ESSFwm	FR	02	Bl - Rhododendron - Azalea
ESSFwm	RA	03	BlHw - Rhododendron - Azalea
ESSFwm	FQ	04	Bl - Azalea - Queen's cup
ESSFwm	WE	05	WETLANDS
ESSFwm	AC	77	AVALANCHE PATH
ESSFwm	AR	88	AVALANCHE RUNOUT ZONE
ICHmk1	AC	77	AVALANCHE PATH
ICHmk1	AR	88	AVALANCHE RUNOUT ZONE
ICHmk1	XA	01/04	*CwSxw - Falsebox / FdPl - Sitka Alder - Pinegrass map entity*
ICHmk1	DP	02	Fd - Juniper - Penstemon
ICHmk1	DT	03	FdPl - Pinegrass - Twinflower
ICHmk1	SG	05	SxwFd - Gooseberry - Sarsaparilla
ICHmk1	SO	06	Sxw - Oak fern
ICHmk1	SH	07	Sxw - Horsetail
ICHmk1	WE	08	WETLAND COMPLEX
IDFdm2	WE	08	WETLAND COMPLEX
IDFdm2	DT	01	FdPl - Pinegrass - Twinflower
IDFdm2	AW	02	Antelope-brush - Bluebunch wheatgrass
IDFdm2	DS	03	Fd - Snowberry - Balsamroot
IDFdm2	SP	04	FdLw - Spruce - Pinegrass
IDFdm2	SS	05	SxwAt - Sarsaparilla
IDFdm2	SH	07	Sxw - Horsetail
IDFdm2N	WE	08	WETLAND COMPLEX
IDFdm2N	DT	01	FdPl - Pinegrass - Twinflower
IDFdm2N	DS	03	Fd - Snowberry - Balsamroot
IDFdm2N	SP	04	FdLw - Spruce - Pinegrass
IDFdm2N	SS	05	SxwAt - Sarsaparilla
IDFdm2N	SH	07	Sxw - Horsetail
IDFxk	CD	05	ActSxw - Red-Osier dogwood
IDFxk	XJ	01/02	Fd - Rocky Mountain juniper - Bluebunch wheatgrass/ Pature sage bluebunch wheatgrass
IDFxk	DP	03	Fd - Pinegrass - Step moss
IDFxk	SS	04	SxwAt - Sarsaparilla
MSdk	AC	77	AVALANCHE CHUTE
MSdk	AR	88	AVALANCHE RUN OUT ZONE
MSdk	SG	01	Sxw - Soopolallie - Grouseberry
MSdk	XL	01/04	Sxw - Soopolallie - Grouseberry/ Pl Oregon -grape pinegrass map entity
MSdk	XS	01/05	Sxw - Soopolallie – Grouseberry/ Sxw - Soopolallie – Snowberry map entity
MSdk	SW	02	Saskatoon - Bluebunch wheatgrass
MSdk	LJ	03	Pl - Juniper - Pinegrass
MSdk	SS	05	Sxw - Soopolallie - Snowberry
MSdk	SH	06	Sxw - Dogwood - Horsetail
MSdk	WE	07	WETLAND
MSdk	aa	n/a	ASPEN DOMINATED SERAL ASSOCIATION, applied to any MSdk site series dominated by At

PPdh2	PW	01	Py - Bluebunch wheatgrass - Junegrass
PPdh2	WJa	02	Bluebunch wheatgrass - Junegrass, steep x to sx phase
PPdh2	WJb	02	Bluebunch wheatgrass - Junegrass, gentle to moderate sm to m phase
PPdh2	AR	03	PyAt - Rose - Solomon's-seal
PPdh2	CD	04	Act - Dogwood - Nootka rose

Table 5. Non-Vegetated Site Series

Map Entity Code	Site Series Code	Site Series Description
65	CF	Cultivated Field
90	GB	Gravel Bar
68	GC	Golf Course
95	GL	Glacier
91	LA	Lake
69	MI	Mine
92	OW	Shallow Open Water
93	PD	Pond
96	RE	Reservoir
94	RI	River
99	RO	Rock Outcrop/Talus
66	UR	Urban/ Suburban

Table 6. Example Portion of IDFdm2 Knowledge Bases Invermere PEM Model

IDFdm2 Landscape Facet	Aspect	Slope (%)	Map Entity	Site Series#
Sharp crest		0-10	AW	02
	K	>10-<25	AW	02
	W	>10-<25	AW	02
	K	25-<50	AW	02
	W	25-<50	AW	02
	K	50-<80	AW	02
	W	50-<80	AW	02
	K	80+	AW	02
	W	80+	AW	02
Level crests		0-10	AW	02
	K	>10-<25	AW	02
	W	>10-<25	AW	02
	K	25-<50	DT	01
	W	25-<50	AW	02
	K	50-<80	DT	01
	W	50-<80	AW	02
	K	80+	DT	01
	W	80+	AW	02
Upper shedding shoulder		0-10	DS	03
	K	>10-<25	DT	01
	W	>10-<25	DS	03
	K	25-<50	DT	01
	W	25-<50	AW	02
	K	50-<80	DT	01
	W	50-<80	AW	02
	K	80+	DT	01
	W	80+	AW	02
Upper swale		0-10	SP	04
	K	>10-<25	SP	04
	W	>10-<25	DT	01
	K	25-<50	DT	01
	W	25-<50	DT	01
	K	50-<80	DT	01
	W	50-<80	DT	01
	K	80+	DT	01
	W	80+	DT	01
Planar midslope		0-10	DT	01
	K	>10-<25	DT	01
	W	>10-<25	DT	01
	K	25-<50	DT	01
	W	25-<50	DT	01
	K	50-<80	DT	01
	W	50-<80	DS	03
	K	80+	DT	01
	W	80+	DS	03

The knowledge base allocates a map entity (site series or combination of site series) to a landscape facet/aspect/slope class combination. A complete list of map entities for the Invermere PEM can be found in Table 4. This forms the basis of the first step of running the PEM model after the compilation of the input layers (see Figure 5). In this way every 25 x 25 metre pixel of the Invermere TSA was initially allocated to a site series based on landscape shape and position.

The targeted terrain mapping is then superimposed on the first run result of the raster PEM. Pixels within the bedrock and dry site classifications outlined in Table 3 are modified using the "second run" rule sets found within the knowledge tables. A complete set of second run rules can be found in Appendix II. An example of a second run rules can be found in Table 7.

Table 7. Second Run Materials Depth Mapping Corrections example IDFdm2

Depth Mapping Correction second run class +	**aspect +**	**Fd leading sp +**	**AW**	**DS**	**DT**	**SP**	**SS**	**SH**	**WE**
D	w	Y	AW	DS	DS	DT	SP	SS	WE
D	w	N	AW	DS	DS	DT	SP	SS	WE
D	k		DT	DT	DT	DT	SP	SS	WE
R1	w	Y	AW/RO	DS/RO	DS/RO	DS/RO	DS/RO	DS/RO	WE
R1	w	N	AW/RO	DS/RO	DT/RO	DT/RO	DT/RO	DT/RO	WE
R1	k		DT/RO	DS/RO	DT/RO	DT/RO	DT/RO	DT/RO	WE
R2	w		AW/RO	DS/RO	DS/RO	DS/RO	DS/RO	DS/RO	WE
R2	k		DT/RO	DS/RO	DT/RO	DT/RO	DT/RO	DT/RO	WE
R3	w		RO/AW	RO/DS	RO/DS	RO/DS	RO/DS	RO/DS	WE
R3	k		RO/DT	RO/DT	RO/DT	RO/DT	RO/DT	RO/DT	WE
R	w		RO	RO	RO	RO	RO	RO	WE
R	k		RO	RO	RO	RO	RO	RO	WE
TD			AW	AW	DS	DS	DS	DS	WE
TM			DT	DT	DT	DT	DT	DT	WE
W			WE	WE	WE	WE	WE	WE	WE

The allocation of landscape facet/aspect/slope combinations to map entity is determined subjectively using a combination of expert opinion and summarized site and terrain data from field data. It is recognized that the model makes predictions that reflect the resolution of the TRIM DEM and that there is ample variability in elevation on the ground that is below the resolution of the DEM. In order to account for this "micro" slope variability the PEM model allocates varying proportions of site series that can occur within a single modeled map entity. For example, in the IDFdm2 the 01 site series DT (FdPl – Pinegrass- Twinflower) is allocated to landscape facet/aspect/slope combinations that could also support one site series drier (03 DS, Fd-Snowberry-Balsamroot) in microtopographic landscape positions where hummocks up to 10 meters in elevation (which do not appear in the DEM), on their warm aspects, are more likely to exhibit the DS site series. This "proportioning" of the map entities is completed during the final run of the PEM once the targeted materials mapping has been superimposed on the first run raster output. In this way on the ground landscape variability can be accounted for. The proportions used were determined by summarization of the transect data and field plot data by landscape facet/aspect/slope categories. The relative proportions of field plots, or proportion of line intercept transect occurring on a given category were determined and the proportions allocated using a combination of that information and expert opinion. Table 8 below gives an example of the proportioning rules for the IDFdm2. A complete set of proportioning rules can be found in Appendix V.

Table 8. Proportioning Rules for the IDFdm2

IDFdm2

	RO	**AW**	**DS**	**DT**	**SP**	**SS**	**SH**	**BH**
AW/RO	0.38	0.62						
DS/RO	0.38		0.5	0.12				
DT/RO	0.38		0.12	0.5				
RO/AW	0.62	0.38						
RO/DS	0.62		0.3	0.08				
RO/DT	0.62		0.08	0.3				
RO	0.7	0.1	0.1	0.1				
AW		1						
DT			0.2	0.8				
DS			0.8	0.2				
SP				0.2	0.8			
SS					0.2	0.7	0.1	
WE							0.34	0.66

2.5 PEM Model Building Field Data Collection

Field data is used in PEM model building and verification. It is a crucial component that helps develop knowledge tables and site series proportioning tables and to test the results of knowledge table map entity spatial allocations. There is abundant existing ecological data already collected within the Invermere TSA as a consequence of previous TEM and PEM mapping projects, however, only a portion of this data, collected since 1998, has accurate, GPS derived spatial locations. Plot data with GPS locations is the best data for developing and testing the model because site series classifications can be specifically related to landscape facet/aspect/slope class variables, as well as to targeted materials mapping variables. Transect data can be used to determine spatial variability in site series at a scale below the resolution of the DEM. Non-spatially explicit plot data, can also be used to develop knowledge bases through non-spatial comparison of site series classifications to plot site features and the landscape facet/aspect/slope class variables.

