Revelstoke Predictive Ecosystem Mapping
Final Report (BAPID # 4316)

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Revelstoke PEM Final Report

Abstract:

This Predictive Ecosystem Mapping (PEM) project was initiated by Susan Hall of Parks Canada – Mount Revelstoke and Glacier, and carried out by the Ministry of Environment with GIS support from Silvatech Consulting Ltd. and the Integrated Land Management Bureau. The funding for this project was provided by Parks Canada, FIA through the Revelstoke Community Forest Corporation (RCFC) and the Ministry of Forests – BC Timber Sales program – Okanagan-Columbia.

The primary purpose for the creation of the PEM maps and Seral Stage maps is for Wildlife Biologists to utilize these in the creation of wildlife habitat maps focusing on the Mountain Caribou herds (mountain ecotype of woodland caribou – *Rangifer tarandus caribou)*. A new hypothesis presented by Parks Canada is that young forest stands in the areas of preferred habitats have been impediments to the movement of the caribou. In order to test this hypothesis, we created an accurate ecosystem map that identifies the preferred habitat areas for the caribou, followed by the creation of seral stage maps that identify the age of the stands located on these habitat sites. These maps will be used by the Biologists to model the caribou habitat in 1985 and 2005 in order to determine if and where the habitat deteriorations are occurring. From this information, forest management strategies can be devised to help increase the size of the endangered Mountain Caribou herds once again.

A secondary, but no less important, use of this PEM map is for timber supply analysis and forest management planning. The PEM map provides valuable information about the distribution of ecosystem units across the land base to enable the management of both timber and non-timber values. The support for this project by RCFC and MoF Small Business program, simultaneously benefits them in their timber supply analyses and landscape unit planning.

The Revelstoke PEM was created with an an upgraded version of EcoGen originally developed by the Ministry of Forests Research Branch amended by Silvatech Consulting Ltd. No bioterrain mapping was used in this PEM, though satellite imagery analysis was used to assist with the assignment of ecosystem labels in non-forested and alpine areas. The accuracy results described in this report verify that the choices made for the creation of this PEM have been successful. This PEM utilized the revised Biogeoclimatic Ecosystem Classification (BEC) system written by Dennis Lloyd, et. al , Regional Ecologist of the Ministry of Forests – Southern Interior Forest Region (2005).

This is a Level 1PEM which produced small-polygons averaging 0.5 ha in size, that are spatially explicit – each site series is shown where it exists on the map. The Internal QA reported an accuracy of 75% for the PEM label matching the ground label, which we believe is a little low due to the samples being located in difficult transition areas. This PEM surpassed the required 65% accuracy level in order to utilize the PEM in all forest management and wildlife management applications. As well, this PEM surpassed our objective of creating pure ecosystem labels and has 91% of all polygons with pure labels. This PEM project was also used as a test case for the new draft PEM Standards version 2.0 which are in development under the direction of the Ministry of Environment (Colleen Jones). This PEM project provided a testing ground to determine if all the data structures are practical, useful and fit seamlessly into the Land and Resource Data Warehouse (LRDW) in Victoria.

We would like to thank Susan Hall of Parks Canada, Bob Clarke and Del Williams of Revelstoke Community Forest Corporation and Dave Gill of the Ministry of Forests Timber Sales program for the opportunity to create this PEM and Seral Stage maps for the Revelstoke TSA. It has been a pleasure working with everyone, and an honour to create these ecosystem products that will be used for the development of many other forest and wildlife management applications.

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1. Introduction

In the spring of 2005, Susan Hall of Parks Canada – Mount Revelstoke and Glacier, contacted the (then) Ministry of Sustainable Resource Management for potential collaboration on the creation of Predictive Ecosystem Maps (PEM) and associated Seral Stage maps for the Revelstoke area north of the Trans-Canada highway. Colleen Jones, TEM/PEM Specialist and Eric Valdal Resource Analyst offered their support and coordination of these two products. Through a bidding process, Silvatech Consulting Ltd. of Salmon Arm was selected as the GIS contractor to provide GIS services for the production of the PEM. The bulk of the funding for this project was provided by Parks Canada, but extra funding was also provided by the Revelstoke Community Forest Corporation (RCFC) and the Ministry of Forests – Timber Sales program – Okanagan-Columbia Business Area.

The primary purpose for the creation of the PEM maps and Seral Stage maps is for Wildlife Biologists to utilize these in the creation of wildlife habitat maps focusing on the Mountain Caribou herds (mountain ecotype of woodland caribou – *Rangifer tarandus caribou)*. The mountain caribou herds of Revelstoke/Glacier have been declared endangered and are high on the interest list of the Species at Risk committee of the Ministry of Environment. Parks Canada has a particular interest in these herds because they reside primarily within the Revelstoke and Glacier National Parks and are thus protected under the Federal Endangered Species regulations. Despite the efforts by Biologists and Forest Managers to protect these herds, the caribou have been decreasing in population size over the last 20 years. A new hypothesis presented by Parks Canada is that the age of the forest stands in the areas of preferred habitats has been a detriment to the movement of the caribou. In particular, formerly old forest stands have been harvested or disturbed in the past and are now reforested with dense young stands that may be limiting the travel of the caribou into other areas of old stands with lichen food sources. The first step to testing this hypothesis is to create an accurate ecosystem map that identifies the preferred habitat areas for the caribou, followed by the creation of seral stage maps that identify the age of the stands located on these habitat sites. The Biologists requested that there be two sets of seral stage maps – the first representing the current stand conditions of 2005, the second being a retro-fit to estimate the ages of the stands in 1985 when the herds were larger and healthier. The Biologists will then take the PEM maps and the seral stage maps to model the caribou habitat in 1985 and 2005, and then analyze the differences to determine if and where the habitat deteriorations are occurring. From this information, forest management strategies can be devised to help increase the size of the endangered Mountain Caribou herds once again.

A secondary, but no less important, use of this PEM map is for timber supply analysis and forest management planning. The rate of forest growth has been correlated to site series (ecosystem units), making it possible to use a PEM map to determine the volume of forest growth on the land base over the next 20 to 100 years. As well, the PEM map provides valuable information about the distribution of ecosystem units across the land base to enable the management of stands and other forest resources for non-timber values. The support for this project by RCFC and MoF Small Business program, simultaneously benefits them in their timber supply analyses and landscape unit planning.

The following report describes the details and process of creating the Predictive Ecosystem Maps and Seral Stage maps for the Revelstoke PEM project.

The Revelstoke PEM project area covers 587,569.29 hectares, covering the former Revelstoke TSA excluding TFL 55 in the north and the area south of the Trans-Canada highway. The PEM does encompass Mount Revelstoke National Park as well as the smaller Provincial Parks within the project boundary. There are 14 Biogeoclimatic Subzones within the project spanning from the Interior Cedar Hemlock (ICH) subzones of the valley floors to the Alpine subzones of the mountain summits. This PEM utilized the revised Biogeoclimatic Ecosystem Classification (BEC) system written by Dennis Lloyd, et. al , Regional Ecologist of the Ministry of Forests – Southern Interior Forest Region (2005).

This is a Level 1PEM which produced small-polygons averaging 0.5 ha in size, that are spatially explicit – each site series is shown where it exists on the map. This is the highest level of precision offered among the PEM varieties available in B.C. In addition, it has surpassed the required 65% accuracy level in order to utilize the PEM in all forest management and wildlife management applications. As well, 91% of the polygon labels in the PEM are pure (single labels only) which means that they are easy to work with in modeling and analyses applications. The pure labels avoid the cross-product problems encountered when multiple labels exist in a polygon. The remaining 9% of the PEM has labels that are tied due to both ecosystem units occurring within the polygon or due to insufficient information for the computer to distinguish one unit. Our objective was to create a PEM maps with greater than 80% pure labels in order to make it easier for managers and analysts to use this PEM map.

The PEM method used was an upgraded version of EcoGen originally developed by the Ministry of Forests Research Branch. It has been upgraded by Silvatech Consulting Ltd. after years of working with the program. No bioterrain mapping was used to create this PEM. In previous projects using bioterrain base inventories with the EcoGen it was noted that there was only a small gain in accuracy realized. Since no bioterrain mapping currently existed for this project area, we chose not to contract the creation of this. However, from our experience we know that satellite imagery has been very useful to help achieve higher PEM accuracy particularly in the areas of non-forested ecosystems and the alpine areas. This is a quick and inexpensive inventory to support this PEM process, which has proven results. The accuracy results described in this report verify that the choices made for the creation of this PEM have been successful.

For this PEM, we collected a total of **1713 ground polygons samples** for use in a calibration dataset and an independent dataset. The accuracy statistics calculated on both datasets complied with the "Protocol for Accuracy Assessment of Ecosystem Maps" (Meidinger, 2003). The calibration dataset was used to compare the PEM labels to the true ground labels and then adjust the PEM until the labels were correct most of the time – in this project the score was 87%. However, this is not a true measure of the accuracy of the maps since the results have been purposefully raised as high as possible. As per the PEM Standards version 1.0 and internal QA must also be completed on the PEM using an independent dataset (in our case 180 polygons) that were not used during the calibration process. This score for the Revelstoke PEM was 75%, which we believe is a little low due to the samples being located in difficult transition areas. The full statistics, graphs and datasets are included in this report within Section 11 and Appendix 1.

Table 1 – Summary of the Independent and Internal Accuracy Results of the Revelstoke PEM									
		Polygon Labels were checked against ground labels as simple correlations – was the label right or wrong?				Polygon Labels were checked against ground labels as proportional correlations – what proportion of the label was correct?			
Type of Dataset Used for the Accuracy Statistics	No. of Poly's	Score Correct	Score Accept-able (½ point)	Correct by Weighted Area	Acceptable by Weighted Area	Proportion of Label Correct	Proportion Acceptable (½)	Proportion Correct by Weighted Area	Proportion Acceptable by Weighted Area
Project Total for Independent Dataset Polygons:	180	**75%**	**84%**	86%	91%	63%	76%	**71%**	**82%**
Project Total for Calibration Dataset Polygons:	1531	**87%**	**92%**	90%	94%	77%	87%	**81%**	**89%**

In addition to the creation of the PEM and the Seral Stage maps, this project was also used as a test case for the new draft PEM Standards version 2.0 which is in development by the Ministry of Environment. The new Standards have been developed under the direction of the Ministry of Environment (Colleen Jones) using the input and collaboration of all government, consultants and licensees with an interest in the PEM products and data structures. This PEM project provided a testing ground to determine if all the data structures are practical, useful and fit seamlessly into the Land and Resource Data Warehouse (LRDW) in Victoria. Areas of concern will be discussed among the Ministry staff then edits will be entered into the new Standards as necessary. This PEM project has the responsibility of complying with the current PEM Standards version 1.0 in that all data files required by the original Standards must be present. Yet this PEM also has the responsibility of providing these files and more, in the data formats, filenames, and database structures required in the new draft Standards version 2.0. All files created for this PEM are listed in the Project Summary Table in Section 2 below.

We would like to thank Susan Hall of Parks Canada, Bob Clarke and Del Williams of Revelstoke Community Forest Corporation and Dave Gill of the Ministry of Forests Timber Sales program for the opportunity to create this PEM and Seral Stage maps for the Revelstoke TSA. It has been a pleasure working with everyone, and an honour to create these ecosystem products that will be used for the development of many other forest and wildlife management applications.

2. Project Summary Table

The following is an index or "table of contents" for all the data files produced in this PEM project, along with their file names and data formats. This file was originally required by the PEM Standards version 1.0, and has been clarified in version 2.0. All data files have been provided in the formats required by the new draft PEM Standards 2.0.