Spatially explicit field data were collected as part of the Invermere PEM model during the 2003 field season. The data consists of randomly located transects and plots within the Timber Harvesting Land Base and stratified randomly located plots within the Non Timber Harvesting Land Base. The sampling designs used to direct data collection are described below.

2.5.1 Field Data Collection Sampling Design

The Timber Harvesting Landbase (THLB) portion of the PEM was supported by Slocan Radium Division and the Non Timber Harvesting Landbase (NHLB) portion of the PEM was supported by the Ministry of Sustainable Resource Management, Nelson under two separate contracts. Consequently, field sampling was divided between the two contracts. Figure 6 shows the extent of the timber and non-timber harvesting landbases. Figure 7 shows the location of both the THLB and NHLB plots within the Invermere TSA.

2.5.1.1 Timber Harvesting Landbase

Within the timber harvesting land base three hundred random points were generated within one kilometer of TRIM road access. These formed the basis of potential transect start points. Forty of these points were sampled with 500 metre long line intercept transects and approximately 80 20 x 20 metre ground inspection plots (BC MOF & MOELP, 1998). The number of sample points was essentially determined by the amount of money available for the PEM project. Of those 40 points, sample selection was based availability and accessibility within a TRIM map sheet. From those forty points a random bearing was established and a 500 metre transect was initiated. Site series data using Braumandl and Curran’s (1992) classification was collected as line intercept distances by site series and structural stage (Ecosystems Working Group, 1998) along the transect. Each site series encountered along the transect was represented by a subjectively located sample plot best representing what is typical of the vegetation and site characteristics of that site series along the transect. Within the plot site, terrain and vegetation data was collected on a Ground Inspection Form (GIF). This data was used to corroborate the site series calls along the transects. These transects were characterized by 82 subjectively located sample plots characterizing the site series noted within each transect. Data was collected between July 23 and August 25, 2003.

The transect data is used to establish spatial site series variability within a terrain type. The plot data was used to determine site series classification using Braumandl and Curran (1992) for the BEC variant the transect represented.

Transect data was collected in the form of strip notes using the format shown in Table 9.

Table 9. Transect Field Data Collection Format

Transect ID
UTM POC (point of commencement)
0 – X metres : site series and structural stage
X – Y metres : site series and structural stage
Y – Z metres: site series and structural stage
UTM COD (change of direction)
Z-etc to
UTM EOT (end of transect)

Transect Map
Transect Notes
Field plot identification number along the transect
Date
Surveyors
Photo numbers

2.5.1.2 Non Timber Harvesting Land Base

Within the non timber harvesting land base (NHLB) twenty areas were subjectively located where road access intercepted NHLB polygons of at least 100 hectares in area. BEC variant distribution was considered, as well as biophysical representation within the NHLB polygon. Areas were chosen based combinations of site characteristics like site series, aspect, slope and location within the TSA where existing mapping (Ketcheson et al., 2002) suggested site types poorly sampled by other ecosystem mapping projects within the Invermere TSA. Within each of these areas twenty five random UTM grid locations were indicated as potential sample points. Field crews choose one to five of these points to sample within a target NHLB polygon based on considerations of access and safety. Each sampled point of 20 x 20 metres was characterized on a GIF form. In addition to site, terrain and vegetation data, coarse woody debris, hardwoods, and wildlife trees were sampled using FS882 (7) and FS882 (3) and FS882 (6) field forms. Within the non timber harvesting land base 50 plots were sampled between September 25 and 29, 2003. This data can be found in Appendix IIIb.

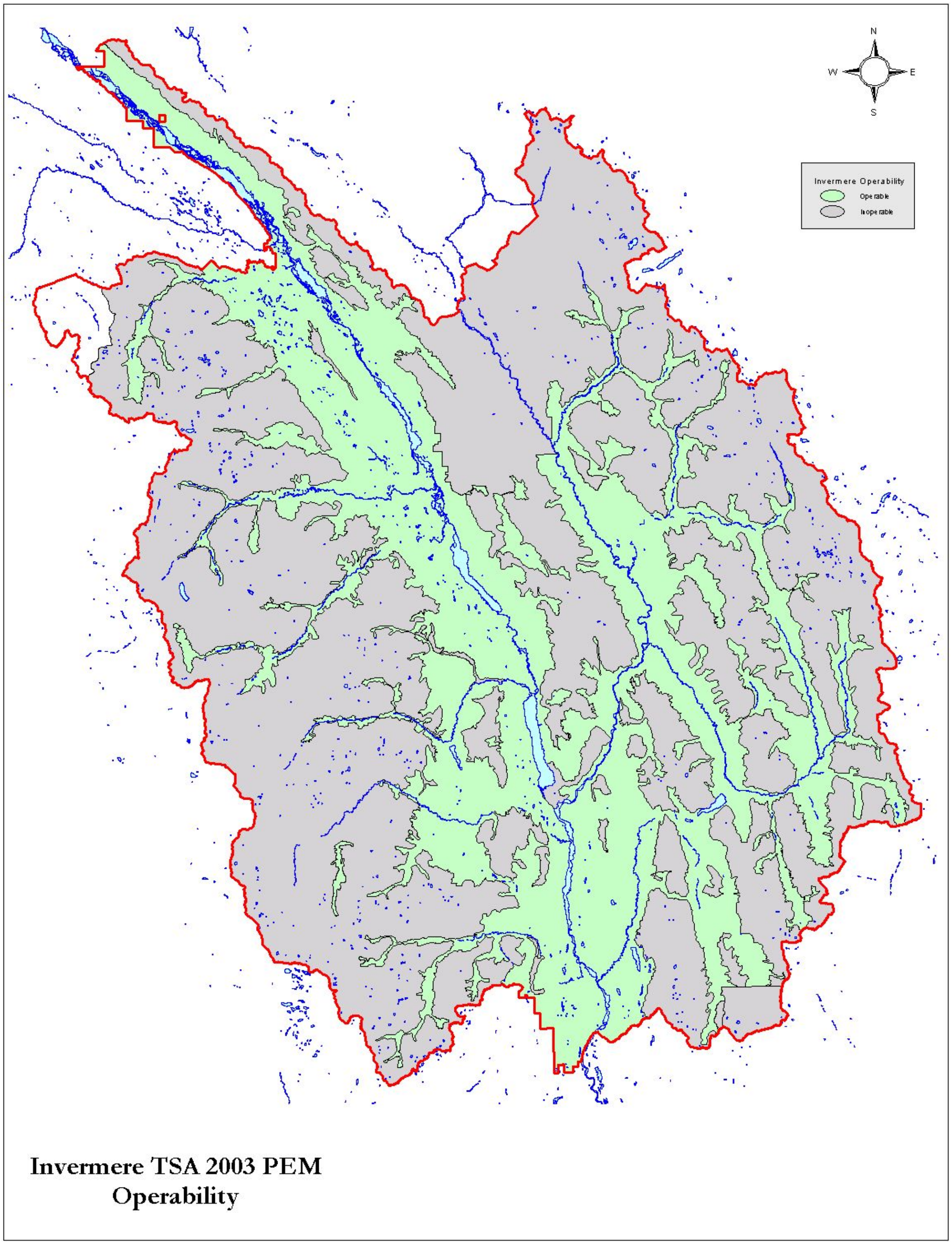


Figure 6. Timber and Non-Timber Harvesting Landbases of the Invermere TSA

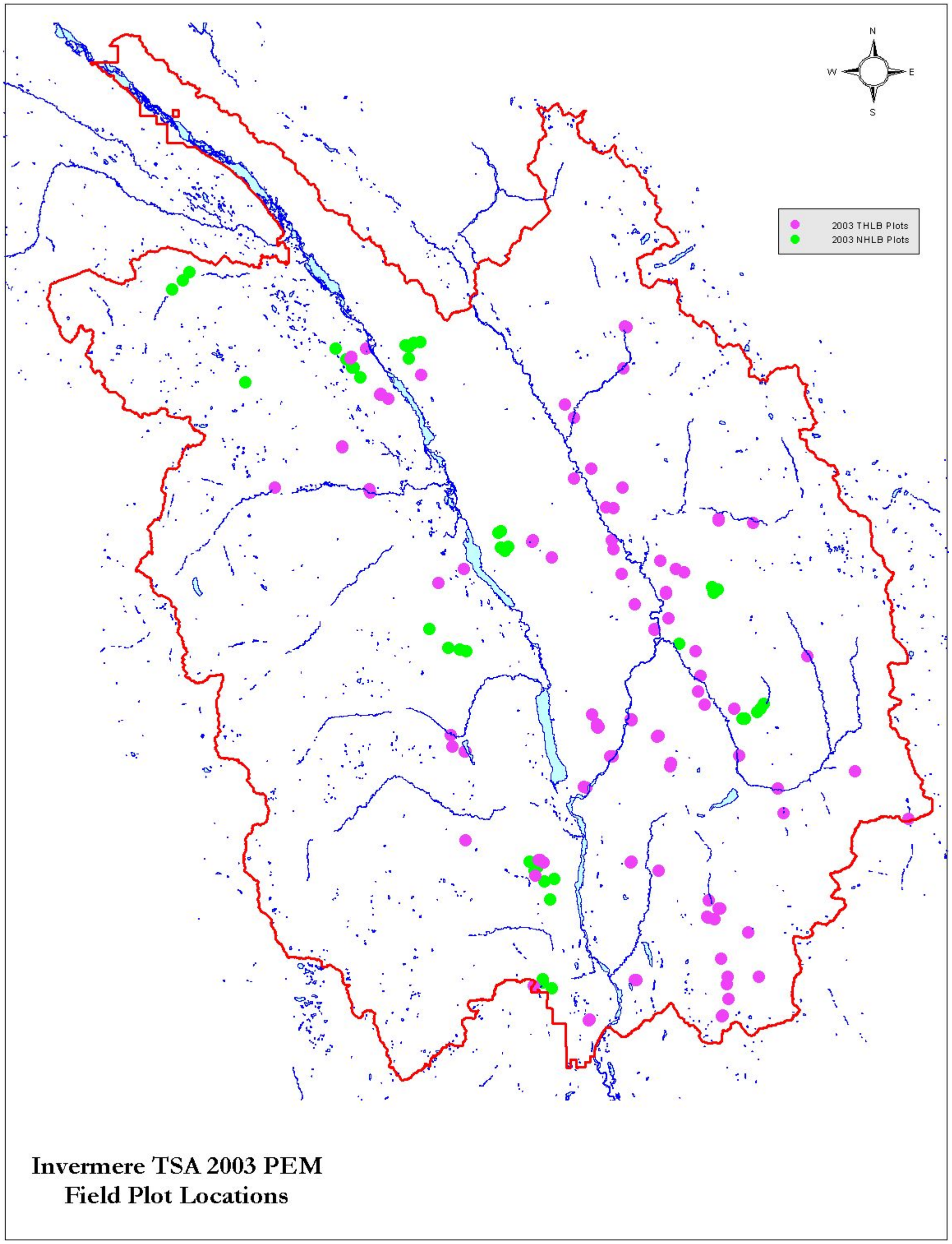


Figure 7. THLB and NHLB Plot Locations within the Invermere TSA

2.5.2 Field Sampling Standards

Plot data was collected on Ground Inspection Forms and FS882 (3), (6) and (7) Forms following the standards outlined in "Describing Ecosystems in the Field" (BC MOF & MOELP, 1998). Ecological classification standards used for field classification of sites are according to Braumandl and Curran. (1992) and the terrain classification used in the field is that of Howes and Kenk (1997). BEC variant mapping used for field sampling was the coverage used for the East Kootenay PEM (Ketcheson et al, 2002). Field data was then reclassified to match BEC variant line work submitted by Braumandl and Dykstra (2003).

2.5.3 Field Data Internal Quality Control

Plot cards and transect notes were checked at the end of each field day to make sure all the necessary information was included. The crews re-visited the plot to obtain missing data if internal review indicated that any portion of the data were lacking.

Plots and transects were located on each crew's field map in the field and on the project master map each evening.

Plot cards were checked again in the office before data entry into the VENUS 4.2 data base. Edits were made via consultation with standards manuals and the field personnel who collected the data. Transect notes were also reviewed in the office before entry into an EXCEL spreadsheet, and any edits were made or clarification obtained from the appropriate field personnel.

Site series classifications were double checked in the office against Braumandl and Curran's 1992 classification.

2.5.4 Field Data Entry

GIF plot data was entered into the VENUS 4.2 data base and transect data was entered into EXCEL spreadsheets following the format in Table 7. This data can be found in Appendix III.

VENUS plot data was summarized in EXCEL for use with spatial data to test the output of the PEM model. This data can be found in Appendix III.

Field data entry was checked against field cards to correct any entry errors. Any questionable codes were verified with the appropriate field personnel.

2.5.5 Field Data Synthesis

Field data collected in 2003 were summarized based on final BEC and site series classification as EXCEL spreadsheets. They were combined with already existing plot data from PEM (Canal Flats PEM, Ketcheson et al 2000), TEM (Brewer Creek, Kernaghan et al., 1997; Stoddart Creek, Marcoux, 1997; Slocan Operating Area FLA18979, Keranaghan et al., 2001; Premier Diorite, Kernaghan et al., 2000; Premier Lake, Kernaghan et al., 2003; TFL 14, Kernaghan et al., 1999) and SIBEC activities within the Invermere TSA (Invermere TSA SIBEC, Ketcheson M.V., 2003; TFL14 SIBEC, Kernaghan et al, 2001) making a total of 2119 sample plots. Plots were summarized by BEC variant, site series, soil moisture regime (SMR), soil nutrient regime (SNR), slope, aspect, and terrain classification. Plot with UTM coordinates (Canal Flats PEM, Invermere TSA 2003 SIBEC, and Premier Lake TEM) were allocated spatially to LMES landscape facets.

The frequency of occurrence of SMR, SNR, slope, aspect and terrain were summarized by BEC variant and site series for all existing and newly collected field data. The range of variables within each site series was noted and a subjective determination of the relationship between LMES landscape facets, aspect, slope and targeted materials was established and documented.

Field data with GPS locations were summarized by BEC variant and site series relative to the LMES landscape facet classification, aspect, slope class and targeted materials mapping. The frequency of occurrence of each combination of variables, by site series, were determined and first draft of the site series allocations were entered into the knowledge tables. The knowledge tables were then run against the landscape facet/aspect/slope class spatial and first run site series determined. This result was compared to in-house field data and the knowledge tables modified to improve the model's fit to the field data. Once the internal fit of the model to the field data was deemed appropriate the second run of the PEM model was undertaken where the targeted terrain mapping was used to modify the results of the first run.

2.5.6 Internal Quality Control

As documented in the previous sections, field data were reviewed at the end of each field day, before data entry and after data entry.

Knowledge tables were reviewed by an internal third party for errors or inconsistencies and approved by M. Ketcheson R.P.Bio.

PEM model output results were also reviewed by in internal third party to insure that they appropriately reflected site series distribution on the ground. In-house field data was compared to the output of the final model. The output of the model was approved by M. Ketcheson R.P.Bio.

2.5.7 External Quality Control

An independent assessment of map accuracy was completed by Timberline Forest Inventory Consultants, Prince George, BC. A copy of this report (Timberline 2003) can be found in Appendix XI. The results of this assessment are reported in Section 3.1.

2.5.8 Structural Stage Model

The structural stage model for the Invermere TSA was completed using the localized BEC mapping and forest cover data. The structural stage classification used follows the standards set for TEM (Ecosystems Working Group, 1998) There is a seven class structural stage model used. The structural stage classes can be found in Table 9 below.

A series of queries were developed for each BEC zone, utilizing non-forest and stand information from the forest cover to target various structural stages. A full set of queries can be found in Appendix VI. An example query can be found in Table 10.

The queries were run, and the relevant structural stages were entered into an attribute called 'STRUC' in the database.

An Arc/Info coverage was then created, called 'TSS_INV'. This is a separate coverage from the PEM site series coverage.

Structural stage data is based on forest cover information and can only be considered as reliable as the forest cover information.

Table 10. Structural Stages Modeled in the Invermere TSA

Structural Stage Code	Description (Ecosystems Working Group 1998)
1	Sparse/bryoid
1b	Bryoid
2	Herb
3	Shrub/herb
3a	Low Shrub (<2 m)
3b	Tall Shrub (2-10 m)
4	Pole Sapling (treed <10 m)
5	Young Forest
6	Mature Forest
7	Old Forest

Table 11. An Example of a Portion of a Structural Stage Knowledge Table Forest Cover Classification

Subzone	Site Series	For Cov age class	ITG	ht class	non prod type	Structural stage	number
IDFdm2	all	NA	NA	NA	Ice	NA	0
	all	NA	NA	NA	Alpine	herb	2
	all	NA	NA	NA	rock	Sparse/bryoid	1
	all	NA	NA	NA	Gravel Pit		0
	all	NA	NA	NA	sand	Sparse/bryoid	1
	all	NA	NA	NA	clay bank	Sparse/bryoid	1
	all	NA	NA	NA	Non Prod Forest	Shrub/herb	3
	all	NA	NA	NA	Non Prod Burn	Shrub/herb	3
	all	NA	NA	NA	Lake		0
	all	NA	NA	NA	Gravel Bar	Sparse bryoid	1
	all	NA	NA	NA	River		0
	all	NA	NA	NA	Mud Flat	Sparse bryoid	1
	all	NA	NA	NA	Swamp	herb	2
	all	NA	NA	NA	Clearing		0
	all	NA	NA	NA	Roads		0
	all	NA	NA	NA	Urban		0
	all	NA	NA	NA	Hayfield	herb	2
	all	NA	NA	NA	Meadow	herb	2
	all	NA	NA	NA	Open Range	herb	2
	all	NA	NA	NA	Non Prob Brush	shrub dominated	3
	all	1		1		shrub dominated	3
	all	1		>1		pole sapling	4
	all	2		>1		pole sapling	4
	all	3		>1		pole sapling	4
	all	4		>1		young forest	5
	all	5		>1		young forest	5
	all	6		>1		young forest	5
	all	7		>1		mature forest	6
	all	8		>1		old forest	7
	all	9		>1		old forest	7

*Group A and B BEC variants are classified according to the predominant natural disturbance regime indicated for that BEC unit. A list of group A and B BEC variants can be found in Ecosystems Working Group (1998) TEM mapping standards

2.6 Spatial and Database Formats

The final format of the spatial and data base files for the Invermere PEM site series and structural stage model follows the specifications for format and documentation as found in the PEM digital data standards document (PEM Data Committee 2000).

Spatial and database files can be found in Appendix IX and the appropriate metadata files located in Appendix VIII.

2.7 Internal Quality Control

2.7.1 Meidinger Approach

The knowledge tables and model results were reviewed after each run of the model. We used Meidinger's 2003 protocol for guidance and for determinations of model goodness of fit to our field plot data. Knowledge tables and results were reviewed by Maureen Ketcheson after each model run. Revisions to the knowledge tables and second run rule sets were done by Maureen Ketcheson.

Final model fit determinations were undertaken and reported as confusion matrices and as confidence intervals around the means for the IDFdm2, MSdk, ICHmk1, ESSFdk1 and PPdh2. These statistics are reported for the final model, but were calculated after each iteration of the model.

Spatial and data bases were reviewed internally for errors after each run of the model. Tom Dool reviewed the final version of the spatial and data bases to insure that they met Provincial PEM data warehouse standards.

2.7.2 Wilson Approach

An independent assessment of PEM map reliability and approach to mapping was conducted by Wilson (2004) after the completion of the final PEM product submitted for accuracy assessment (Timberline 2003). Wilson's approach to more efficient utilization of field data during the model building process involves determination of the "experience" values which assess the proportion of the variability of the land base sampled by the field data. The "experience" map of the Invermere PEM was generated based on Wilson's analysis, that map can be found in Appendix X. The final run of the PEM model was depicted in terms of Wilson's calculated "confidence" of the site series being greater or less than 75%. This map can also be found in Appendix X. These values were used to calculate a kappa statistic, which measured the probability that the result of the model is better than that which would be predicted simply by chance. The results of his analysis are reported in Section 3.1.3 below.