Table 2 - Project Summary Table

Project Name: Revelstoke PEM	BAPID 4316	Created by: B.C. Ministry of Environment & Silvatech Consulting	Date of this Record: March 27, 2006
Geographic Location: Revelstoke, BC	**Version of PEM Standards Used:** PEM Inventory and Digital Data Capture Standards version 1.0 & Test case of the draftVersion 2.0		
File Name:	**Description:**		**Data Format:**
PEM_4316_pro	Project Summary – this table (formerly in ".rtf" format)		.pdf
PEM_4316_meta	Metadata report – Input Data Quality (IDQ) (formerly in ".csv" format)		.pdf
Standard Input Layers:			
PEM_4316_cbgc	1:100,000 Legacy BEC spatial linework completed by MoF with embedded Info database and metadata		.e00
PEM_4316_tvri	Vegetation Resource Inventory spatial layer with embedded Info database and metadata		.e00
PEM_4316_ttrim	TRIM spatial layer with embedded Info database and metadata		.e00 – Return to Client not gov't
Non-standard Input Layers:			
PEM_4316_tsat	Satellite Imagery spatial layer (1:20,000) with embedded Info database and metadata		.e00
PEM_4316_cgeo	Bedrock Geology spatial layer (1:100,000) with embedded Info database and metadata		.e00
Output Data Files:			
PEM_4316_ecp	PEM polygon spatial layer with embedded Info database and metadata – may need to assign "_1" and "_2" if this coverage is divided due to the size of the project area		.e00
PEM_4316_ecp_10 PEM_4316_ecp_12 PEM_4316_ecp_14 PEM_4316_ecp_15 PEM_4316_ecp_16 PEM_4316_ecp_19E PEM_4316_ecp_19W PEM_4316_ecp_20 PEM_4316_ecp_WE PEM_4316_ecp_NE	PEM polygon spatial layer for each Landscape Unit of the PEM with embedded Info database and metadata 12 includes 9 & 12 NE includes 6 & 18 WE includes 7, 8, & 11		.e00
PEM_4316_mtx_10 PEM_4316_mtx_12 PEM_4316_mtx_14 PEM_4316_mtx_15 PEM_4316_mtx_16	Matrix/Resultant database (can be divided into Landscape Units i.e. PEM_4316_mtx_*LU*) 12 includes 9 & 12		.mdb linked to ecp_*LU* spatial layer

PEM_4316_mtx_19E PEM_4316_mtx_19W PEM_4316_mtx_20 PEM_4316_mtx_WE PEM_4316_mtx_NE	NE includes 6 & 18 WE includes 7, 8, & 11	
PEM_4316_dbleg	Matrix database Attribute legend (formerly in ".rtf" format as "pem_4316_ursAttribute_Legend.rtf")	.pdf
PEM_4316_sts	Structural Stage spatial layer with embedded Info database and metadata	.e00
PEM_4316_sts_knb	Structural Stage knowledge tables – if these were created	.xls
PEM_4316_ser	Seral Stage spatial layer with embedded Info database and metadata	.e00
PEM_4316_ser(1985)	Seral Stage spatial layer with embedded Info database and metadata for the retrofitted forest cover age classes	.e00
PEM_4316_ser_knb	*Optional:* Seral Stage knowledge tables – if these were created	.xls
PEM_4316_fbdy	Final Boundary of the PEM project area (for LRDW) with embedded Info database	.e00
PEM_4316_mleg	Map Legend (formerly in ".rtf" format as "pem_4316_ursMapEntities.rtf")	.pdf
PEM_4316_ent	PEM Entities Legend (formerly in ".rtf" format as "pem_4316_ ursPEMEntities.rtf")	.pdf and .xls
PEM_4316_knb	Knowledge tables – each BEC subzone has its own worksheet within this file. If necessary, each BEC subzone has its own file with multiple KB's on individual worksheets – i.e. PEM_4316_knb_IDFdk1 (formerly in ".rtf" format as "pem_4316_ knb01.rtf" – one for each KB)	.xls
Field Data Files:		
PEM_4316_eci	Sample Points spatial layer with embedded Info database and metadata – if necessary add codes to describe multiple spatial files and their databases PEM_4316_eci_IDFdk1 (denotes BEC) PEM_4316_eci_IDFdk1_LU (for landscape unit)	.e00
PEM_4316_val	Validation results – spreadsheet showing the statistical results using the calibration dataset which may be included as separate worksheet(s) within this file.	.xls or .mdb
Final Report Files:		
PEM_4316_rpt	Final report for the PEM project	.pdf
PEM_4316_app_8	Revised BEC Classification from D. Lloyd (2005), MoF Regional Ecologist	.pdf
PEM_4316_app_10	Seral Stage mapping report from E. Valdal, Resource Analyst – Min of Ag & Lands, ILMB	.pdf

Quality Assessment Files:		
	Internal QA points are included in the "eci" file	
PEM_4316_iqa	Internal QA calculated – spreadsheet of field samples	.xls or .mdb
	Internal QA – Included within the Final Report	
PEM_4316_iqc	Quality Control Sign-off Forms (MAL) – provide 1 copy with digital signature with the gov't deliverables; provide a hardcopy with original signature with the final report	.pdf
General Information:		
Metadata Recorder:	Kevin Stehle, Silvatech Group Consulting	
Geographic Description:	The former Revelstoke TSA, excluding TFL 55 near Mica Dam and the areas south of the Trans-Canada Highway. The area includes Mount Revelstoke National Park and all other Provincial and National Parks within the project boundary. Includes urban and alpine areas.	
Map Scale:	1:20,000	
Mapsheet Numbers:	Incomplete Revelstoke TSA - Landscape Units: R6, R7, R8, R9, R10, R11, R12, R14, R15, R16, R18, R19, R20. Excluding R5, R17 (TFL 55) and R1, R2, R3 (south of the Trans-Canada Highway)	
BEC Subzones:	ICHmw2, ICHwk1, ICHvk1, ESSFvc, ESSFvv, ESSFwc1, ESSFwc2, ESSFwc4, ESSFvcp, ESSFvvp, ESSFwcp, ESSFwcw, ATun, ATunp	
EcoSections:	Northern Kootenay Mountains (NKM)	
Ecocat key words: **	EcoGen, Satellite imagery, Solar Insolation Model, Bedrock Geology, Revised BEC Classification, Retrofitted Seral Stages, Caribou Habitat	
Ecosystem Survey Intensity Level	Level D – 0.14% of the project polygons were ground checked	
Consultant/ Department:	B.C. Ministry of Environment, Kamloops Silvatech Group Consulting, Salmon Arm	
PEM Supervisor:	Colleen Jones, PEM Specialist, Ministry of Environment, RPBio	
GIS Supervisor:	Kevin Stehle, GIS Specialist, BSc, Silvatech Group Consulting	
KB Supervisor:	Colleen Jones, PEM Specialist, Ministry of Environment, RPBio	
Quality Assessment / Accuracy Assessment:	Internal Independent Quality Assessment (using ground points exceeding the required 2 x the number of forested site series mapped)	

3. Project Area

The Revelstoke PEM project area encompasses much of the Revelstoke TSA with a total area of 587,569.29 hectares. As seen in Figure 1 below, the area extends from the Trans-Canada highway north to Mica Dam. It excludes the two landscape units (R5 and R17) that make up TFL 55, due to the need of these Managers to have access to a completed PEM by September, 2005, in advance of this PEM product. The area also excludes the Landscape units south of the Trans-Canada highway (R1, R2, R3, R4) since this is not the area of concern for the Mountain Caribou herd. The project does include Mount Revelstoke National Park and all other Provincial Parks within its boundary. The project area does include the alpine and urban areas as well.

Figure 1 – Revelstoke PEM Project Area & Landscape Unit Locations
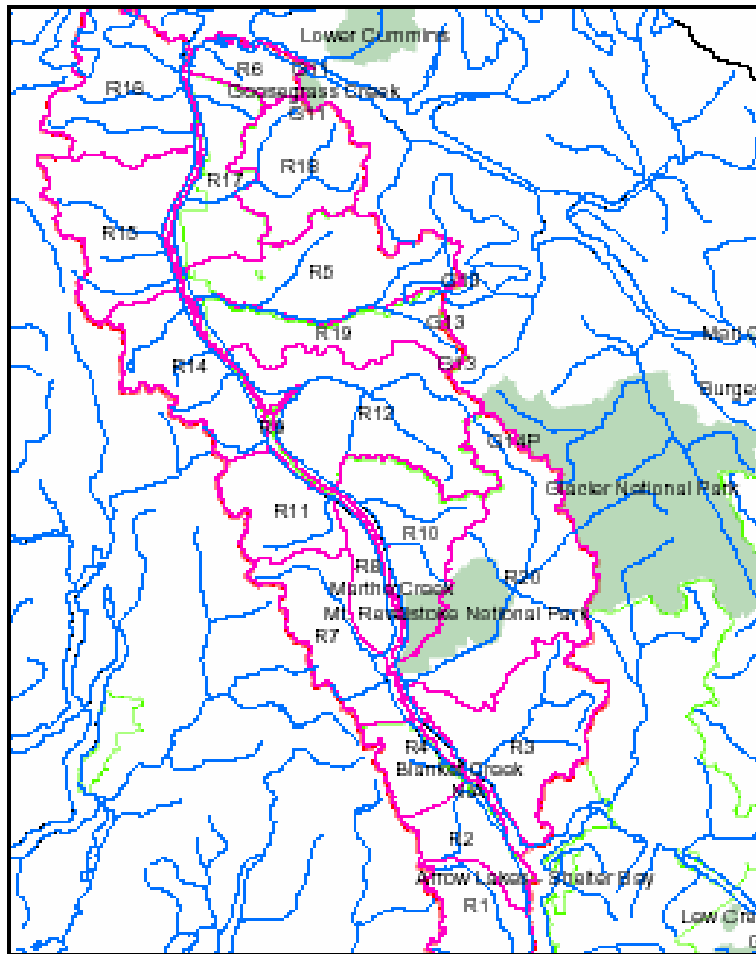
The Revelstoke PEM area was formerly divided into 13 Landscape Units for forest management purposes. We used these landscape unit boundaries for the processing of the PEM due to the size of the databases and limitations on our computer capacities. For the most part, the landscape unit portions comprised the limit of our processing capacity. In some cases, several smaller landscape units were tiled together into a processing blocks in order to speed up our work. The NE block is comprised of R6 and R18, while the WE block is comprised of R7, R8 and R11. The processing block of R12 includes R9. In one case, the landscape unit R19 had to be divided in half – R19E and R19W – since ArcInfo has a limitation on the number of polygons it can process horizontally. As such, there are 10 processing blocks

in the Revelstoke PEM, encompassing the 13 landscape units. As seen in the Project Summary Table, the polygon coverages and matrix databases correspond to these 10 processing blocks.

As per the Standards, a full "ecp" coverage is required with all landscape units tiled together. However, this full "ecp" coverage includes only the polygon number, ecosystem label and deciles. This is a very large data file and cumbersome to use. No other information that was collected and analyzed to produce the PEM is included in this "ecp" due to size limitations. The Structural Stage file is also in a full project area file, and contains no other information. Though these two files will be useful to some Users, they are too large and lack the information needed by other Resource Managers and Biologists for their work. In order to meet other User's needs, we have included the smaller landscape unit coverages and their extensive matrix databases. In each of the matrix databases, the "ecp_tag" is included as a separate column in order to allow a linkage between the two spatial coverages.

The project area includes 14 Biogeoclimatic Subzones as listed in Table 3 below. In this PEM, we used the Revised BEC Classification from Dennis Lloyd (2005), Regional Ecologist of the Southern Interior Forest Region. As per the emails included in Appendix 9, we used the classification that was created for the former Kamloops region. An example of one new classification for one BEC Subzone has been included in Appendix 8, with the full digital files included on the accompanying DVD.

Table 3 – List of BEC Subzones in the Revelstoke PEM	
Biogeoclimatic (BEC) Subzone	**Area (hectares)**
ATun	56,887.02
ATunp	0.04
ESSFvc	209,154.48
ESSFvcp	102,609.55
ESSFvv	0.85
ESSFvvp	3,857.95
ESSFwc1	5,148.90
ESSFwc2	3,080.64
ESSFwc4	9,313.67
ESSFwcp	8,265.13
ESSFwcw	2,040.48
ICHmw2	14,581.37
ICHvk1	99,831.50
ICHwk1	72,797.72
Total:	**587,569.29**

The BEC linework has not yet been revised by D. Lloyd, so we used the Legacy BEC linework created at the 1:100,000 scale. A few changes were made to this BEC layer in accordance with the new classification scheme from D. Lloyd. The ESSFvv subzone in the north was changed to ESSFwcw as per Dennis' instructions in his email. In retrospect, the adjacent ESSFvvp should also have been changed to ESSFwcw, but was not. However, they are both treated the same in the knowledge tables. A very small piece of ESSFvv occurs in R20 that was missed during the conversion, and so continues to show up in the list of BEC subzones, though only as 0.8 ha. Nevertheless, the ESSFwcw knowledge table was used on this subzone anyway. The Legacy BEC map shows ICHmw3 in the valley bottom along the Columbia River and reservoirs, however, according to the new classification, this subzone is actually ICHmw2, so this change was made to the BEC layer. In addition, the ICHmw2 polygons were often more extensive than in reality, so these were shrunk with their removed areas joined to the adjacent ICHwk1 polygons. It is anticipated that the Regional Ecologist will revised this BEC linework further

and potentially assign new BEC labels. At this time, though, we strived to utilize the given linework and classification to the greatest accuracy and fit.

The Bedrock Geology of the Revelstoke area was an interlaced assemblage of rich limestone to poor granites. This data layer was incorporated into the PEM with the intention of using it to identify shifts in ecosystem units due to changes in nutrient quality and availability. At this time, however, the geology was not utilized to its fullest potential. More fieldwork is required to determine and verify the associated changes in ecosystem patterns in order to fully utilize this data layer. Nevertheless, we believe that this is an important contributing factor to ecological patterns and thus have made it available to Resource Managers and Biologists for their use in forest planning and analyses.

The road access around the PEM area was generally sufficient such that we did not require helicopter time for this project. Road access is preferred over helicopter access because it is easier to recognize the changes in ecosystem units and record these precisely on the field maps. It is also easier to stop to see and walk around ecosystem complexes as they are discovered. The Mount MacKenzie ski hill road provided great access to the ESSFwc1, wc4 and parkland, however, it was just outside the boundary of the R20 landscape unit and instead in an area that was not PEM mapped. In order to utilize these ground points for the calibration of these Knowledge Tables, we created a PEM map for this mapsheet and named it R20a. This mapsheet is not included in the final PEM and was only used in the calibration process.