3.0 Results

3.1 PEM Model Accuracy and Fit to Field Data

3.1.1 Independent Assessment of Model Accuracy in the THLB Using Meidinger 2003 Protocol

An independent assessment of PEM map accuracy within the THLB only was undertaken by Timberline Forest Inventory Consultants, Prince George. Dan Bernier (personal communication) provided us with the information found in Table 12 below. Based on this assessment of model accuracy, using the Meidinger (2003) protocol, it was recommended that the Invermere THLB portion of the PEM was suitable for use in Timber Supply Review activities. However, for a complete discussion of the results of the independent assessment of the Invermere PEM model's accuracy please refer to Timberline's final report (Timberline, 2003).

The independent assessment of accuracy refers to the THLB within ESSFdk1, ICHmk1, MSdk, IDFdm2 and PPdh2 BEC variants only. These are the only BEC units assessed by that project.

Table 12. Results of an Independent Assessment of PEM Map Accuracy THLB Invermere TSA (Timberline 2003)

BGC Variant	ESSFdk1	ICHmk1	IDFdm2	MSdk	PPdh2	THLB
Total Area in THLB	70,964.90	44,531.70	97,617.90	143,266.50	12,406.56	368,787.56
% of THLB	19.24%	12.08%	26.47%	38.85%	3.36%	100.00%
Area Assessed (ha)	1501.41	609.05	1676.36	5070.64	3725.57	12583.03
% of Variant Assessed	2.12%	1.37%	1.72%	3.54%	30.03%	3.41%
% of THLB Assessed	11.93%	4.84%	13.32%	40.30%	29.61%	3.41%
Length of transects (m)	5,279	2,503	8,642	15,665	2,081	34,170
% of transect length	15%	7%	25%	46%	6%	100%
# Polygons Assessed	32	15	56	115	4	222
Minimum Polygon Area (ha)	0.02	0.19	0.06	0.06	49.13	0.02
Maximum Polygon Area (ha)	903.86	441.14	410.25	1,111.03	2188.01	2,188.01
Median Polygon Area (ha)	2.4	8.0	5.15	2.69	744.2	4.03
Dominant Correct	43.75%	33.33%	58.93%	45.22%	50.00%	46.62%
Dominant Correct with Alternate Calls	46.88%	40.00%	64.29%	50.43%	50.00%	52.03%
% Overlap	46.72%	26.40%	51.41%	47.87%	47.50%	47.11%
% Overlap with Alternate Calls	50.67%	31.91%	57.28%	53.41%	55.00%	52.76%
Area Weighted - Dominant Correct	7.51%	76.27%	85.28%	78.40%	96.45%	74.25%
Area Weighted - Dominant Correct with Alternate Calls	9.32%	84.59%	89.89%	79.16%	96.45%	76.96%
Area Weighted - % Overlap	58.79%	43.97%	71.73%	72.31%	74.28%	69.82%
Area Weighted - % Overlap with Alternate Calls	66.68%	45.76%	76.73%	76.49%	89.80%	78.16%
Transect Length Weighted - Dominant Correct	42.94%	57.34%	69.97%	45.85%	85.50%	52.66%
Transect Length Weighted - Dominant Correct with Alternate Calls	43.56%	70.99%	75.84%	51.22%	85.50%	60.02%
Transect Length Weighted - % Overlap	47.63%	39.92%	62.76%	54.05%	68.90%	55.05%
Transect Length Weighted - % Overlap with Alternate Calls	54.66%	45.66%	69.75%	60.71%	82.14%	62.56%

3.1.2 Model Goodness of Fit to Field Data

Field data collected in 2003 as part of the Invermere PEM project was compared to the final PEM model's output using Meidinger's (2003) confusion matrix approach. The results are reported in Tables 13 to 17.

Table 13. PPdh2 Confusion Matrix 2003 Field Plot Data Invermere TSA

		FIELD CALL				
PEM CALL		**01**	**02a**	**03**	**total**	**omission**
01		5	0	3	8	37.5%
02a		0	0	0	0	0.0%
03		0	1	0	1	100.0%
	Total:	5	1	3	**9**	
comission		0%	100%	100%		
Total Plots		9				
Number Correct		5				
Number Wrong		4				
Percent Correct (68/96)		55.56%				
Lower Confidence Value		2	22.2%			
Median Confidence Value		5	55.6%			
Upper Confidence Value		8	88.9%			
Overall Accuracy		55.6%				
Avg. Comission:		66.7%				
Avg. Omission		45.8%				

Table 14. IDFdm2 Confusion Matrix 2003 Field Plot Data Invermere TSA

PEM CALL	FIELD CALL 01	02	03	04	05	99	total	omission
01	8.3	2.2	1.3	0.6	0.8	0.1	13.3	36.8%
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
03	3.3	1.6	2.3	0.0	0.2	0.3	7.7	70.1%
04	0.0	0.0	0.0	2.4	0.0	0.0	2.4	0.0%
05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
99	0.4	1.2	0.4	0.0	0.0	0.6	2.6	76%
Total:	12.0	5.0	4.0	3.0	1.0	1	**26**	
comission	30.7%	100.0%	42.5%	20.0%	100.0%	38.0%		

Total Plots	26	
Number Correct	14	
Number Wrong	12.36	
Percent Correct (68/96)	52.46%	
Lower Confidence Value	9	34.6%
Median Confidence Value	14	53.8%
Upper Confidence Value	19	73.1%
Overall Accuracy	52.5%	
Avg. Comission:	55.2%	
Avg. Omission	30.5%	

Table 15. ICHmk1 Confusion Matrix 2003 Field Plot Data Invermere TSA

PEM CALL	01	02	03	FIELD CALL 04	05	06	07	08	total	omission
01	2.5	0	0.4	3	1	0.0	0.0	0	6.5	61.5%
02	0.0	0	0.4	0	0	0.0	0.0	0	0.4	100.0%
03	0.0	0	1.6	0	0	0.0	0.0	0	1.6	0.0%
04	1.0	0	1.6	3.1	0	0.0	0.0	0	5.7	45.6%
05	2.5	0	0	1.9	2.4	0.0	0.0	0	6.8	64.7%
06	1.0	0	0	0	0	0.0	0.0	0	1	100%
07	0.0	0	0	0	0	0.0	0.0	1	1	100%
08	0.0	0	0	0	0	0	0.0	0	0	0%
Total:	7.0	0.0	4.0	8.0	3.0	0.0	0.0	1	**23**	
comission	64.3%	0.0%	60.0%	61.3%	20.0%	0.0%	0.0%	0.0%		

Total Plots	23	
Number Correct	10	
Number Wrong	13.4	
Percent Correct (142/165)	41.74%	
Lower Confidence Value	5	21.7%
Median Confidence Value	10	43.5%
Upper Confidence Value	14	60.9%
Overall Accuracy	41.7%	

Avg. Comission:	25.7%
Avg. Omission	59.0%

Table 16. MSdk Confusion Matrix 2003 Field Plot Data Invermere TSA

PEM CALL	01	02	03	04	05	06	99	total	omission
01	12.7	0.6	6.7	8.2	5.6	0.3	0	34.05	60.9%
02	0.0	1.0	1.7	0.0	0.6	0.0	0	3.34	70.1%
03	0.0	0.0	4.1	1.0	0.0	0.0	0	5.1	19.6%
04	4.8	0.4	3.7	5.4	2.4	0.0	0	16.75	67.6%
05	3.5	0.0	0.0	0.0	6.0	0.7	0	10.2	41.2%
06	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0.0%
99	0.0	0.0	2.8	0.4	0.4	0.0	0	3.6	100.0%
Total:	21.00	2.00	19.00	15.00	15.00	1.00	0.00	**73**	
comission	39.5%	50.0%	54.6%	61.3%	57.5%	0.0%	0.0%		

Overall Accuracy	38.7%	
Avg. Comission:	37.6%	
Avg. Omission	51.3%	
Summary		
Total Plots	73	
Number Correct	29	
Number Wrong	44	
Percent Correct (142/165)	40.03%	
Lower Confidence Value	21	28.8%
Median Confidence Value	29	39.7%
Upper Confidence Value	37	50.7%

Table 17. ESSFdk1 Confusion Matrix 2003 Field Plot Data Invermere TSA

FIELD CALL								
PEM CALL	**01**	**02**	**03**	**04**	**05**	**06**	**total**	**omission**
01	1.0	0.0	0.0	0.0	0.9	0.0	1.9	47.4%
02	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0%
03	0.4	0.2	1.2	1.8	0.4	0.0	4	70.0%
04	3.6	0.8	0.8	7.2	1.9	0.0	14.3	49.7%
05	0.0	0.0	0.0	0.0	1.5	0.0	1.5	0.0%
06	0.0	0.0	0.0	0.0	0.3	0.0	0.3	100.0%
Total:	5.0	1.0	2.0	9.0	5.0	0.0	**22**	
comission	80.0%	0.0%	40.0%	20.0%	70.0%	0.0%		

Overall Accuracy	49.5%
Avg. Comission:	35.0%
Avg. Omission	44.5%

Summary

Total Plots	22	
Number Correct	11	
Number Wrong	11.1	
Percent Correct (142/165)	49.55%	
Lower Confidence Value	6	27.3%
Median Confidence Value	11	50.0%
Upper Confidence Value	15	68.2%

3.1.3 Wilson Approach to Assessment of Model Reliability

An independent assessment of PEM map reliability was undertaken by Dr. Steve Wilson, Ecological Research using the PEM result, knowledge bases and 2003 field data. His report can be found in Appendix X. In general he found the output of the Invermere model did not meet the level considered acceptable as measured by the Kappa calculation. He suggests an alternative approach to the utilization of field plot data in PEM model development which could greatly improve the output of the model.

3.2 PEM Model Result

3.2.1 Map Entity Area by BEC Variant by THLB, NHLB and TSA

The PEM model predicted the following distribution of site series. The area and percentage of area by within the THLB and NTHLB by BEC variant and over the entire project TSA is reported in Table 18. The spatial and data base depiction of the PEM can be found in Appendix IX.

Table 18. Area of Subzones and Site Series in the Invermere TSA Mapped by the PEM Model

			Timber Harvesting Landbase (THLB)		Non-Timber Harvesting Landbase (NHLB)		Entire Invermere TSA	
BEC Zone	**Site Series #**	**Site Series Code**	**Area hectares**	**% of Subzone**	**Area hectares**	**% of Subzone**	**Area hectares**	**% of TSA**
AT	01	AW			18,549.3	16.13%	18,549.3	1.67%
AT	01/99	AW/RO			340.6	0.30%	340.6	0.03%
AT	02	SL			18,303.0	15.92%	18,303.0	1.64%
AT	02/99	SL/RO			502.7	0.44%	502.7	0.05%
AT	03	BP			1,123.5	0.98%	1,123.5	0.10%
AT	03/99	BP/RO			9.1	0.01%	9.1	0.00%
AT	04	KR			37,965.1	33.02%	37,965.1	3.41%
AT	05	WE			7.1	0.01%	7.1	0.00%
AT	77	AC			15,222.3	13.24%	15,222.3	1.37%
AT	88	AR			817.5	0.71%	817.5	0.07%
AT	91	LA			482.1	0.42%	482.1	0.04%
AT	92	OW			12.6	0.01%	12.6	0.00%
AT	93	PD			0.3	0.00%	0.3	0.00%
AT	95	GL			10,493.7	9.13%	10,493.7	0.94%
AT	99	RO			2,702.4	2.35%	2,702.4	0.24%
AT	99/01	RO/AW			3,140.5	2.73%	3,140.5	0.28%
AT	99/02	RO/SL			5,235.4	4.55%	5,235.4	0.47%
AT	99/03	RO/BP			76.2	0.07%	76.2	0.01%
AT Total					**114,983.3**	**100.00%**	**114,983.3**	**10.33%**
ESSFdk1	01	FA	4,552.7	6.42%	24,378.8	12.30%	28,931.5	2.60%
ESSFdk1	01/99	FA/RO	56.9	0.08%	759.1	0.38%	816.0	0.07%
ESSFdk1	02	DM	4,071.6	5.74%	5,931.1	2.99%	10,002.7	0.90%
ESSFdk1	02/99	DM/RO	320.7	0.45%	446.9	0.23%	767.6	0.07%
ESSFdk1	03	FG	0.7	0.00%	682.6	0.34%	683.3	0.06%
ESSFdk1	03/99	FG/RO	2.1	0.00%	1,794.4	0.90%	1,796.4	0.16%
ESSFdk1	04	FS	199.2	0.28%	70,610.3	35.61%	70,809.5	6.36%
ESSFdk1	05	FM	33.4	0.05%	10,992.2	5.54%	11,025.6	0.99%
ESSFdk1	05/99	FM/RO	0.9	0.00%	343.0	0.17%	343.9	0.03%
ESSFdk1	07	WS	73.3	0.10%	156.7	0.08%	230.1	0.02%
ESSFdk1	43	XF	52,774.8	74.37%	51,154.0	25.80%	103,928.8	9.33%
ESSFdk1	43/99	XF/RO	1,087.0	1.53%	12.5	0.01%	1,099.5	0.10%
ESSFdk1	56	XM	6,279.0	8.85%	182.3	0.09%	6,461.3	0.58%
ESSFdk1	56/99	XM/RO	23.8	0.03%	0.4	0.00%	24.1	0.00%
ESSFdk1	77	AC	543.9	0.77%	11,051.5	5.57%	11,595.4	1.04%
ESSFdk1	78	AS	373.7	0.53%	13,138.9	6.63%	13,512.6	1.21%
ESSFdk1	87	AW	64.9	0.09%	523.3	0.26%	588.2	0.05%
ESSFdk1	88	AR	122.7	0.17%	983.9	0.50%	1,106.6	0.10%
ESSFdk1	90	GB	3.4	0.00%	4.1	0.00%	7.4	0.00%
ESSFdk1	91	LA	20.1	0.03%	127.4	0.06%	147.5	0.01%
ESSFdk1	92	OW	0.9	0.00%	4.0	0.00%	4.9	0.00%
ESSFdk1	93	PD		0.00%	0.2	0.00%	0.2	0.00%

ESSFdk1	94	RI	39.3	0.06%	23.5	0.01%	62.8	0.01%
ESSFdk1	99	RO	231.0	0.33%	4,363.7	2.20%	4,594.7	0.41%
ESSFdk1	99/01	RO/FA	5.4	0.01%	232.8	0.12%	238.3	0.02%
ESSFdk1	99/02	RO/DM	3.1	0.00%	90.9	0.05%	94.0	0.01%
ESSFdk1	99/03	RO/FG	0.0	0.00%	171.3	0.09%	171.3	0.02%
ESSFdk1	99/05	RO/FM	0.1	0.00%	117.7	0.06%	117.8	0.01%
ESSFdk1	99/43	RO/XF	74.5	0.11%	1.4	0.00%	75.9	0.01%
ESSFdk1	99/56	RO/XM	5.1	0.01%	0.1	0.00%	5.2	0.00%
ESSFdk1 Total			**70,964.4**	**26.36%**	**198,278.7**	**73.64%**	**269,243.1**	**24.18%**
ESSFdk2	01	FP	3,451.9	33.23%	4,227.3	13.07%	7,679.2	0.69%
ESSFdk2	02	FG	167.0	1.61%	1,493.0	4.62%	1,660.0	0.15%
ESSFdk2	02/99	FG/RO	7.2	0.07%	2,518.7	7.79%	2,525.8	0.23%
ESSFdk2	03	FV	3,909.4	37.63%	10,508.1	32.49%	14,417.5	1.29%
ESSFdk2	03/99	FV/RO	37.5	0.36%	2,839.0	8.78%	2,876.4	0.26%
ESSFdk2	04	FH	2,374.8	22.86%	2,062.4	6.38%	4,437.2	0.40%
ESSFdk2	04/99	FH/RO	5.5	0.05%	190.5	0.59%	196.0	0.02%
ESSFdk2	05/06	FS/WE	46.7	0.45%	19.7	0.06%	66.4	0.01%
ESSFdk2	06	WE	120.2	1.16%	84.6	0.26%	204.7	0.02%
ESSFdk2	77	AC	168.3	1.62%	6,769.9	20.93%	6,938.2	0.62%
ESSFdk2	88	AR	44.7	0.43%	402.0	1.24%	446.7	0.04%
ESSFdk2	90	GB	6.1	0.06%	22.1	0.07%	28.2	0.00%
ESSFdk2	91	LA	1.0	0.01%	51.9	0.16%	52.9	0.00%
ESSFdk2	92	OW	0.3	0.00%	1.3	0.00%	1.6	0.00%
ESSFdk2	93	PD	0.1	0.00%		0.00%	0.1	0.00%
ESSFdk2	94	RI	21.2	0.20%	6.0	0.02%	27.1	0.00%
ESSFdk2	95	GL		0.00%	4.8	0.01%	4.8	0.00%
ESSFdk2	96	RE	0.1	0.00%			0.1	0.00%
ESSFdk2	99	RO	27.3	0.26%	658.6	2.04%	685.9	0.06%
ESSFdk2	99/01	RO/FS		0.00%	0.6	0.00%	0.6	0.00%
ESSFdk2	99/02	RO/FG		0.00%	250.3	0.77%	250.3	0.02%
ESSFdk2	99/03	RO/FV	0.2	0.00%	132.4	0.41%	132.6	0.01%
ESSFdk2	99/04	RO/FH		0.00%	96.2	0.30%	96.2	0.01%
ESSFdk2 Total			**10,389.3**	**24.31%**	**32,339.3**	**75.69%**	**42,728.6**	**3.84%**
ESSFdku	01	EM	1,145.1	49.34%	67,679.1	25.90%	68,824.1	6.18%
ESSFdku	01/02	EM/AW	2.2	0.10%	169.3	0.06%	171.5	0.02%
ESSFdku	02	AW	256.6	11.05%	13,310.9	5.09%	13,567.4	1.22%
ESSFdku	02/99	AW/RO	70.5	3.04%	8,508.5	3.26%	8,579.0	0.77%
ESSFdku	03	WF	315.3	13.59%	25,624.5	9.80%	25,939.8	2.33%
ESSFdku	03/99	WF/RO	27.5	1.19%	5,802.2	2.22%	5,829.7	0.52%
ESSFdku	04	YW	110.7	4.77%	21,550.7	8.25%	21,661.4	1.95%
ESSFdku	05	LM	295.7	12.74%	11,201.3	4.29%	11,497.0	1.03%
ESSFdku	06	FH	3.6	0.15%	414.7	0.16%	418.3	0.04%
ESSFdku	07	WE	0.3	0.01%	256.0	0.10%	256.2	0.02%
ESSFdku	08	DV	40.1	1.73%	2,523.8	0.97%	2,563.9	0.23%
ESSFdku	77	AC	17.8	0.77%	49,587.8	18.97%	49,605.6	4.45%
ESSFdku	88	AR	9.0	0.39%	4,602.5	1.76%	4,611.5	0.41%
ESSFdku	91	LA	0.3	0.01%	1,241.9	0.48%	1,242.2	0.11%
ESSFdku	92	OW		0.00%	42.1	0.02%	42.1	0.00%