4. Methodology

The PEM methodology used in the Revelstoke PEM project is "EcoGen", originally developed by the BC Ministry of Forests Research Branch and Prince Rupert Forest Region (developed with Shamaya Consulting). EcoGen (Ecosystem Generator) is an automated program that combines existing land base inventories with expert knowledge tables to produce ecosystem maps over large areas. The EcoGen methodology has since been adjusted in recent years to accommodate more inventory input layers such as bioterrain mapping, satellite imagery, solar insolation analysis, bedrock geology mapping, and soils mapping. The most recent update of EcoGen has been called the "Silvatech Version". Both the previous version of EcoGen PEM and the current revision have been used successfully in Timber Supply Analyses. The original EcoGen PEM maps were used in a Timber Supply Analysis by Gerrard Olivotto and Del Meidinger "Development of EcoYield – A Conceptual Model for Timber Supply Analysis Using Predictive Ecosystem Mapping and Site Index – Ecosystem Relationships", EcoNote 2001-01, Ministry of Forests - Research Branch. In addition, the revised EcoGen PEM maps were also utilized by Cam Brown of Silvatech (2002) in a test of the Timber Supply Analysis capability.

The ecosystem is a fundamental unit of resource management in British Columbia. In British Columbia, the Biogeoclimatic Ecosystem Classification (BEC or BGC) system provides a common language to describe the plant species and relative abundance, the soil types and moisture/nutrient regimes, and the general climatic and geomorphological influences on natural ecosystem units[1]. Maps that spatially display these ecological units at a scale of 1:20,000 are effective integrated planning tools providing a record of the location and distribution of ecosystems within a management area. PEM maps create a framework for developing various landscape or site-specific management plans. They take into consideration the productivity, species richness, fragility, and regenerative potential of the site, all of which can be interpreted into the site's "value" for timber production, wildlife habitat, unique plant communities, restoration, and so on. By using ecosystem maps as a tool during the resource planning phases, forest managers can predict "the consequences of their decisions, thus enabling them to practice forestry as applied ecology"[2]. (See Figure 4 for an example of a Revelstoke PEM map)

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[1] For more information, please see www.for.gov.bc.ca/hre/becweb/aboutbec/aboutbec

[2] Pojar, J., K. Klinka and D.V. Meidinger. 1987. Biogeoclimatic Ecosystem Classification in British Columbia. in *Forest Ecology and Management*, 22 (1987) 119-154, Amsterdam

The general process of a PEM is shown in Figure 2 below. The GIS component of the process incorporates existing or newly created inventory layers, overlays these, and then produces both a spatial layer and an attribute database (matrix database). The ecological component of the process gathers ecosystem-pattern information from the field specifically to fill in the knowledge tables. The field sampling varies for the PEM methodologies and may be in the form of point samples, polygon inspections, line-intercepts, transects, or toposequence sampling. The ground samples are also used to calibrate the ecosystem labels produced by the PEM and adjust the knowledge tables as necessary. A separate dataset of ground samples collected by the Practitioner is set aside as an independent dataset and not used in the calibration process. When the Ecologist is satisfied with the PEM results, the final output database is run against this independent dataset to complete the Internal QA. The final output database is then returned to the GIS Analyst to reconnect with the spatial polygon or raster layer in order to produce the Ecosystem Map. The ecosystem labels may be written within large polygons or themed out by color if the polygons are small. Accompanying the final EcoMap are several integral and supplemental spatial coverages with their databases. Throughout the PEM process, the metadata reports are completed and submitted along with the final report.

Figure 2 - General Process for the Creation of a PEM
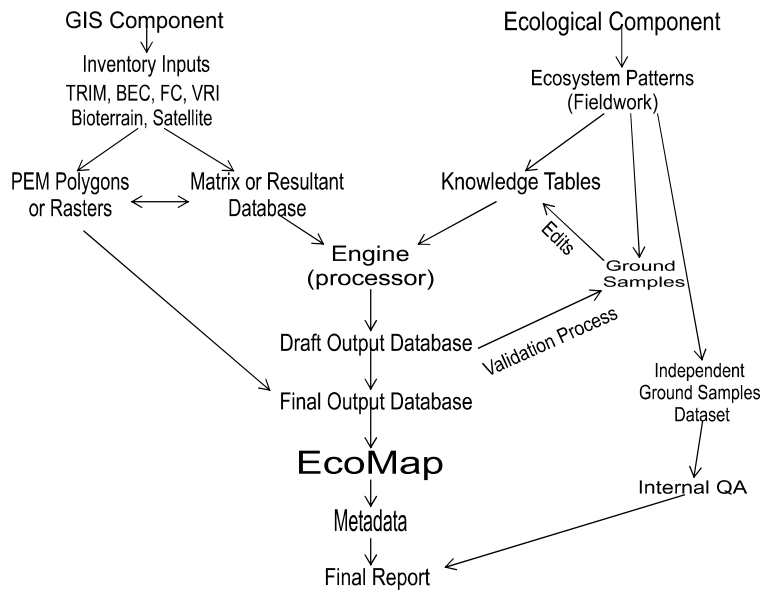
One PEM methodology developed by the BC Ministry of Forests to create ecosystem maps efficiently and cost-effectively over large areas is the GIS-based computer program "EcoGen"[3]. The strength of EcoGen is its use of existing inventory maps produced for BC's forested areas, combined with leading-edge computer technology to derive reliable ecosystem maps (see Figure 3). Features from these inventories are extracted and derived to reflect vegetative and landform characteristics. Knowledge tables are then created capturing expert ecological knowledge about the patterns of ecosystems across these landscapes. EcoGen then processes the GIS databases and knowledge tables together to produce the Ecosystem Maps. The maps can be displayed in hardcopy form using color schemes to represent the ecosystem units, or in digital form to enable large-scale viewing of specific sites. In the digital format, the maps can be readily queried to extract a variety of information needed by the resource managers.

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[3] For more information about EcoGen, see the MoF Research Branch webpage at www.for.gov.bc.ca/research/ecogen/

Figure 3 – EcoGen Process for Creating a PEM Map
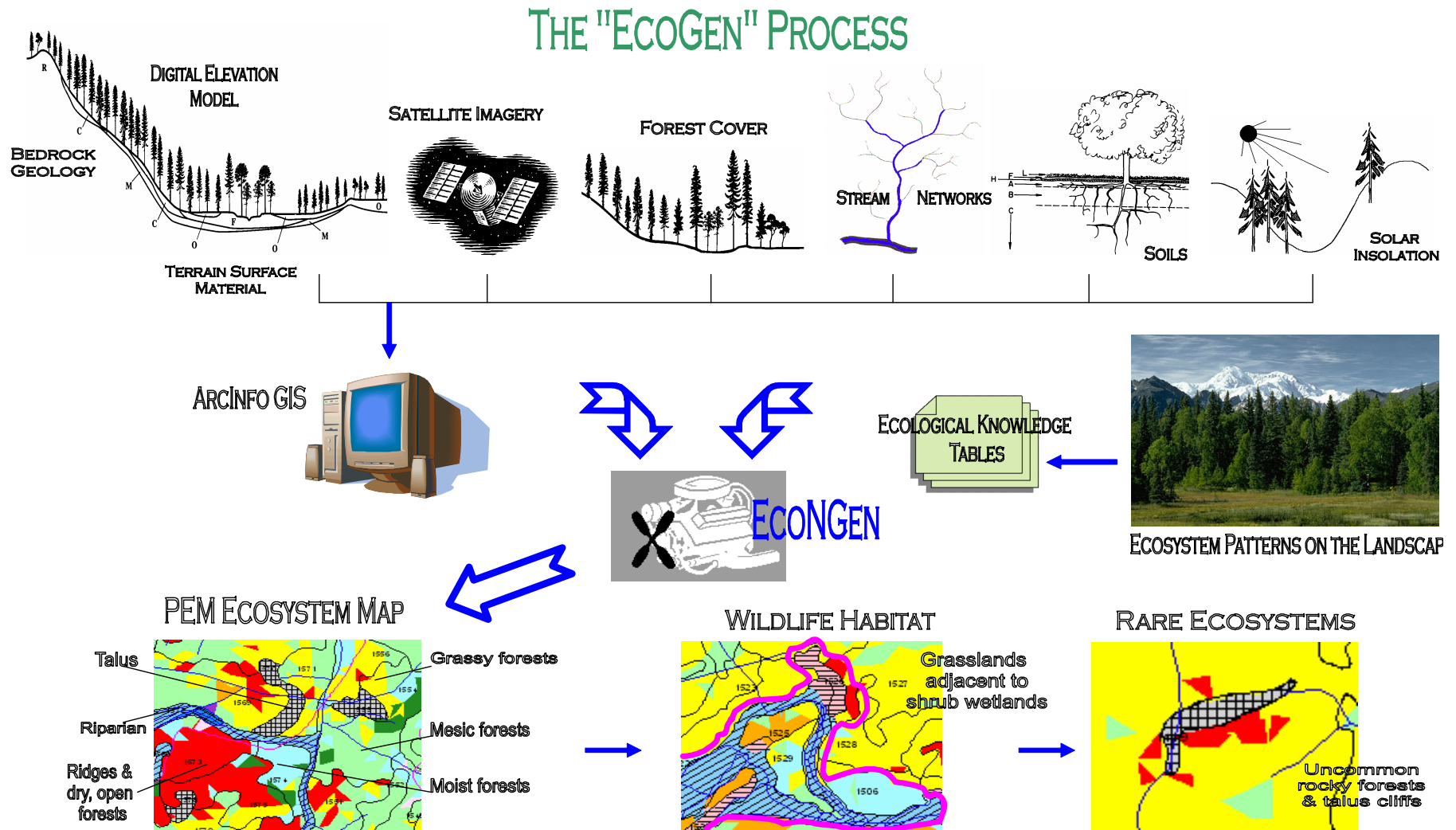
4.1. GIS Component – PEM Polygon & Matrix Database Creation

A PEM is created through an automated GIS and database-management program that combines existing land base inventories with knowledge tables to produce ecosystem maps over large areas. The PEM's will utilize a wide variety of inventories such as BEC, TRIM, Forest Cover, VRI, Bioterrain, Geology, Geomorphology, Soils, Landscape Analyses, and TEM. In some cases, where the Clients have requested so, new inventories are created to support the PEM, such as Bioterrain or Satellite Imagery Classification. The GIS Analysts then extract information from these inventories such as tree species, canopy characteristics, surface material, bedrock type, and landform type, and derive new information mainly from the TRIM Digital Elevation Model (DEM). Through a series of GIS algorithms, the slope position and soil moisture potential of every parcel of land is determined. This is accomplished by identifying a continuous network of topographic positions across the landscape through measures such as relative slope position, slope profiles, soil moisture regimes, distance to ridges, proximity to streams and wetlands, and solar radiation classes. This resultant database, the Matrix, becomes the "muscle" of the program.

The first inventory layer used to create the PEM polygons is the Biogeoclimatic (BEC) Zone layer. All PEM's require the BEC lines to be projected at the 1:20,000 scale. In the case of this project, we were authorized by the Regional Ecologist to use the 1:100,000 Legacy BEC mapping with minor amendments in order to make it correspond to the Revised BEC Classification by D. Lloyd. The BEC linework is used to break all forest cover polygons, and thereby assign only one BEC label to each PEM polygon.

The next inventory layer used to create the PEM polygons is the Forest Cover or Vegetation Resource Inventory (VRI) data. In the case of the Revelstoke PEM, about half of the area has been re-inventoried according to the new VRI standards. The remaining areas still contain older Forest Cover inventories, but rolled over into the new VRI database structure. Not all VRI attribute fields are available in the rolled-over forest cover, and older attribute values still exist. As such, the knowledge tables had to incorporate both the old and new attribute values in order to capture as much information as possible from this inventory layer

The third inventory layer used to create the PEM polygons is the DEM. In the EcoGen method, the base forest cover polygons are subdivided into smaller slope and aspect polygons in order to create small polygons of near-homogeneous site qualities. The intention is to assign a single ecosystem label to the small PEM polygons in order to show the biodiversity within the whole forest cover polygon – not only the diversity of labels but the location of each ecosystem type.

Once the PEM polygons have been created, the next step of the GIS process is to overlay all inventories and all derived-feature layers, sort the attributes that are available within each PEM polygon and record this information in the Matrix Database. The PEM polygons act like "cookie cutters" slicing through the input layers to assemble the information within. A sliver elimination process is used to clean up the "cookie crumbs" that result from sorting the attribute data into their respective polygons.

In addition to extracting information from the overlain inventories, other information is derived from the TRIM base and also assigned as attributes to the polygon. In this PEM we created topographic profiles, features such as hills, ridges, upper slopes, lower slopes, toes of slopes, gullies, wetland benches, fluvial benches, and so on, modelled from the DEM. These features are overlain by the PEM polygons and assigned as present/absent or as a proportion of the polygon. See Table 4 for a list of attributes created for this PEM.

For this project we did not create a bioterrain inventory to assist with the assignment of ecosystem labels. We felt confident that we would be able to achieve a high accuracy without this inventory

layer, and in fact did achieve this. The exclusion of this inventory layer meant that we did not have to deal with the "cross-product" problems created by the bioterrain complex (multiple) labels corresponding to multiple forest cover labels when the two polygons layers do not align directly. See EcoNote 2000-02 for more of this discussion http://www.for.gov.bc.ca/hre/ecogen/furinfo

We did, however, create a satellite imagery layer for this PEM to assist with the assignment of ecosystem labels. From our experience, we know that satellite imagery is particularly useful for identifying characteristics of the non-forested ecosystem units, especially in the parkland and alpine. Since half the number of subzones in this PEM are in the parkland and alpine, and these areas are important for the caribou habitat mapping, we wanted to utilize an inventory layer that would help create a high level of accuracy in these areas.