ESSFdku	93	PD		0.00%	2.4	0.00%	2.4	0.00%
ESSFdku	95	GL		0.00%	667.0	0.26%	667.0	0.06%
ESSFdku	99	RO	18.1	0.78%	10,614.2	4.06%	10,632.3	0.95%
ESSFdku	99/02	RO/AW	5.0	0.22%	24,314.8	9.30%	24,319.9	2.18%
ESSFdku	99/03	RO/WF	3.1	0.13%	13,232.1	5.06%	13,235.2	1.19%
ESSFdku Total			**2,320.9**	**0.88%**	**261,345.7**	**99.12%**	**263,666.6**	**23.68%**
ESSFwm	01	FA	363.8	34.03%	340.8	23.83%	704.6	0.06%
ESSFwm	02	FR	101.4	9.49%	208.1	14.55%	309.5	0.03%
ESSFwm	02/99	FR/RO		0.00%	78.2	5.47%	78.2	0.01%
ESSFwm	03	RA	237.1	22.18%	293.7	20.53%	530.8	0.05%
ESSFwm	04	FQ	345.5	32.32%	183.6	12.84%	529.1	0.05%
ESSFwm	77	AC	14.1	1.32%	266.5	18.63%	280.6	0.03%
ESSFwm	88	AR	4.4	0.41%	24.3	1.70%	28.7	0.00%
ESSFwm	90	GB	0.9	0.09%	1.1	0.08%	2.1	0.00%
ESSFwm	94	RI	0.7	0.06%		0.00%	0.7	0.00%
ESSFwm	99	RO	0.9	0.08%	13.3	0.93%	14.1	0.00%
ESSFwm	99/02	RO/FR		0.00%	20.9	1.46%	20.9	0.00%
ESSFwm Total			**1,068.9**	**42.77%**	**1,430.4**	**57.23%**	**2,499.3**	**0.22%**
ESSFwmu	01	EM	14.0	41.16%	679.1	38.13%	693.1	0.06%
ESSFwmu	01/02	EM/AW		0.00%	0.4	0.02%	0.4	0.00%
ESSFwmu	02	AW	0.4	1.12%	63.7	3.58%	64.1	0.01%
ESSFwmu	02/99	AW/RO		0.00%	67.6	3.79%	67.6	0.01%
ESSFwmu	03	WF	2.8	8.38%	72.8	4.09%	75.6	0.01%
ESSFwmu	03/99	WF/RO		0.00%	14.7	0.82%	14.7	0.00%
ESSFwmu	04	YW	15.6	45.90%	236.8	13.30%	252.4	0.02%
ESSFwmu	05	LM	1.2	3.45%	30.4	1.71%	31.6	0.00%
ESSFwmu	06	FH		0.00%	0.1	0.01%	0.1	0.00%
ESSFwmu	08	DV		0.00%	21.3	1.19%	21.3	0.00%
ESSFwmu	77	AC		0.00%	460.1	25.83%	460.1	0.04%
ESSFwmu	88	AR		0.00%	21.2	1.19%	21.2	0.00%
ESSFwmu	91	LA		0.00%	3.0	0.17%	3.0	0.00%
ESSFwmu	92	OW		0.00%	0.1	0.00%	0.1	0.00%
ESSFwmu	95	GL		0.00%	1.4	0.08%	1.4	0.00%
ESSFwmu	99	RO		0.00%	1.7	0.09%	1.7	0.00%
ESSFwmu	99/02	RO/AW		0.00%	85.2	4.78%	85.2	0.01%
ESSFwmu	99/03	RO/WF		0.00%	21.6	1.21%	21.6	0.00%
ESSFwmu Total			**34.0**	**1.87%**	**1,781.1**	**98.13%**	**1,815.1**	**0.16%**
ICHmk1	01	RF	43.6	0.10%		0.00%	43.6	0.00%
ICHmk1	02	DP	476.0	1.07%	169.8	1.11%	645.8	0.06%
ICHmk1	02/99	DP/RO	18.3	0.04%	154.3	1.01%	172.6	0.02%
ICHmk1	03	DT	2,510.8	5.64%	1,919.0	12.53%	4,429.9	0.40%
ICHmk1	03/99	DT/RO	249.4	0.56%	1,545.9	10.10%	1,795.3	0.16%
ICHmk1	04	DA	7,618.8	17.11%	2,924.4	19.10%	10,543.2	0.95%
ICHmk1	05	SG	4,689.2	10.53%	623.7	4.07%	5,312.9	0.48%
ICHmk1	05/99	SG/RO	21.4	0.05%	37.4	0.24%	58.8	0.01%
ICHmk1	06	SO	4,764.1	10.70%	264.0	1.72%	5,028.1	0.45%
ICHmk1	06/99	SO/RO	12.1	0.03%	6.6	0.04%	18.8	0.00%

ICHmk1	07	SH	493.6	1.11%	22.6	0.15%	516.1	0.05%
ICHmk1	08	WE	261.0	0.59%	3.0	0.02%	264.0	0.02%
ICHmk1	41	XA	21,978.1	49.35%	5,470.1	35.73%	27,448.2	2.47%
ICHmk1	41/99	XA/RO	256.0	0.57%	498.8	3.26%	754.8	0.07%
ICHmk1	77	AC	240.4	0.54%	1,034.1	6.75%	1,274.5	0.11%
ICHmk1	88	AR	35.9	0.08%	53.0	0.35%	88.8	0.01%
ICHmk1	90	GB	8.1	0.02%		0.00%	8.1	0.00%
ICHmk1	91	LA	393.7	0.88%	12.3	0.08%	406.0	0.04%
ICHmk1	92	OW	10.3	0.02%	0.3	0.00%	10.6	0.00%
ICHmk1	93	PD	2.1	0.00%		0.00%	2.1	0.00%
ICHmk1	94	RI	266.7	0.60%		0.00%	266.7	0.02%
ICHmk1	99	RO	77.5	0.17%	467.8	3.06%	545.3	0.05%
ICHmk1	99/02	RO/DP	3.9	0.01%	9.4	0.06%	13.3	0.00%
ICHmk1	99/03	RO/DT	33.5	0.08%	77.7	0.51%	111.1	0.01%
ICHmk1	99/05	RO/SG	0.8	0.00%	0.4	0.00%	1.2	0.00%
ICHmk1	99/06	RO/SO		0.00%	0.1	0.00%	0.1	0.00%
ICHmk1	99/41	RO/XA	66.8	0.15%	16.3	0.11%	83.1	0.01%
ICHmk1 Total			**44,531.8**	**74.41%**	**15,310.9**	**25.59%**	**59,842.7**	**5.37%**
IDFdm2	01	DT	64,832.2	66.41%	1,833.8	34.01%	66,665.9	5.99%
IDFdm2	01/99	DT/RO	911.5	0.93%	229.1	4.25%	1,140.6	0.10%
IDFdm2	02	AW	4,094.8	4.19%	41.3	0.77%	4,136.1	0.37%
IDFdm2	02/99	AW/RO	87.6	0.09%	23.6	0.44%	111.2	0.01%
IDFdm2	03	DS	12,452.1	12.76%	833.2	15.45%	13,285.3	1.19%
IDFdm2	03/99	DS/RO	1,291.6	1.32%	1,378.4	25.56%	2,670.0	0.24%
IDFdm2	04	SP	5,346.0	5.48%	30.6	0.57%	5,376.6	0.48%
IDFdm2	05	SS	3,465.5	3.55%	229.3	4.25%	3,694.9	0.33%
IDFdm2	06/07	WE	1,823.8	1.87%		0.00%	1,823.8	0.16%
IDFdm2	90	GB	332.6	0.34%	0.8	0.02%	333.4	0.03%
IDFdm2	91	LA	1,012.9	1.04%	5.3	0.10%	1,018.3	0.09%
IDFdm2	92	OW	50.1	0.05%	0.2	0.00%	50.4	0.00%
IDFdm2	93	PD	15.8	0.02%		0.00%	15.8	0.00%
IDFdm2	94	RI	984.0	1.01%	6.9	0.13%	990.8	0.09%
IDFdm2	96	RE	20.6	0.02%		0.00%	20.6	0.00%
IDFdm2	99	RO	448.8	0.46%	439.1	8.14%	887.9	0.08%
IDFdm2	99/01	RO/DT	178.4	0.18%	20.3	0.38%	198.7	0.02%
IDFdm2	99/02	RO/AW	12.3	0.01%	12.3	0.23%	24.6	0.00%
IDFdm2	99/03	RO/DS	258.0	0.26%	308.3	5.72%	566.3	0.05%
IDFdm2 Total			**97,618.5**	**94.77%**	**5,392.5**	**5.23%**	**103,011.1**	**9.25%**
IDFdm2n	01	DT	8,390.0	40.89%	26.9	15.49%	8,416.9	0.76%
IDFdm2n	01/99	DT/RO	35.9	0.18%	9.2	5.30%	45.1	0.00%
IDFdm2n	03	DS	1,342.9	6.55%	42.3	24.37%	1,385.2	0.12%
IDFdm2n	03/99	DS/RO	55.5	0.27%	45.3	26.12%	100.8	0.01%
IDFdm2n	04	SP	2,611.9	12.73%	13.6	7.84%	2,625.5	0.24%
IDFdm2n	04/99	SP/RO	17.1	0.08%	4.1	2.36%	21.2	0.00%
IDFdm2n	05	SS	2,488.5	12.13%	3.6	2.07%	2,492.1	0.22%
IDFdm2n	05/99	SS/RO	5.4	0.03%	2.1	1.19%	7.4	0.00%
IDFdm2n	06	BH	2,168.3	10.57%		0.00%	2,168.3	0.19%
IDFdm2n	06/07	BH/SH	50.5	0.25%		0.00%	50.5	0.00%