Table 4 – Data Attributes Derived or Extracted from each Inventory Layer	
TRIM Digital Elevation Model – derived attributes:	• Slope class (used in deriving PEM polygon) • Aspect class (used in deriving PEM polygon) • Density of streams in each PEM polygon • Riparian benches off of lakes and wetlands • Fluvial benches off of rivers • Glaciofluvial terraces off of rivers • Gullies and influence of gullies • Hilltops and influence of hilltops • Ridges and influence of ridges – both large and small ridges • Toes of slopes • Elevation classes • Adjacency to features • Solar Insolation classes
TRIM – extracted Attributes:	• Eskers, cliffs, scarps, slides, ridges, pits • Beaver dams, flooded areas, springs, islands, sandbars • Moraine, skree, lava flows • Glaciers, snow fields, ice caps • Lakes, marshes, swamps, creeks, and rivers
Forest Cover/ VRI – extracted Attributes:	• Non-productive (or Basic Class) forest codes such as alpine, non-productive brush, or clay banks • Non-productive descriptors – i.e. NPBr • Forest species – only the first three listed in the files are used • Species percent composition of the stand • Canopy descriptions: tree height, crown closure, stand age • Disturbance history – in some areas the burn category is used • Shrub layer – type, crown closure, height • Herb cover type • Soil Moisture regime class • Soil Nutrient regime class • Component 1, 2 &3 – forest and non-forest descriptors • BCLC levels 1-5 – vegetation classes and layers
Bio-terrain and Terrain Stability – extracted Attributes:	• Not used in this PEM
Bedrock Geology – extracted Attributes:	• Rich – i.e. limestone, marble • Moderately – rich – i.e. chert, basalt • Moderate – i.e. mudstone, shale • Moderately-poor – i.e. coarse sedimentary rock

	• Poor – i.e. granite, quartz diorite • Undivided – i.e. mixed bedrock material (this category is identified but does not contribute to the ecological site series)
Satellite Imagery derived classes	• Water • Snow or Ice • Bare – exposed rock, talus, landslide • Forest – closed, coniferous or deciduous • Parkland Forest – open forests with moist meadow pockets • Krummholtz • Deciduous shrub • Grasslands • Heathlands – alpine heathers • Herbaceous Meadows – alpine moist meadows

At the end of this GIS process, the large Matrix database details all of the attributes present in each of the PEM polygons. This Matrix database is the powerhouse of the PEM. Each polygon has a wealth of information available about the biotic and abiotic factors for each parcel of land. All of the information assembled in this Matrix database is useful to subsequent Users of the PEM maps. Giving Users access to this information on a per-polygon basis enhances their models and planning analyses, and eliminates their need to duplicate the production of the same information – ultimately saving time and money.

For those PEM's that produce small polygons, the land base is typically divided into smaller blocks such as Landscape Units due to the large size of this Matrix database. Though ArcInfo has a very large processing capacity, it does have size limitations beyond which it aborts the program. In these cases, the Matrix database and associated polygon coverages can be delivered in their segmented blocks, in addition to the overall seamless PEM polygon coverage ("ecp"). This will enable subsequent Users of the PEM's to use either format for their analyses.

The size of these Matrix databases is an advantage to Users since the entire set of available inventory layers have already been overlain and are ready for data manipulation. Modellers using computers prefer to have a detailed database from which to conduct their analyses, whereas people reading the PEM maps prefer to have a simplified cartographic display so that they can "see" the ecosystem units or polygons easily. The contradiction is that computers want to work with more data, but people want to see less. These diverging needs are easily accommodated with this PEM by providing the powerful Matrix databases yet simplifying the cartographic display of the maps (See Section 4.8 - PEM Maps).

When completed, the Matrix Database is then passed on to the PEM Ecologist to be used in the knowledge table calibration process, described below. When the Ecologist is satisfied with the PEM results, the final output database is returned to the GIS Analyst to produce the final Ecosystem Maps. This step is described in Section 4.8 - PEM Maps.

4.2.   Ecological Component – Field Data Collection

The purpose of the fieldwork is primarily to confirm the ecosystem unit patterns of distribution that the PEM model will replicate. For this PEM, the field information relates specifically to the break points at which one site series changes into another – the detailed parameters that define where each site series will exist. The information provided in the Revised BEC classification was not sufficiently detailed to fill in these knowledge tables. The fieldwork serves to not only further refine the environmental patterns of ecosystems, but also to correlate the attributes of the various inventory inputs with these patterns of ecosystems. Along this line, the fieldwork also serves to determine the

errors and patterns within the inventories, such as alpine areas being variously labelled as NPBr, NCBr, Slide, Wetland or Open Range, in order to compensate and capture these in the KB's. In this regard, previous experience in the BEC subzones of a project area is of low importance…. the fieldwork must be completed anew to determine these very detailed patterns and attribute correlations.

The balance of previous field experience in the BEC Subzones versus experience in completing a KB plays out here. An experienced Ecologist can recognize the differences between site series within a couple hours of being in a new BEC subzone, thereby making previous Subzone experience of low importance. Yet the experience to know what fieldwork is required to fill out a KB can take years to develop, and thereby makes this factor of high importance. It takes years of experience to become a proficient at creating knowledge tables and understanding what field information is required to correlate with inventory attributes. Creating knowledge tables is both an art and a science, which begins with an understanding of the nuances of ecological patterns in the field then extends into a sophisticated matrix of numbers that produces an interpretation of the ecology.

The second purpose for the fieldwork is to collect a dataset of ground samples with known ecosystem units used to calibrate the attributes within the knowledge tables. The ground samples are digitized into their own spatial layer and then applied to the PEM spatial layer to identify their corresponding polygons. The Practitioner will adjust the KB's in order to correct errors and thus produce a more accurate PEM map.

The third purpose for ground sampling is to collect an independent ground sample dataset that will be used to conduct the Internal Quality Assessment (see Section 4.7). The size of the independent dataset is equal to 86 polygons or 2 times the number of mapped forested ecosystem units in forested BEC Subzones of the PEM project – for this project 106 polygons are required. These independent ground samples are digitized within the "eci" ground sample spatial layer, and set aside until the final PEM is complete. This dataset is then overlain on the final PEM polygons and compared using the rigorous Accuracy Assessment Protocol statistics (Meidinger, 2003). The value of the Internal QA is that it satisfies the government's requirement for a QA according to the PEM Standards. There are cost-efficiencies to the Client to pay the Practitioner to collect this independent dataset rather than hiring another QA Contractor.

The field work methodology we used is faster and more efficient than the traditional TEM methodology. We relied primarily on visual ecosystem calls accurately located on the base maps, with a few Ground Inspection Forms completed in areas of uncertainty or high complexity. No Full Plot (FS882) forms are completed. This method enabled the Ecologists to gather a large number of ground data points in a short time, with the information collected being directly applicable to the PEM knowledge table development.

The Ecologists spent one day per BEC subzone covering the full variety of ecosystem units in a wide range of locations within the project area. In total, we gathered 1713 ground points during the field work to be utilized in the knowledge table development and calibration, with 180 points set aside as the independent dataset for the Internal Quality Assessment. The Ecologists worked together during this fieldwork, but to improve the efficiency of the team, they split up while walking in order to record more ecosystem unit locations in the same amount of time.

The Ecologists specifically look for areas of topographical diversity in order to capture the range of site conditions for ecosystem units, in forested and non-forested ecosystems, and record the changes from one unit to the next. The ecosystems do, in fact, follow a pattern on the landscape that is predictable and it is up to the Ecologists to recognize these patterns along with all of the climatic and biophysical influences that led to these patterns. Traversing across many areas is required to distinguish between the normal patterns and variations to these patterns.

During this fieldwork session, ground points were collected in four landscape units spanning the length of the project area: the northeast – R6, the north central – R12, the central – R20 and the west central – R7 & 8. Please refer to the file "PEM_4316_eci" for the spatial coverage of the ground points and the respective PEM polygons that they represent.

This is the fundamental difference between our field work methodology and simply using existing field plot data. By walking through areas of diversity, the Ecologist is able to see how the ecosystem units interact with each other and why they change. Existing plot data records only what is within the 0.10 ha plot, and little or nothing about the ecosystems surrounding the plot. Nor do the plot data record where the boundaries of the adjacent ecosystem units lie, or any contributing influences which led to the changes. This missing information is vital to the accuracy that can be achieved in the knowledge tables.

For all forested BEC subzones, we ensured that we gathered information for more than 30 polygons which is the minimum required by the PEM Inventory Standards version 1.0 (section 4.6.1.1, 1999). For the calibration purposes, however, we needed more than this. A larger dataset allows us to see the variations in polygon attributes that must be calibrated to the correct labels. In the Revelstoke PEM we far exceeded the minimum sample size with a total of 1713 checked polygons.

The timing sequence of this PEM meant that the field work was completed prior to the PEM polygon creation. We used Forest Cover polygons with labels super-imposed over the TRIM base map to record ground information. We applied strict control over our ground location with respect to the Forest Cover polygons and TRIM topography in order to record the ecosystem units in their correct location. This is a crucial point for creating a PEM map. The ground points must be accurately placed in relation to the TRIM and Forest Cover inventories since these are the foundations of the PEM program. GPS was not relied upon due to its inherent inaccuracy in dense forests and due to its normal range of error between 10 and 40 meters depending on site conditions. These coordinates allow for too many chances of incongruity with the TRIM base of the PEM.

Ground Inspection Forms (GIF's) were not completed in this project due to the limited field time available. Normally, the GIF's provided a pause opportunity to verify the ecosystem unit and provide documentation of the units for future reference during the calibration phase. For this project only field notes and map notes were collected to assist with the creation and calibration of the knowledge tables.

4.3.   Thematic Positioning the Ground Points

The digitization of ground points to the correct PEM polygon is called thematic positioning. Thematic positioning (topological accuracy) is very important for small-polygon PEM's, but not for medium- or large-polygon PEM's. (Large polygon PEM's do not require this thematic positioning as described here since there is a wide perimeter around the GPS point that still falls within the polygon.) In general, the smaller the polygon, the more accurate and precise the ground sample point must be. Thematic positioning refers to ensuring that the sample points and transects are located on the same piece of ground that is represented by the input layers, namely TRIM and VRI. For example, if the field person is standing 20 metres due east of the confluence of a lake and outflow stream, the sample point must be digitized on the base map at 20 metres due east of the confluence of a lake and outflow stream. The GPS may, as an example, place the point at the toe of slope nearby. It is erroneous in this case to compare the ground label of this confluence area to the PEM polygon located on the toe of slope. The Practitioner and QA contractor must evaluate the same piece of ground that the computer is looking at, regardless of where a GPS reading places the point. The importance of thematic positioning of the sample points has been greatly under-valued in the last 10 years of PEM development. In the words of Del Meidinger, MoF Research Branch

(personal conversation, March 2004) "it is the QA person's responsibility to assess the same piece of ground as the PEM polygon they are evaluating".

Some people have referred to TRIM maps as having errors when compared to the "real-world positioning" as represented by GPS readings (i.e. the ridge is displayed 20 m too far to the east). They have stated that the GPS readings, if done properly by trained individuals, are more accurate than the base data that the person is trying to verify. This is a problematic statement for all inventory mapping projects. The Province has declared that the TRIM base will be used by terrestrial inventory projects in B.C. in order to ensure consistency and integration between the maps. As such, any errors in the TRIM base are irrelevant since everyone is using the same base – the errors become null and void. Any effort to "fix" the TRIM map for a PEM project will put it out of alignment with all other inventories; as such, the Province will not authorize any Inventory Mapper to adjust the TRIM base. Further, it has been demonstrated that some GPS readings are suspect due to the "swing" in their readings for any given point throughout the day, and under different cloud and canopy covers. The accuracy of GPS units can range from poor to precise depending on the quality of the unit. Even a very precise GPS unit may still not align with the thematic TRIM base – it is likely, in fact, more accurate than the TRIM – but that is a moot point. The issue is that the GPS units are reading from a different DEM than the one recorded in the TRIM. If the GPS was using the exact same DEM as the TRIM, then the two would align, but this is not the case. Put another way, the field samples cannot be plotted using a different DEM than the one that the PEM was given to create the maps. Since the PEM maps were created using thematic layers, all ground samples used to correlate with the PEM maps must therefore also be located using thematic representation.

Thematic positioning, simply put, is using the same inventory layers as used in the PEM, to record the location of the sample point. For example, if VRI/Forest Cover and TRIM are used to create the PEM polygons, then these should be overlain on each other and used as navigation tools. If desired, the outline of the final PEM polygons may also be overlain to provide further positional accuracy. Using these field maps then, the Ecologist must ensure that s/he is in the correct VRI/Forest Cover polygon and on the exact same slope position as represented for that PEM polygon. The Ecologist must become very proficient at using the thematic layers for field navigation since not all topographic undulations are shown on the TRIM maps (the underlying DEM is more precise than the topographic lines suggest). The sample point must be precisely located on the field maps, regardless of whether the topographic undulations are represented or not. GPS is sufficient to locate the general area, but thematic maps must be used to narrow down the exact location of the sample points. Likewise, airphoto navigation can be equally or more imprecise than GPS readings.

The issue of thematic positioning is very important for small-polygon PEM's. The Ecologist is specifically looking for shifts in ecosystem units based on subtle environmental changes occurring at very fine resolutions (down to 0.1 ha). These shifts must be very precisely recorded in order to determine if the PEM is accurately picking them up. An imprecise sample point location will result in the field ecosystem label being associated with the wrong PEM polygon. The Practitioner will then attempt to calibrate all polygons with similar attributes to this wrong ecosystem label, across the entire BEC Subzone. Errors in the sample point locations cause compounding errors across the entire PEM map, and will result in a low accuracy for the whole PEM project. The consequences of miscalculating the location of these ground samples can be very grave both for the calibration of the PEM and the accuracy assessment of it.

4.4.   Digital Ground Sample Files – "eci" coverage

The ground plot and point data collected for this PEM project have been digitized into individual landscape unit files, and then merged into a single "eci" spatial coverage for the entire project area. The embedded database structure complies with the PEM Standards version 2.0 requirements. The Internal QA ground points are included in the "eci" spatial file.

4.5.　Ecological Knowledge Tables

Ecological knowledge tables (or knowledge bases – KB's) are created by the PEM Practitioner utilizing all of the attributes necessary from the Matrix database that will contribute towards the determination of the most likely ecosystem unit for each PEM polygon. The KB's are typically quite large since they must list every possible attribute or combination that may be useful in determining the site series for the polygon.

In this PEM, we used Belief Matrix knowledge tables which are grid tables that list single or combinations (strings) of attributes that are useful to indicate a likely ecosystem unit. All site series (forested and non-forested) are listed in the grid table and assigned a belief value for each attribute string. The Practitioner uses a scoring scheme to rank each site series for its potential to possess the attributes in each line of the table. Each PEM polygon is run through the full KB. All of the lines in the KB that apply to the individual PEM polygon are summed up and the "scores" for each site series are recorded for that polygon. The site series with the highest "score" is assigned as the ecosystem label for that polygon. The following excerpt was taken from the EcoGen EcoNote 2000-03 (www.for.gov.bc.ca/research/ecogen/) - for more information, please refer to the entire document.

> "Once the attributes and their values are determined and the basic format of the knowledge table has been created, the ecological weightings are entered. The basic coding is 0 to 3, whereby 0 equals no chance of occurrence, 1 = slight chance of occurrence, 2 = average chance of occurrence, and 3 = high chance of occurrence. For each statement in the knowledge table, the ecologist must evaluate the likelihood of each ecological unit for that biogeoclimatic unit occurring in a location with that attribute value or values….

> The result for a polygon is determined by a cumulative tally method, i.e., adding up the weightings for the set of attribute statements found in the polygon data. In some cases, the basic weighting of 0 to 3 is insufficient to achieve the intended ecological outcome. In order to ensure that obvious, unintended outcomes are impossible, an extreme weighting, e.g., "-100", is used. …

> When testing the knowledge table against known data, other possible unintended outcomes could occur. Adjusting the knowledge table weightings can usually "correct" these problems. Small negative weightings can be useful at this time for separating out ecological units. In one knowledge table, we used a "-1" weighting in an elevation attribute value to separate two grassland units in which one is commonly at higher elevations than the other." (Jones and Meidinger, EcoGen EcoNote#3)

Most PEM's now use **cumulative logic** statements in which multiple lines in the KB's can apply to a polygon. The sum of all the statements that apply to a polygon leads to the ecosystem label. Some of these statements are complimentary to each other while others may be contradictive. A contradiction will occur when the information in one inventory does not match the information in another. This is a common occurrence with hand-drawn polygons in bioterrain and VRI/Forest Cover, when the lines are drawn too far for a terrain type, forest cover type, slope break, and so on. An example is, when a fluvial bioterrain polygon is drawn too far up the slope from the river bottom, or a very wet Black Spruce stand encompasses an esker that was too narrow to delineate. The PEM Practitioners plan for these contradictions and allow the results to shift according to the confidence they have in the various attributes. The Practitioners adjust the values for the attributes in order to downplay or increase the influence of these attributes should they show up as contradictory information within a polygon. As such, the Practitioner is able to apply her expert knowledge to incorporate "balancing" logic into the KB. The values in these KB's do not necessarily reflect the

strength of the belief that a site series is correct, instead they reflect the balancing logic purposefully entered by the Practitioner.

The final scores for a PEM polygon are also not reflective of a higher or lower confidence that the site series label is correct. The scores are simply cumulative sums after all the attributes present have been taken into consideration. So for example, a polygon with few attributes has a low winning score of "5", whereas another polygon with many attributes has a high winning score of "12", yet the Practitioner may be equally confident in the eco-label for both of these cases. More attributes available in a polygon does not always equate to greater confidence, reliability or accuracy. Likewise, these scores should not be used to rank the site series in order of likelihood, as some people have been tempted to do in order to create a complex label. The Practitioner designs the table to identify the most likely site series only, and does not design it to also identify the second most-likely site series, etc. The next lower scores are merely artefacts of the summation system and not directly linked to the 2nd, 3rd, 4th most-likely site series, nor components of the polygons.

4.6.   Calibration of the Knowledge Tables

After the KB's are created, they are run through a series of interface programs, Matrix Summary and SSORT, written to automate the production of tables that enable the knowledge tables to mesh with the Matrix database. When prepared, the knowledge tables and interface tables are combined with the Matrix database then run through the engine processor, named "EcoNGen version 1.0c" available from the MoF Research Branch EcoGen web page. The result is an output database with the resultant ecosystem labels for each PEM polygon. The engine processor works like the venturi of a carburetor combining the KB's and Matrix database like fuel and air. The processor runs each polygon through the KB, tallies the score for the polygon, then assigns the ecosystem label to the output database for each polygon.

Following this, the ground labels are compared to the PEM labels and the calibration process begins. The "eci" ground samples assigned to the calibration dataset are transferred to an Access database and run through a ScoreOne interface program that creates two tables, the first being a summary of the PEM labels compared to the ground labels; the second being a "polygon log" which is a full listing of all attributes in each polygon and their respective lines from the KB. The summary table enables the Ecologist to identify where errors are occurring, while the polygon log enables the Ecologist to see which attributes and values in the KB's caused the errors.

The calibration of the KB's is an iterative process in which the Ecologist adjusts the values within the KB's in order to create a cumulative tally that results in the correct ecosystem label for those polygons. The revised KB's are then re-run with the Matrix database through EcoNGen to produce a new output database. The new PEM labels are then compared to the ground labels to ensure they are now correct. Often times, the correction of one error can create new errors in other polygons which now have to be resolved. This calibration process usually requires multiple iterations of adjusting the KB's and re-running them through the engine processor, before the Ecologist is satisfied that the PEM labels are as accurate as possible.

Because of the time spent in the field, the Ecologist knows which of the errors should not be fixed since they are due to anomalies in the ecosystem patterns and therefore she avoids transferring a new set of errors across the whole project area. As an example, the Ecologist may know that normally a mid-slope, gentle slope is a zonal ecosystem for that particular BEC subzone, but the ground label identifies an atypical sub-hygric ecosystem unit due to a pocket seepage site – the Ecologist will let the PEM label of zonal stand and be wrong in this case to avoid labelling other "normal" sites as sub-hygric.

When the Ecologist has completed the calibration of the knowledge tables and is satisfied that the labels are as accurate as possible, all landscape unit blocks within the project area are re-run using the finalized knowledge tables. Any last minute changes to the knowledge tables require that all areas within the project area must be re-run with the updated KB's. The final output files are sent back to the GIS Analyst for connection to the PEM polygons and the creation of the final "ecp" coverages.

4.7. Validation Results & Internal Quality Assessment

After the calibration process is complete, the Ecologist then calculates the statistical accuracy results for both the calibration dataset and the independent data set. The statistics are completed according to the Accuracy Assessment Protocol (Meidinger, 2003). The results calculated from the calibration dataset are called the Validation results and cannot be used to true accuracy of the PEM. Because the Ecologist adjusted the KB's until the PEM labels matched this set of ground labels (as much as possible), these results are naturally skewed higher than the likely true accuracy score. Nevertheless, it is useful to see how well the Ecologist was able to calibrate the KB's.

The Ecologist then transfers the "eci" ground samples assigned to the Independent QA dataset into an Access file, and runs these through the ScoreOne program, in order to produce the summary table comparing the PEM labels to the ground labels. The statistics calculated are the same as for the Validation results. The results calculated from the independent dataset are called the Internal Quality Assessment (iQA) and are used to determine true accuracy of the PEM.

The Independent dataset must be the higher of either 86 polygons or two times the number of forested site series within forested BEC subzones mapped within the PEM project, according to the AA Protocol. The Revelstoke PEM falls into the latter category. There are 7 forested BEC subzones (excluding parkland and alpine), and 53 forested site series within these subzones; therefore 106 polygons must be ground checked and used in the Internal QA. Our iQA sample set was comprised of 180 polygons. Please refer to Section 11 - Statistical Accuracy for the full set of statistics calculated for the Validation Results and Internal QA.

4.8. PEM Maps

The PEM maps are the final step in the production of the PEM. The resulting output file from the EcoNGen is re-attached to the polygon database. For small-polygon PEM's like this one, there is typically not enough room in the polygon to print the label, so they are best displayed by color representing the site series label. The map colors are shown in the Map Legend within Appendix 3 (see Table 11). The color sequence ranges from reds representing the driest ecosystems, through yellows and greens representing circum-mesics, to blues and purples representing the wettest ecosystems. Non-forested ecosystem units are generally represented with the same color scheme but also with cross-hatching.

Lastly, the original forest cover polygons are re-overlain on the map as a simple black outlines with the forest cover polygon ID number displayed. This assists Users to recognize the context and location of the ecosystem units in relation to the primary management inventory – Forest Cover. The VRI/Forest Cover polygons are also easily recognizable on airphotos which are often used in the field to assist with navigation. As well, roads and water networks are displayed on the maps for georeference. Figure 4 shows an example of a PEM map for the R16 landscape unit in the northwest of the Revelstoke District.

Figure 4 – Example PEM Map for the R16 Landscape Unit

5. BEC Mapping and Map Labels for this PEM

The following is a listing of items of note that we encountered during the development of the PEM. These pieces of information may be useful for other Forest Planning applications.

1) The BEC classification used for this project is the revised version (2005) provided by Dennis Lloyd, MoF Regional Ecologist of the Southern Interior Forest Region. Appendix 8 contains one example – ICHwk1 – of the new classification. The full set used for this project is included in digital format with the project files.

2) The BEC linework map has not yet been revised down to the 1:20,000 scale by Dennis Lloyd, Regional Ecologist. By permission from Dennis, we used the Legacy BEC map produced at the 1: 100,000 scale and made some small changes as per Dennis' instructions and to match the revised BEC Classification. As per Dennis' email (see Appendix 9), the ESSFvv was changed to ESSFwcw. Some ESSFvv still remains near Mount Revelstoke National Park (only 0.8 ha) that was missed during the edits of the BEC map.

   In accordance with the new classification, the ICHmw3 was changed to ICHmw2. The ICHmw2 polygons on the BEC map were shortened based on ground reviews, with the removed areas being merged into the ICHwk1 polygons

3) We identified the topographic patterns of the ecosystem units described in the Revised BEC Classification and recorded these patterns in the PEM Entities Legend (Appendix 4). This legend provides a quick and easy reference for the physical descriptions of the ecosystem units. The full vegetative descriptions are best provided in the Revised BEC classification produced by D. Lloyd.

4) In this PEM, only a few ecosystem units were lumped together. We strived to identify each site series identified in the new BEC classification (Lloyd, et. al, 2005) and map these uniquely. In a few cases, however, we were not able to separate out closely-related ecosystem units given the data inputs available. This was due to either the inventory inputs being too coarse, as in the distinction between the Horsetail Forests and Swamp Forests of the ESSF subzones; or due to the patterns of the ecosystems themselves being to variable, as in the elevation break at which the lower zonal changes to the upper zonal in the ESSF subzones. Those units that were lumped are shown clearly in the Map Legend and the PEM Entities Legend for this project.

5) No bioterrain mapping was used in this project. We elected not to use bioterrain mapping for this project – none currently exists, nor was it contracted as part of this project. From our experience, our PEM methodology does not require a bioterrain base to assist in the labelling of the ecosystem units. As expected, the exclusion of this inventory did not create a detriment to the success of this mapping. We were able to achieve high levels of accuracy in each BEC subzone without the use of bioterrain mapping.

6) We did, however, contract the analysis of LandSat 7 satellite imagery in order to improve the quality and accuracy of the non-forested ecosystems. We learned from previous projects that satellite imagery is vital to identifying the type of ecosystem units for areas that have no forest cover information, be they in the lowlands or parkland/alpine. We also learned to reduce the number of analysis classes in order to increase the accuracy of the labels. Therefore, imagery classes intended for the alpine that show up in the lowland openings were utilized equally well regardless of the intended interpretation. The Ecologist merely associated the alpine class label with a corresponding ecosystem unit in the lowlands. For this PEM methodology, satellite imagery is definitely more useful than the bioterrain layer as a PEM input.

7) In this PEM, we used the satellite imagery pixels as the polygons in the parkland and alpine BEC subzones where no forested polygons exist. All forest cover "alpine" polygons were subdivided into satellite pixels rather than the regular slope/aspect PEM polygons. This smaller polygon size allowed us to capture the very subtle distinctions in the high-elevation ecosystem units. Alpine ecosystem units can literally change every 20 metres. We chose not to go below the precision of these 25 x 25 m pixels in order to stay within the accuracy limitations of the satellite imagery.