IDFdm2n	90	GB	1.4	0.01%		0.00%	1.4	0.00%
IDFdm2n	91	LA	2,363.1	11.52%		0.00%	2,363.1	0.21%
IDFdm2n	92	OW	273.3	1.33%		0.00%	273.3	0.02%
IDFdm2n	93	PD	30.1	0.15%		0.00%	30.1	0.00%
IDFdm2n	94	RI	656.0	3.20%		0.00%	656.0	0.06%
IDFdm2n	99	RO	27.2	0.13%	26.5	15.25%	53.7	0.00%
IDFdm2n	99/03	RO/DS	0.3	0.00%		0.00%	0.3	0.00%
IDFdm2n Total			**20,517.3**	**99.16%**	**173.5**	**0.84%**	**20,690.8**	**1.86%**
IDFxk	02	SW	1,079.0	3.33%	78.9	4.38%	1,157.9	0.10%
IDFxk	02/99	SW/RO	130.5	0.40%	81.7	4.54%	212.3	0.02%
IDFxk	03	DP	1,223.9	3.78%	17.4	0.97%	1,241.3	0.11%
IDFxk	03/99	DP/RO	27.6	0.09%	1.5	0.08%	29.1	0.00%
IDFxk	04	SS	4,797.3	14.82%	84.5	4.69%	4,881.7	0.44%
IDFxk	04/99	SS/RO	21.1	0.07%	9.1	0.50%	30.2	0.00%
IDFxk	05	CD	1,149.3	3.55%	95.1	5.28%	1,244.4	0.11%
IDFxk	05/99	CD/RO	0.2	0.00%		0.00%	0.2	0.00%
IDFxk	06	WE	2,299.1	7.10%	206.3	11.45%	2,505.4	0.22%
IDFxk	21	XJ	17,160.6	53.01%	476.7	26.46%	17,637.2	1.58%
IDFxk	21/99	XJ/RO	67.3	0.21%	9.5	0.53%	76.8	0.01%
IDFxk	90	GB	36.2	0.11%	0.1	0.01%	36.4	0.00%
IDFxk	91	LA	3,740.8	11.56%	625.2	34.70%	4,365.9	0.39%
IDFxk	92	OW	4.8	0.01%	2.1	0.12%	6.9	0.00%
IDFxk	93	PD	13.8	0.04%		0.00%	13.8	0.00%
IDFxk	94	RI	437.1	1.35%	1.1	0.06%	438.2	0.04%
IDFxk	96	RE	8.7	0.03%		0.00%	8.7	0.00%
IDFxk	99	RO	51.8	0.16%	82.7	4.59%	134.5	0.01%
IDFxk	99/02	RO/SW	82.3	0.25%	21.6	1.20%	103.9	0.01%
IDFxk	99/03	RO/DP	25.2	0.08%	0.6	0.04%	25.9	0.00%
IDFxk	99/04	RO/SS	14.3	0.04%	7.4	0.41%	21.7	0.00%
IDFxk Total			**32,370.8**	**94.73%**	**1,801.5**	**5.27%**	**34,172.3**	**3.07%**
MSdk	01	SG	16,025.9	11.16%	6,026.0	13.43%	22,051.8	1.98%
MSdk	02/99	SW/RO	685.7	0.48%	2,048.5	4.57%	2,734.2	0.25%
MSdk	03	LJ	2,979.9	2.08%	801.0	1.79%	3,780.9	0.34%
MSdk	03/99	LJ/RO	28.3	0.02%	4.5	0.01%	32.7	0.00%
MSdk	05	SS	6,758.7	4.71%	1,283.7	2.86%	8,042.4	0.72%
MSdk	05/99	SS/RO	23.1	0.02%	52.3	0.12%	75.4	0.01%
MSdk	06	SH	828.2	0.58%	47.0	0.10%	875.2	0.08%
MSdk	06/07	SH/SB	1,061.8	0.74%	76.0	0.17%	1,137.8	0.10%
MSdk	07	SB	879.3	0.61%	73.6	0.16%	952.9	0.09%
MSdk	15	XS	13,583.3	9.46%	2,349.3	5.24%	15,932.6	1.43%
MSdk	41	XL	95,444.7	66.46%	22,607.2	50.40%	118,051.8	10.60%
MSdk	41/99	XL/RO	1,193.8	0.83%	2,619.7	5.84%	3,813.5	0.34%
MSdk	90	GB	347.9	0.24%	73.4	0.16%	421.3	0.04%
MSdk	91	LA	736.1	0.51%	3.6	0.01%	739.7	0.07%
MSdk	92	OW	22.5	0.02%	1.3	0.00%	23.8	0.00%
MSdk	93	PD	1.3	0.00%		0.00%	1.3	0.00%
MSdk	94	RI	1,158.6	0.81%	129.1	0.29%	1,287.7	0.12%
MSdk	96	RE	0.1	0.00%		0.00%	0.1	0.00%

MSdk	99	RO	479.9	0.33%	1,710.7	3.81%	2,190.6	0.20%
MSdk	99/02	RO/SW	1,304.2	0.91%	4,735.7	10.56%	6,039.9	0.54%
MSdk	99/05	RO/SS	2.9	0.00%	9.0	0.02%	11.9	0.00%
MSdk	99/41	RO/XL	59.5	0.04%	201.6	0.45%	261.1	0.02%
MSdk Total			**143,605.7**	**76.20%**	**44,852.8**	**23.80%**	**188,458.5**	**16.92%**
PPdh2	01	PW	7,980.8	64.35%			7,980.8	0.72%
PPdh2	01/99	PW/RO	18.8	0.15%			18.8	0.00%
PPdh2	02a	WJa	1,571.6	12.67%			1,571.6	0.14%
PPdh2	02b	WJb	384.8	3.10%			384.8	0.03%
PPdh2	02b/99	WJb/RO	16.4	0.13%			16.4	0.00%
PPdh2	03	AR	1,301.5	10.49%			1,301.5	0.12%
PPdh2	03/99	AR/RO	3.2	0.03%			3.2	0.00%
PPdh2	04	CD	342.1	2.76%			342.1	0.03%
PPdh2	04/99	CD/RO	0.1	0.00%			0.1	0.00%
PPdh2	05	WE	255.7	2.06%			255.7	0.02%
PPdh2	90	GB	57.4	0.46%			57.4	0.01%
PPdh2	91	LA	80.3	0.65%			80.3	0.01%
PPdh2	92	OW	4.7	0.04%			4.7	0.00%
PPdh2	93	PD	0.3	0.00%			0.3	0.00%
PPdh2	94	RI	327.4	2.64%			327.4	0.03%
PPdh2	96	RE	37.2	0.30%			37.2	0.00%
PPdh2	99	RO	5.1	0.04%			5.1	0.00%
PPdh2	99/01	RO/PW	5.0	0.04%			5.0	0.00%
PPdh2	99/02b	RO/WJb	7.4	0.06%			7.4	0.00%
PPdh2	99/03	RO/AR	2.0	0.02%			2.0	0.00%
PPdh2 Total			12,401.7	100.00%			12,401.7	1.11%
Grand Total			**435,823.1**	**39.14%**	**677,689.9**	**60.86%**	**1,113,513.0**	

3.2.2 Structural Stage Area by BEC Variant

Structural stage was modeled as a layer separate to map entity throughout the Invermere TSA. Table 19 reports the distribution of structure by BEC variant within the THLB, NHLB and throughout the TSA.

Table 19. Structural Stage Distribution by BEC, Invermere TSA

BEC variant	Structural Stage	THLB hectares	THLB Percentage	NHLB hectares	NHLB Percentage	Entire TSA hectares	Entire TSA percentage
AT un	0			2339.2	2.03%	2339.2	2.03%
	1			158.9	0.14%	158.9	0.14%
	2			111432.7	96.83%	111432.7	96.83%
	3			699.8	0.61%	699.8	0.61%
	4			0.3	0.00%	0.3	0.00%
	5			9.4	0.01%	9.4	0.01%
	6			169.4	0.15%	169.4	0.15%
	7			274.5	0.24%	274.5	0.24%
AT un Total				**115084.3**	**100.00%**	**115084.3**	**100.00%**
ESSFdk 1	0	3821.4	5.39%	1942.6	0.98%	5764.0	2.14%
	1	245.7	0.35%	4292.7	2.16%	4538.4	1.69%
	2	1309.7	1.85%	34194.2	17.25%	35503.9	13.19%
	3	18414.7	25.95%	28127.9	14.19%	46542.6	17.29%
	4	3078.9	4.34%	8243.3	4.16%	11322.3	4.21%
	5	16339.8	23.03%	43466.7	21.92%	59806.6	22.21%
	6	24090.4	33.95%	69401.3	35.00%	93491.6	34.72%
	7	3662.9	5.16%	8614.5	4.34%	12277.4	4.56%
ESSFdk 1 Total		**70963.5**	**100.00%**	**198283.3**	**100.00%**	**269246.8**	**100.00%**
ESSFdk 2	0	223.0	2.15%	111.5	0.34%	334.5	0.78%
	1	27.0	0.26%	505.7	1.56%	532.7	1.25%
	2	386.4	3.72%	9575.5	29.61%	9961.9	23.31%
	3	2157.8	20.77%	3345.6	10.35%	5503.5	12.88%
	4	425.2	4.09%	554.5	1.71%	979.7	2.29%
	5	2758.1	26.54%	5924.9	18.32%	8683.0	20.32%
	6	2696.7	25.95%	9482.5	29.32%	12179.2	28.50%
	7	1716.1	16.52%	2837.9	8.78%	4554.0	10.66%
ESSFdk 2 Total		**10390.4**	**100.00%**	**32338.2**	**100.00%**	**42728.5**	**100.00%**
ESSFdku	0	118.8	5.09%	2440.7	0.93%	2559.4	0.97%
	1	18.8	0.81%	4250.4	1.63%	4269.3	1.62%
	2	64.9	2.78%	139106.4	53.21%	139171.3	52.77%
	3	362.4	15.52%	28796.5	11.02%	29158.8	11.06%
	4	23.4	1.00%	1298.1	0.50%	1321.5	0.50%
	5	323.3	13.84%	13356.5	5.11%	13679.8	5.19%
	6	1041.9	44.62%	62533.7	23.92%	63575.6	24.10%
	7	381.6	16.34%	9632.5	3.68%	10014.1	3.80%
ESSFdku Total		**2335.1**	**100.00%**	**261414.8**	**100.00%**	**263749.9**	**100.00%**
ESSFwm	0	68.5	6.41%	13.6	0.95%	82.2	3.29%
	1	0.9	0.09%	13.2	0.92%	14.1	0.56%
	2	33.6	3.14%	498.6	34.87%	532.2	21.30%
	3	394.8	36.92%	188.5	13.18%	583.3	23.34%
	4	103.5	9.68%	1.4	0.10%	104.9	4.20%
	5	57.8	5.41%	109.8	7.68%	167.6	6.70%