8) The bedrock geology inventory layer (1:100,000 scale) was incorporated into this PEM but not utilized to its fullest. The bedrock geology often plays a role in shifting ecosystem units off of their normal pattern due to an increase in available nutrients (marble) or a sharp decrease (granite). However, not enough time was spent in the field testing these theories in order to incorporate them into the knowledge tables. Nevertheless, the bedrock geology is available in the Matrix databases for other Users to access and test their theories.

9) We created unique knowledge tables (KB's) for each forested BEC Subzone in this PEM. We were able to capture the unique ecosystem patterns expressed in each subzone, such as the ICHvk1 having more robust forests growing on more difficult sites due to the higher rainfall in this subzone, and incorporate these differences in separate KB's.

10) In the ESSF subzones, each had two to three zonal units identified in the new BEC Classification. Typically there was a low elevation zonal that occurred near the boundary of the ICH subzones, which was in fact the zonal of that ICH. Only in the ESSFvc did we try to map this lower zonal (05) separately using an elevational break line to distinguish them. For the most part, we were successful at distinguishing these two zonals except at the transition line where 01 and 05 became interchangeable. In all other ESSF's we lumped the lower zonal with the 01 to avoid this confusion. In addition, in the ESSFvc and wc4, at upper elevations, the drier 03 became the zonal replacing the 01 as the boundary with the parkland became nearer. We attempted to use elevational breaks to distinguish this change, but were not always successful particularly near the transition. As such, in both of these cases, the Score Matrices (see Appendix 2) indicate that the similar zonals are interchangeable and given full points.

11) During the fieldwork, we noted that the ICHmw2 04 in its upper toe of slope position rises much higher along the valley floor of the Columbia River than elsewhere in this subzone. It was surmised that there must be greater seepage flowing from Mount MacKenzie above than from other mountains in the area. The normal pattern identified elsewhere in this subzone is for a narrower band of 04 rising up from the toe of slope position.

12) For the parkland and alpine subzones though, we used the same KB based on the classification for the ESSFwcw subzone. The ESSFwcw provided a good basis for the generalized map labels that are necessary for the parkland and alpine. The range of diversity of plant communities in the mountains can vary considerably, especially in relation to bedrock geology and climatic pockets. It is a challenge for the Regional Ecologist to sample and classify these ecosystems, and it will be even more of a challenge to map these once they are classified. As a solution, we created generic alpine ecosystem labels for the non-forested units that correspond to what we are able to successfully map (particularly with the help of satellite imagery). The parkland and alpine generic ecosystem labels are:

    KR – krummholtz
    HE – heathlands
    HM – herbaceous meadows (moist)
    AW – alpine wetland
    AG – alpine grasslands
    AV – Avalanche

RT – rock or talus
GL – glacier

Note that we used the code HM instead of ME as stated in the new draft PEM Standards 2.0. This was an unintentional mistake that can not be fixed at this point.

13) Other non-forested ecosystem units mapped within this PEM at lower elevations are:
US – upland shrub – alder or willow swales along slope seepages
WG – gramminoid-dominated wetlands; can include some shrub and open water
WS – shrub-dominated wetlands
LA – lake
RI – river
IS – islands – may range from no vegetation to dense shrubs
AV – avalanche tracks
RT – rock or talus
ES – exposed soil; such as road cuts or gravel pits
RZ – roads
UR – urban areas including mining sites

14) The avalanche paths are rich forage value for grizzlies. We are very pleased with the outcome of how the PEM identified these avalanche paths. The PEM was able to distinguish between the sections of the avalanche paths that are bare rock, the mid slide sections and the toes. The PEM was further able to distinguish between the toes that are the moist alder swales and shrubby wetlands. In the ICHmw2 and wk1, avalanche tracks and brush pockets that are on slopes greater than 10% are called US (upland shrub) since there are more alder swales at this elevation than avalanche tracks. In the ICHvk1 and the ESSF's, all shrub pockets on slopes are called avalanche tracks. In all subzone, shrub patches on slopes less than 10% are called WS (shrub wetlands), even if they are the toes of avalanche paths. This was done to indicate the higher soil moisture content of these avalanche toes and thus higher herbaceous and shrub diversity of the plant communities.

6. Forest Cover Retrofit Project

As a mapping product associated with this PEM, two seral stage layers have been created using the retrofitted forest cover data created by Eric Valdal of the BC Integrated Land Management Bureau, to represent the current seral conditions (2005) and those that existed in 1985. The VRI data was first analyzed with seral stage algorithms to produce a present-state seral stage map. The VRI data was then retro-fitted to represent the forest cover that existed in 1985, and then re-run with the same seral stage algorithms to create a seral stage layer for 1985. The PEM and the Seral Stage layers will be used by Wildlife Biologists, under the direction of the National Park Biologist, to produce wildlife habitat maps for the current and historical forests.

The following is an excert from E. Valdal's forest cover retro-fitting report for this project. The full report is contained in Appendix 10.

"Landscape scale analyses with historical natural resource data provide invaluable insight into the past conditions of ecosystems (Morgan 1999, Mladenoff et. al. 2002, Wells and Valdal 2002). Applications of such data include the assessment of the extent of ecosystem change and the creation ecological baselines for habitat management, population modeling and species recovery (Mladenoff et. al. 2002, McNay 2005). Analysis of historic information may also provide understanding into the ecological function of current systems (Wells and Valdal 2002, Utzig and Holt 2002). The purpose

of this project was to model a 1985 forested landscape in the Revelstoke Forest District, with the applied aim of contributing to a historic habitat suitability benchmark for the mountain ecotype of woodland caribou (Rangifer tarandus caribou).

In British Columbia, forestry and natural disturbances are updated into the digital forest cover inventory by the Ministry of Forests (MOF). Although comprehensive archives of forest cover data exist back to 1994, digital and hard-copy forest cover information before this time are often not available because of unstable archive media problems and destruction of historic data, in part due to a lack of corporate understanding of its value (Carpentier 2005, Beard 2005).

All methods for obtaining a historic forested landscape have drawbacks. The ideal method is to retype forest stands using old aerial photography; however, this process is prohibitively costly over large study areas. The MOF manages digital silviculture surveys containing stand level forest information that existed before a forest block was harvested. Incorporating this information is also problematic though, because it does not meet all the pre-disturbance information needs for the project, is relatively costly to incorporate over a large landscape, and the scale and spatial orientation of the survey's forest stand information is not in concert with the original forest cover inventory (Rousseau 2005). The most pragmatic and cost effective method is to simulate the composition of post 1985 disturbances using the adjacent forest inventory information within a modeling framework like the Spatially Explicit Landscape Event Simulator (SELES) (Fall and Fall 2001).

The use of adjacent inventory information to model missing forest stand information has had levels of success in the past (Wells and Valdal 2002). Using forest cover age class and leading species as testing targets, the modeling accuracy is generally higher in ecosystems with stand-initiating events and larger patch sizes rather than those with stand-maintaining disturbances and smaller patch sizes (BCMOF 1995). The forest ecosystems in the Revelstoke study area are characterized as having rare and infrequent stand-initiating events (BCMOF 1995) that align well with our project objectives."

The results of the comparison between the seral stages of 1985 and 2005 are shown below in Figure 5 – Forest Age Class Summary by Area and Year. Please refer to the full report in Appendix 10 for the details of the analysis.

Figure 5 – Forest Age Class Summary by Area and Year
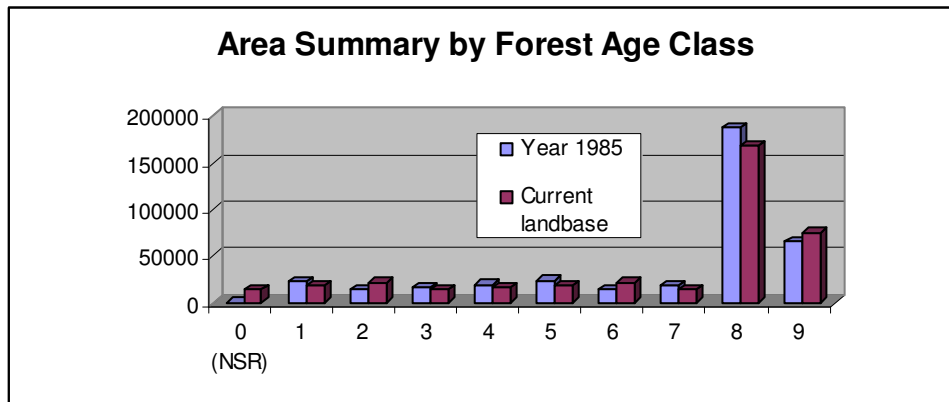
7. Seral Stage Maps

Two seral stage maps were created for the Revelstoke PEM. The first used the current forest cover ages for 2005, the second used the retrofitted forest cover ages for 1985. The following tables describe the seral stage classes and the structure of the knowledge table.

Table 5 - Seral Stage Descriptions		
Seral Stage	**Name**	**Description**
NV	Non-Vegetated	talus, rock, roadways, gravel pits; urban developments
PS	Pioneer Seral	1st stage of regeneration – herb and shrub species are dominant; less than 1 year for cutblocks.
ES	Early Seral	Between 20 and 50 years; self-thinning has not occurred.
YS	Young Seral	Between 51 and 100 and years old for ICH; Between 51 and 120 years old for ESSF;
MS	Maturing Seral	Between 101 and 250 and years old for ICH; Between 121 and 250 years old for ESSF; thinning has occurred; is a dominant canopy with and understory developing (shrub to intermediate canopy)
OS	Overmature Seral	Greater than 250 years old; now has a multilevel, uneven age canopy with more shade tolerant species.

The age class divisions were taken from both the BC Biodiversity Guidebook for Natural Disturbance Type 1, and from the Describing Ecosystems in the Field Handbook. The Early Seral stage has been added to capture the young dense stands that are of particular interest to the Biologists creating habitat maps for the Mountain Caribou.

Table 6 - Seral Stage Knowledge Table									
BEC	**Site Series**	**Age (yrs)**	**Seral Stage**						
			NV	**DS**	**PS**	**ES**	**YS**	**MS**	**OS**
All	US				1				
All	WS				1				
All	WG					1			
All	LA		1						
All	RI		1						
All	IS				1				
All	AV				1				
All	RT		1						
All	GL		1						
All	ES		1						
All	RZ		1						
All	UR		1						
All	AG					1			
All	HE					1			
All	HM					1			
All	KR							1	

All	AW				1				
ESSF	all	0 - 20			1				
	all	21 - 50				1			
	02,03	51 - 120						1	
	all others	51 - 120					1		
	02,03	121 - 250							1
	all others	121 - 250						1	
	all	250 +							1
ICH	all	0 - 20			1				
	all	21 - 50				1			
	02,03	51 - 100						1	
	all others	51 - 100					1		
	02,03	101 - 250							1
	all others	101 - 250						1	
	all	250 +							1

8. Structural Stage Maps

As per the PEM Standards version 1.0, structural stage maps are required as a PEM product. The structural stage classes listed below were taken from the Describing Ecosystems in the Field handbook.

Forest Age	Structural Stage Class				
	3	4	5	6	7
1 - 20	1				
21 - 40		1			
41 - 80			1		
81 - 240				1	
> 240					1

9. Uses of this PEM

This is a Level 1PEM which produced small-polygons averaging 0.5 ha in size, that are spatially explicit – each site series is spatially shown on the map. It is not a large-polygon PEM with multiple labels that are not shown where they exist within that large polygon. As such, it is the highest level of precision offered among the PEM varieties available in B.C. In addition, it has surpassed the required 65% accuracy level in order to utilize the PEM in all forest management and wildlife management applications. As well, 91% of the polygon labels in the PEM are pure (single labels only, no ties) which means that they are much easier to work with in other modeling and analyses applications. The pure labels prevent cross-product problems encountered when multiple labels exist in a polygon. As listed in the new draft PEM Standards, some of the suggested applications are as follows:

- Wildlife Habitat Modelling
- Rare ecosystem mapping
- Wetland mapping
- Spatial timber supply analysis

- Operational forest management planning
- Wildlife Habitat Capability/Suitability
- Research selection & stratification of sites
- TSR – Timber Supply Review
- SIBEC Adjustment
- Coarse- and Fine-filter biodiversity mapping for baseline & monitoring
- Ecosystem Representation
- Old growth management area analyses
- Cultural use modeling/traditional use studies/archaeology
- Criteria & indicators for sustainable forest management
- Hydrology analyses
- Interior water shed assessments
- Disturbance analysis / post fire regeneration analysis / restoration analysis
- Carbon budgeting / credits / sequestering
- Downed woody material/ Coarse woody debris analyses and planning
- Berry and mushroom production & mgmt
- Fuel-loading potential and fire forecasting
- Agriculture and Lands planning
- Local/Regional Management Plans
- Strategic Planning at broad levels

Primary use of this PEM, however, is for caribou habitat mapping and seral stage mapping – **wildlife planning and habitat management**. The site series mapping provided by this PEM can be considered the basic building blocks for wildlife planning/management. PEM data partitions the land base into ecosystems with sufficient detail to allow biologists to tell where certain habitat types can occur or are likely to occur. From this information, any number of questions around wildlife habitat can begin to be addressed. This may include, flagging potential red/blue species habitats, refinement of LRMP ungulate winter range (UWR) zones, or the projection of habitat supply over time associated with various harvesting scenarios.

The secondary, but important use of this PEM is for **Timber Supply Analyses** – to improve the estimates of site productivity for forest stands. The current site index estimates in forest cover files are often based on old growth stands and tend to underestimate the productivity of managed stands. One method of improving these site indexes is to use the relationship between ecosystems (and their attributes like soils, moisture, slopes, aspect, etc) and site productivity. This is referred to as the SIBEC Approach and links site index estimates to specific BEC variant / site series by Forest Region (MoF Research Branch). The site series mapping provided by the PEM is the critical first step in being able to complete the process. These site index estimates can have dramatic implications on predictions of long term harvest levels and can affect short term AAC setting in some cases. Harvest levels improved significantly if an increase in site index occurs because stands produce more volume and reach critical ages/heights/volumes more quickly (green-up/visual heights).

The original EcoGen PEM maps were used in a Timber Supply Analysis by Gerrard Olivotto and Del Meidinger "Development of EcoYield – A Conceptual Model for Timber Supply Analysis Using Predictive Ecosystem Mapping and Site Index – Ecosystem Relationships", (EcoNote 2001-01) http://www.for.gov.bc.ca/hre/ecogen/furinfo. As described simply by Cam Brown, Timber Supply Analyst, if the polygon or raster has a site series with a decile, it can be run through a timber supply model. The following letter from Cam Brown of Foresite Consultants Ltd. describes the applicability and ease of this PEM for use for Site Index Adjustment purposes.

FORSITE
INNOVATIVE SOLUTIONS

February 25, 2004

Shamaya Consulting Ecological Services
5577 Silver Star Road
Vernon, BC   V1B 3P7

Attention: Colleen Jones, RPBio

Re: Acceptability of Patry PEM for SIBEC Site Index Adjustment.

Dear Colleen,

I have reviewed the Patry PEM data provided to me on February 20th, 2004 with the goal of assessing its acceptability for use in a SIBEC site index adjustment process.

A PEM product must have the following attributes in order to complete a SIBEC site index adjustment process:

- Spatial data representing ecosystem units at the site series level (PEM polygons),
- Attribute data linking to the spatial data indicating site series that occur in the PEM polygons,
- If more than one site series is present within a PEM polygon, proportions (deciles) for each site series must be provided.

Your PEM product easily meets these tests and thus can be used to complete a SIBEC site index adjustment project. In addition, it should be noted that the format of your PEM data makes this adjustment process relatively simple in comparison to other PEM products I have encountered. The vast majority (84%) of the area classified by your PEM has been assigned a single site series, leaving only 16% of the area with mixed site series. This simplifies the SIBEC process and also makes the PEM more useful for other planning initiatives (wildlife capability/suitability, ecosystem rarity/representation, etc) because mapping can accurately display the distribution of site series across the landscape.

In order for the Ministry of Forests - Forest Analysis Branch to accept the results of any site index adjustment project that is based on a PEM, an independent accuracy assessment of the PEM must first be completed. The resulting accuracy level must then meet published threshold limits in order to be used in a Base Case analysis. As no accuracy assessment has been completed at this time, I cannot state that your PEM product is acceptable for use in a Base Case timber supply analysis, only that it is well suited for use in adjusting site index values once its accuracy is proven.

In addition, I wish to note that the provision of your source attribute data for the PEM polygons will likely prove very useful in future planning initiatives in the Patry area. This condensation of forest cover, slope, aspect, elevation, soils, bedrock, and terrain features can be utilized to identify very specific combinations of attributes on the land base (e.g. mesic site series on south facing slopes under 1000m in elevation). This dataset could also be used to do strategic planning for a SIBEC project because it contains leading tree species and can be linked to the PEM output table to obtain ecosystem identification. One of the largest cost components of a PEM project is the collection and cleaning of digital data – your inclusion of this data with the product allows further value to be obtained from this investment.

In conclusion, I find your PEM product outputs to be of excellent quality and well designed for use in both operational and strategic forest planning projects.   Once the accuracy of the product is proven, it will be an excellent base from which to complete a site index adjustment project.

Sincerely yours,

Forsite Consultants Ltd.

Cam Brown, RPF
Resource Analyst / Strategic Planning Forester

A third significant use of this PEM is for **Landscape Unit Planning**. When implementing land use planning requirements within an LU, site series representation can be an issue (rarity / distribution). Selection of stands for retention (OGMA, wildlife requirements) can be guided by the data provided by PEM mapping. For example, rare site series are a high priority for OGMA designation and dry rocky ridges with fir are great ungulate winter range (UWR). Hydrological analyses and watershed assessments utilize the distribution and location of each site series. This PEM can also be used to assist with **First Nations** issues such as the location of site series with specific plant communities (rare plants, berry picking sites, etc), or those likely to have historical cultural sites.

A fourth significant use of this PEM is for **Initial Silvicultural Prescription** (SP) direction. The site series provide by the maps can provide a good starting point for field staff completing SP data collection. This is likely not a significant benefit because crews will still have to ground truth and map the site series in a block and develop management units (SU's) for the prescription (i.e. mosaics of site series where the management will be the same).

10. Test of the new draft PEM Standards (2006, in progress)

This PEM project has also been the test case for the new draft PEM Standards version 2.0 (in development). The data files have been provided in the formats recommended in the new Standards as opposed to the formats of the original PEM Standards. All files required in version 1.0 are present, though the formats are in accordance to the version 2.0 Standards.

As a collaborative effort of this project with the Ministry of Environment – Kamloops and Victoria, we have agreed to try creating all the data files required by the new Standards and report to MoE on the practicality of creating these. In addition, MoE Victoria will evaluate these data files for their incorporation into the LRDW (Land and Resource Data Warehouse). Recommendations from this test case will be discussed within MoE for potential edits to the new draft PEM Standards.

11. Statistical Accuracy Calculations

This section reports the results of the various statistical evaluations of the PEM according to the Protocol for Accuracy Assessment of Ecosystem Maps (Meidinger, 2003).

The following are the basic statistics for this PEM project:
1. Size of the project area = 587,569 ha
2. Number of PEM polygons in the Revelstoke PEM = 1,206,018
3. **Average polygon size = 0.49 ha**
4. Minimum polygon size = 0.06 ha for alpine and 0.1 ha for non-alpine polygons
5. Maximum polygon size = the lakes
6. **Percentage of single label polygons = 91%**
7. Percentage of tied label polygons = 9%
8. Number of BEC subzones = 14
9. Number of Forested BEC subzones = 7
10. Number of Forested Site Series within the Forested BEC Subzones = 53
11. Number of polygons required for Internal Independent QA: 53 x 2 = 106
12. **Number of polygons used in the Independent QA = 180**
13. Independent QA sample size confidence level= 90% with +/- 0.065% error and 0.5 probability of random point correctly classified;
14. Number of polygons used in the calibration datasets = 1531
15. **Total number of ground checked polygons = 1713**
16. Total sample size Confidence Level= at 95% with +/- 0.025% error and 0.5 probability of random point correctly classified, was "0" on either side of the 81% score – the sample size was large enough to produce a likely error of "0".
17. Survey intensity "Level D" = all polygons were checked by ground inspection
18. Percent of the project area sampled = 0.14%
19. The area (ha) of each BEC in the project area is shown in the figure below.

Figure 6 - Distribution of BEC Subzones in the Revelstoke PEM
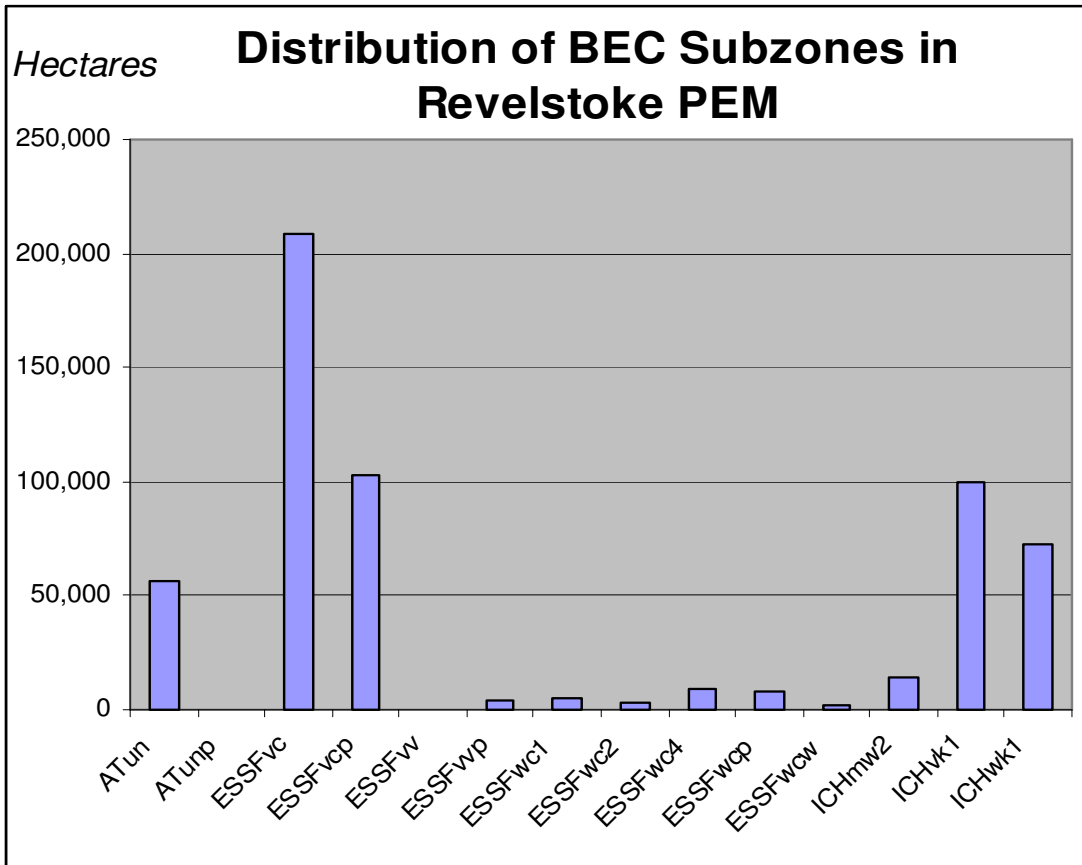
In Table 7 below the scores for the Dominant Correct and Overlap calculations are shown for both the calibration and independent data sets. In Table 8 , the summaries are shown for both the Validation Results and Internal QA. Please refer to file "PEM_4316_val" for more information on how the values were calculated. The first values are scored against the total number of polygons in the sample, whereas the second set of values are scored against the area within each polygon.

Table 7 - Validation & Internal QA Results by BEC Subzone

Summary of Scores:	No. of Samples	% Dominant Correct	% Dominant Acceptable (½ point)	% Dominant by Weighted Area	% Dominant Acceptable by Weighted Area	Proportion of Label Correct	Proportion Acceptable (½)	Proportion Correct by Weighted Area	Proportion Acceptable by Weighted Area
ICHmw2 Calibration data	381	81%	88%	90%	94%	69%	82%	79%	85%
ICHmw2 Independent data	34	77%	86%	85%	92%	65%	79%	62%	79%
ICHwk1 Calibration data	328	79%	87%	87%	91%	70%	81%	75%	86%
ICHwk1 Independent data	40	81%	87%	89%	92%	62%	76%	72%	84%
ICHvk1 Calibration data	307	85%	91%	88%	93%	78%	87%	81%	90%
ICHvk1 Independent data	38	74%	86%	89%	94%	67%	80%	86%	92%
ESSFvc Calibration data	221	87%	91%	93%	95%	75%	85%	81%	89%
ESSFvc Independent data	24	68%	78%	75%	84%	57%	71%	69%	79%
ESSFwc2 Calibration data	54	96%	98%	92%	96%	86%	93%	85%	93%
ESSFwc4 Calibration data	104	90%	93%	94%	95%	81%	89%	86%	92%
ESSFwc4 Independent data	44	77%	81%	91%	92%	64%	74%	65%	78%
ESSFwcp Calibration data	136	91%	95%	90%	94%	83%	91%	81%	90%

Table 8 - Overall Internal QA Results – Calibration and Independent Datasets

Summary of Scores:	No. of Samples	% Dominant Correct	% Dominant Acceptable (½ point)	% Dominant by Weighted Area	% Dominant Acceptable by Weighted Area	Proportion of Label Correct	Proportion Acceptable (½)	Proportion Correct by Weighted Area	Proportion Acceptable by Weighted Area
Project Total for Calibration Dataset Polygons:	1531	87%	92%	90%	94%	77%	87%	81%	89%
Project Total for Independent Dataset Polygons:	180	75%	84%	86%	91%	63%	76%	71%	82%

For us, as the PEM Practitioners, we consider the first set of numbers more relevant because we treat all the polygons equally regardless of their size. We don't create a preference for the large polygons and overlook the smaller ones. In the EcoGen methodology, a polygon label is recorded as right or wrong regardless of its size. The weighted by area scores can fluctuate up or down randomly, as seen above, depending on the size of the polygons in the dataset. However, the Accuracy Protocol prefers the values weighted by area in order to determine if the majority of the project area was correctly mapped, so the weighted by area values are included in this table.

In addition, the Accuracy Protocol requires that all ecosystem maps be assessed according to their proportion of the label correctly capturing the true ground ecosystem labels. These values are also included in this table. Proportional calculations are particularly relevant to large polygons similar to TEM maps that are generally greater than 5 hectares. These TEM-like labels necessarily need to be complexed (have multiple labels) in order to capture the diversity on the ground within the polygon boundaries. Each of the ground-truthed ecosystems represent areas in the size of hectares, which are then compared to the map labels which also represent areas in hectares. In this PEM, however, the average polygon size is 0.5 ha and therefore identifies the ecosystem units at a much finer resolution well beyond the capability of a TEM. The proportions of ground ecosystem units within these PEM polygons boundaries occupy areas in square meters.