	6	115.7	10.82%	335.7	23.47%	451.4	18.06%
	7	294.3	27.53%	269.3	18.83%	563.6	22.55%
ESSFwm Total		**1069.1**	**100.00%**	**1430.1**	**100.00%**	**2499.2**	**100.00%**
ESSFwmu	0	4.5	13.13%	9.0	0.50%	13.4	0.74%
	1	0.0	0.00%	1.6	0.09%	1.6	0.09%
	2	0.0	0.00%	1193.0	66.96%	1193.0	65.71%
	3	0.0	0.00%	185.9	10.44%	185.9	10.24%
	5	0.2	0.48%	51.1	2.87%	51.2	2.82%
	6	0.0	0.00%	141.2	7.93%	141.2	7.78%
	7	29.4	86.27%	199.8	11.22%	229.2	12.63%
ESSFwmu Total		**34.1**	**100.00%**	**1781.6**	**100.00%**	**1815.7**	**100.00%**
ICH mk 1	0	3350.7	7.53%	55.6	0.36%	3406.3	5.69%
	1	111.8	0.25%	466.3	3.05%	578.1	0.97%
	2	787.7	1.77%	1372.8	8.97%	2160.5	3.61%
	3	5393.9	12.11%	681.4	4.45%	6075.4	10.15%
	4	2995.6	6.73%	1341.6	8.76%	4337.3	7.25%
	5	20686.9	46.46%	6896.1	45.05%	27583.0	46.10%
	6	10082.5	22.64%	4262.7	27.84%	14345.2	23.97%
	7	1116.4	2.51%	232.2	1.52%	1348.7	2.25%
ICH mk 1 Total		**44525.6**	**100.00%**	**15308.7**	**100.00%**	**59834.4**	**100.00%**
IDF dm 2	0	11532.0	11.82%	77.6	1.44%	11609.6	11.27%
	1	800.2	0.82%	501.2	9.29%	1301.3	1.26%
	2	6299.7	6.46%	55.5	1.03%	6355.2	6.17%
	3	14070.6	14.42%	454.6	8.43%	14525.1	14.11%
	4	7592.8	7.78%	229.4	4.25%	7822.2	7.60%
	5	43150.1	44.22%	2262.6	41.95%	45412.8	44.10%
	6	14061.2	14.41%	1812.6	33.61%	15873.9	15.42%
	7	69.6	0.07%		0.00%	69.6	0.07%
IDF dm 2 Total		**97576.2**	**100.00%**	**5393.5**	**100.00%**	**102969.7**	**100.00%**
IDF dm 2n	0	5510.0	26.84%		0.00%	5510.0	26.61%
	1	35.9	0.17%	26.4	15.25%	62.2	0.30%
	2	4413.9	21.50%	0.0	0.00%	4413.9	21.32%
	3	776.7	3.78%	12.7	7.35%	789.5	3.81%
	4	1339.2	6.52%	9.9	5.70%	1349.0	6.52%
	5	6859.3	33.41%	100.1	57.85%	6959.4	33.62%
	6	1589.9	7.74%	24.0	13.88%	1613.9	7.80%
	7	4.7	0.02%		0.00%	4.7	0.02%
IDF dm 2n Total		**20529.5**	**100.00%**	**173.0**	**100.03%**	**20702.6**	**100.00%**
IDF xk	0	10004.0	30.90%	1055.6	58.60%	11059.6	32.36%
	1	1040.5	3.21%	85.0	4.72%	1125.4	3.29%
	2	5588.6	17.26%	26.0	1.44%	5614.5	16.43%
	3	1759.4	5.44%	203.9	11.32%	1963.3	5.75%
	4	710.0	2.19%	27.4	1.52%	737.5	2.16%
	5	11549.6	35.68%	179.3	9.95%	11728.9	34.32%
	6	1719.4	5.31%	224.3	12.45%	1943.7	5.69%
IDF xk Total		**32371.5**	**100.00%**	**1801.4**	**100.00%**	**34172.9**	**100.00%**
MS dk	0	11093.3	7.72%	595.3	1.33%	11688.6	6.20%

	1	1014.1	0.71%	1607.2	3.58%	2621.3	1.39%
	2	1578.1	1.10%	2698.7	6.02%	4276.7	2.27%
	3	35209.5	24.51%	6056.3	13.50%	41265.8	21.89%
	4	7161.4	4.99%	3623.5	8.08%	10784.9	5.72%
	5	51815.3	36.07%	17384.8	38.76%	69200.1	36.71%
	6	34185.1	23.80%	12297.6	27.42%	46482.7	24.66%
	7	1599.9	1.11%	592.5	1.32%	2192.4	1.16%
MS dk Total		**143656.8**	**100.00%**	**44855.8**	**100.00%**	**188512.5**	**100.00%**
PP dh 2	0	1401.7	11.30%			1401.7	11.30%
	1	7.5	0.06%			7.5	0.06%
	2	2509.8	20.23%			2509.8	20.23%
	3	1305.6	10.52%			1305.6	10.52%
	4	686.9	5.54%			686.9	5.54%
	5	4862.0	39.19%			4862.0	39.19%
	6	1632.2	13.16%			1632.2	13.16%
PP dh 2 Total		**12405.7**	**100.00%**			**12405.7**	**100.00%**
Grand Total		435857.5		677864.7		1113722.2	

3.3 An Illustrated Depiction of Some Site Series of the Invermere TSA

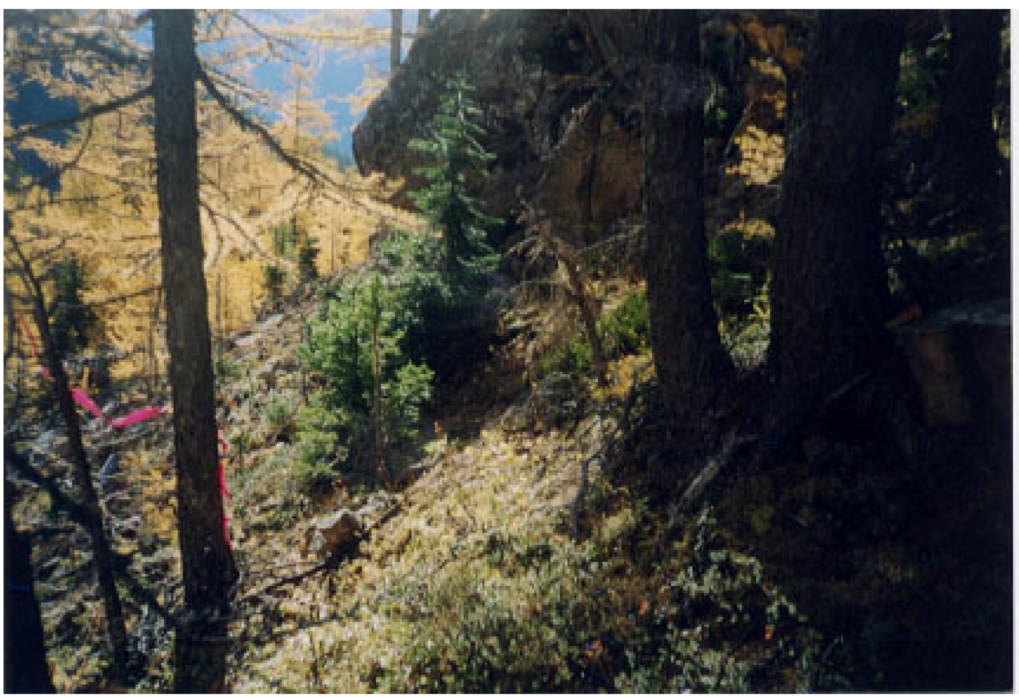
AT/01 AW Dry Meadow Structural Stage 2/3a

ESSFdk1/01 FA Bl – Azalea – Foamflower Structural Stage 5

ESSFdk1/04 FS Bl – Azalea – Soopolallie Structural Stage 4

ESSFdk2/01 FP Bl – Black Huckleberry – Red-stemmed Feathermoss Structural Stage 6

ESSFdk2/02 FG Bl – Pa – Grouseberry Structural Stage 3



ESSFdku/01 EM Submesic to Mesic Forests Structral Stage 6

ESSFdku/03 WF Subxeric to Submesic Forests Structural Stage 5.

ICHmk1/01 RF CwSxw – Falsebox Structural Stage 5.

ICHmk1/03 DT FdPl – Pinegrass – Twinflower Structural Stage 5

ICHmk1/04 DA FdPl – Sitka Alder – Pinegrass Structural Stage 5.

ICHmk1/08 WE Wetland Complex Structural Stage 3

ICHmk1/88 AR Avalanche Runout Zone Structrual Stage 3

IDFdm2/01 DT FdPl – Pinegrass – Twinflower Structural Stage 5.

IDFdm2/02 AW – Antelope Brush – Bluebunch wheatgrass Structural Stage 2/5

IDFdm2/05 SS Swx At – Sarsaparilla Structural Stage 5.

IDFxk/02 SW Fd – Rocky Mountain Juniper–Bluebunch Wheatgrass Structural Stage 2

MSdk/01 SG Sxw – Soopolallie Grouseberry Structural Stage 5

MSdk/02 SW Saskatoon – Bluebunch Wheatgrass Structural Stage 2/3

MSdk/03 LJ Pl Juniper- Pinegrass Structural Stage 5

MSdk/04 LP Sxw Soopolallie – Pinegrass Structural Stage 5

MSdk/05 SS Swx – Soopallie – Snowberry Structural Stage 5.

PPdh2/01 PW Py – Bluebunch Wheatgrass- Junegrass Structural Stage 5.

PPdh2/02a WJa Bluebunch Wheatgrass – Junegrass subxeric to xeric phase Structural Stage 5.

4.0 Discussion

The Invermere PEM project modeled map entities depicting site series and proportions of site series based on the site series classification of Braumandl and Curran (1992) using revised BEC variant spatial data provided by Braumandl and Dykstra (2003). The reliability of the model varies with BEC variant and with the method of approach to assessing map reliability (Timberline, 2003, Wilson, 2004). The model could be improved as more sophisticated methods of utilizing field data information for clarifying the relationship between landscape shape, terrain, slope and aspect is determined. Changes to the BEC classification that may be up coming can also be incorporated into the model when they are available. There is opportunity for improvement in this PEM model. For the short-term it is a useful description of the spatial depiction of site series within the Invermere TSA for use in Timber Supply Review activities, sensitivity analyses, and assessment of wildlife habitat distribution (Timberline, 2003).

As reported in Wilson (2004) there are ways the model can be improved. Field data, in the form of "experience" are lacking in 37% of the map units depicted within the project area. Knowledge bases derived from expert knowledge and tabularly summarized field data do not adequately represent the uncertainty of the relationship between field data and knowledge bases. The experience and reliability of the PEM model relative to the 2003 field data is depicted in Appendix X.

Other sources of error within the PEM model include; spatial accuracy of field plot data, TRIM and forest cover, shortcomings of the existing site series classification and BEC variant mapping. We are particularly concerned about the result of the MSdk. We believe, based on extensive field experience, that this BEC subzone needs subdivision into at least two variants based on location within the EPM and SPK ecosections. There is a significant difference in the distribution of some key indicator plants used in the present MSdk site series classification.

Field sample data for model building and testing was limited by the resources available to complete this project, although adequate (62% of the scope of map entities had at least one plot representing them). Many difficult to depict map units had no field data in them.

The lack of traditional bioterrain input may have had some influence on the accuracy and reliability of this PEM model. However, this could be best tested by running the model with a traditional bioterrain component on a portion of the TSA that has bioterrain mapping and comparing results between the two approaches.

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