This PEM is designed to identify only the dominant ecosystem units, not the smaller ecosystem units. As such, the polygons must be quite small in order to avoid including multiple ecosystem units within their boundaries. The size of small inclusions of other ecosystem units within these PEM polygons is far smaller than would ever be considered in the proportional assessment of a TEM map. This PEM is not designed to pick up the pocket ecosystem units, therefore this is an overly rigorous accuracy test. TEM maps are not expected to nor required to map this level of resolution either.

Confusion matrices are optional according to the Accuracy Assessment Protocol. These tables show how often PEM labels were classified as wrong ecosystem units – the committed error, and how often the labels were not classified as the right ecosystem labels – the omission error. Due to a lack of time, we did not create these confusion matrices for the 14 BEC subzones.

The CRITBINOM calculation (Table 9) identifies the upper and lower limits of the confidence interval for the accuracy of the map. Using the Dominant Correct score of the accuracy statistics, this calculation determines the likely range of error around this score based on the number of samples in the dataset. The CRITBINOM calculations have been completed for both the independent dataset and the full ground dataset collected during the fieldwork for the Revelstoke PEM.

Table 9 - CRITBINOM Calculations for the Revelstoke PEM

CRITBINOM - 80% Confidence Interval	No. of polygons	% Dom. Correct	Lower CI %	Upper CI %
Independent dataset	180	**74%**	70%	78%
All ground samples	1713	**81%**	Null – 81%	Null – 81%
CRITBINOM - 95% Confidence Interval				
Independent dataset	180	74%	68%	80%
All ground samples	1713	81%	Null – 81%	Null – 81%
Note: The CRITBINOM calculation produces a "Null" answer since sample set is so large (1713 polygons). As such this calculation states that there is likely no error in these scores – the confidence interval is "0".				

In order to compare the value of the ground sample set to the finished PEM map, two statistics are created according to the Accuracy Protocol (Meidinger, 2003). **These statistics do not reflect the accuracy of the map.** These are the PEM Entity Proportions graph (Figure 7) and the Percent Overlap for Map Area (

Table 10). These two stats show how well the range of ecosystem units were captured in the sample set. As illustrated, there were often proportionally more samples of the uncommon ecosystem units than were mapped in the PEM (i.e. ICHmw2 07, 08, 09, and 10). And in other cases, no samples were collected for units that were mapped (i.e. AV and ES – avalanche and exposed soil). The Percent Overlap for Map Area score for ICHmw2 confirms that there was 67% correlation between those ecosystem units sampled and those mapped. However, the purpose for the ground sample dataset is to collect as many examples of the range of ecosystem units as is necessary to calibrate the KB's in order to accurately map them. In some cases, the Ecologist needed more samples to understand and replicate the patterns for these unique ecosystem units. These statistics would show if the ground sample set contained only a few ecosystem units while ignoring others – this would result in a potential bias towards those units and the creation of errors for the other units. These statistics are useful to see how solid a foundation the ground samples provided in order to create the PEM map.

Though these stats are supposed to be created for each BEC Subzone in the project area, they are both very time-consuming to create, so only two subzones are shown. Please refer to the attached DVD in the "PEM_4316_val" file to view these in more detail.

Figure 7 - PEM Entity Proportions Graphs
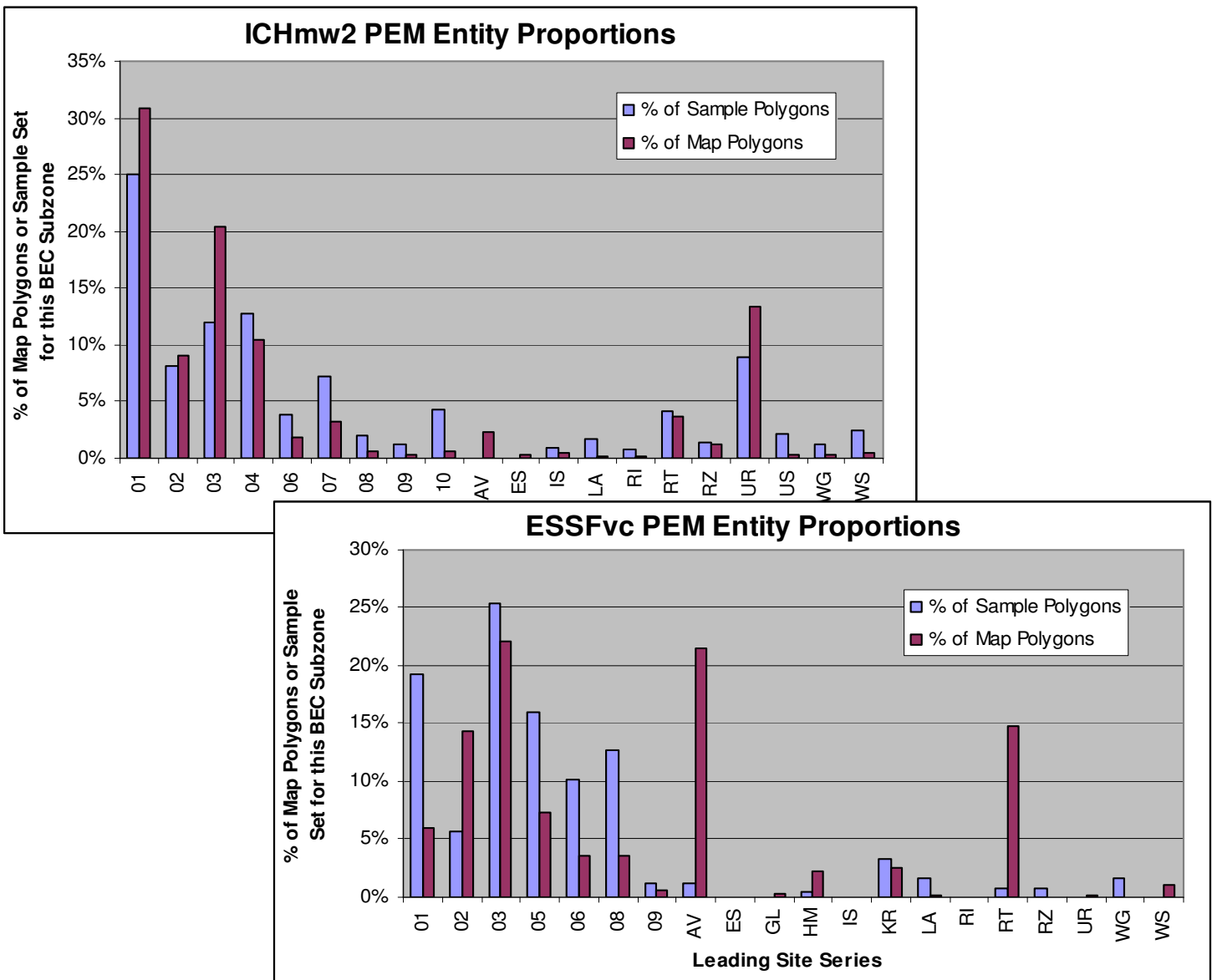
Table 10 - Percent Overlap for Map Area

ICHmw2 Percent Overlap for Map Area					
Map Entity	Map Area (ha)	Map Area %	Sample Plots (n)	Sample Plot %	Overlap %
01	3654.51	21%	104	25%	21%
02	741.65	4%	34	8%	4%
03	1804.11	10%	50	12%	10%
04	951.07	5%	53	13%	5%
06	174.44	1%	16	4%	1%
07	170.55	1%	30	7%	1%
08	99.48	1%	8	2%	1%
09	32.66	0%	5	1%	0%
10	556.04	3%	18	4%	3%
AV	247.93	1%	0	0%	0%
ES	98.75	1%	0	0%	0%
IS	640.06	4%	4	1%	1%
LA	1031.21	6%	7	2%	2%
RI	261.33	1%	3	1%	1%
RT	265.40	2%	17	4%	2%
RZ	96.97	1%	6	1%	1%
UR	2602.65	15%	37	9%	9%
US	604.89	3%	9	2%	2%
WG	2332.63	13%	5	1%	1%
WS	1309.97	7%	10	2%	2%
					67%

ESSFvc Percent Overlap for Map Area					
Map Entity	Map Area (ha)	Map Area %	Sample Plots (n)	Sample Plot %	Overlap %
01	16188.49	8%	47	19%	8%
02	24857.09	13%	14	6%	6%
03	46108.45	24%	62	25%	24%
05	24636.17	13%	39	16%	13%
06	5785.68	3%	25	10%	3%
08	6821.17	4%	31	13%	4%
09	791.18	0%	3	1%	0%
AV	30725.83	16%	3	1%	1%
ES	37.79	0%	0	0%	0%
GL	567.75	0%	0	0%	0%
HM	2678.07	1%	1	0%	0%
IS	4611.22	2%	0	0%	0%
KR	3738.78	2%	8	3%	2%
LA	795.73	0%	4	2%	0%
RI	472.85	0%	0	0%	0%
RT	21625.72	11%	2	1%	1%
RZ	11.87	0%	2	1%	0%
UR	687.80	0%	0	0%	0%
WG	534.61	0%	4	2%	0%
WS	1884.18	1%	0	0%	0%
					62%

12. Bibliography

BC Ministry of Environment, 2006 – in progress. *Standards for Predictive Ecosystem Mapping – Inventory and Digital Data Standard and PEM User's Guide – Version 2.0.* BC Ministry of Environment, Kamloops and Victoria, BC.

BC Ministry of Forests and BC Ministry of Environment. 1998. *Field manual for describing terrestrial ecosystems.* BC Min. For. and BC Min. Environ., Lands and Parks, Victoria, BC.

BC Ministry of Environment. 1995. *Forest Practices Code - Biodiversity Guidebook* . BC Min. Environ., Lands and Parks, Victoria, BC.

BC Ministry of Forests. 1999. *A Method for Large-scale Biogeoclimatic Mapping in British Columbia.* Version 1. Eng, M. Research Branch, Victoria, BC.

Demarchi, D.A. 1995. *Ecoregions of British Columbia (Fourth Edition).* 1:2,000,000 Map. B.C. Ministry of Environment, Lands and Parks. Victoria, B.C. Ministry of Environment.

Demarchi, D.A. 1996. *Introduction to ecoregions of British Columbia.* Ministry of Environment, Lands and Parks, Wildlife Branch. Victoria, BC

Erwin, C. 2003. *Draft Quality Assessment Protocol for TEM and PEM Projects – Inventory and Digital Data Capture Standards.* Ministry of Environment, Victoria, BC.

Howes, D.E., and E. Kenk. 1997. *Terrain classification system for British Columbia, Version 2. MOE Manual 10.* B.C. Min. Environment, Lands and Parks and Ministry of Crown Lands, Victoria, B.C.

Jones, C. and D. Meidinger. 2000. *Introduction to Attribute Selection in PEM, EcoNote 2000-03.* B.C. Min. For. Research Branch, Victoria, B.C.

Jones, C. 2003. *PEM – BEC Classification Protocol for FIA Audits.* Price Waterhouse Coopers, Vancouver, B.C.

Jones, C. 2003. *North Coast Predictive Ecosystem Mapping Report 2002-2003.* for Allen Banner – Regional Ecologist, Ministry of Forests – Coastal Region, Smithers, B.C.

Jones, C. and G. MacGregor. 2004. *Patry Lake Predictive Ecosystem Mapping Final Report.* Slocan Group Nelson Division, Fort Nelson, B.C.

Jones, C. and G. MacGregor. 2004. *Lillooet TSA Predictive Ecosystem Mapping Final Report.* Ainsworth Lumber Company, Savonna, B.C.

Jones, R.K., D.V. Meidinger, D. Clark, F. Schultz, D.E. Moon, and R.A. Sims. 1999. *Towards the establishment of a predictive ecosystem mapping standard: A White Paper.* BC Min. Environ., Lands and Parks, Resources Inventory Committee, TEM Alternatives Task Force, Victoria, BC.

Lloyd, D., M. Ryan, N. Brand, M. Doney, V. Larson, J. MacDonald. May, 2005. DRAFT *Site Classification for 52 Biogeoclimatic Units in the Southern Interior Forest Region.* BC Ministry of Forests – Southern Interior Forest Region, Kamloops, B.C

Luttmerding, H., D.A. Demarchi, E.C. Lea, D.V. Meidinger and T. Vold. 1990. *Describing ecosystems in the field. MOE Manual 11, 2nd ed.,* Victoria, Ministry of Environment, Lands and Parks and Ministry of Forests.

Meidinger, D. and J. Pojar (compilers and editors). 1991. *Ecosystems of British Columbia. B.C.* Ministry of Forests Special Report Series 6. 330 pp.

Meidinger, D. 1999. *Protocol for quality assurance and accuracy assessment of ecosystem maps.* B.C. Min. For., Research Br., Victoria, BC. Internal Rep.

Meidinger, D., B. Enns, A. Banner, C. Jones, S. Reed. 2000. *EcoGen – A Model for Predictive Ecosystem Mapping, EcoNote 2000-01.* B.C. Min. For. Research Branch, Victoria, B.C.

Meidinger, D. and C. Jones. 2000. *Dealing with Complex Polygon Attributes as PEM Input, EcoNote 2000-02.* B.C. Min. For. Research Branch, Victoria, B.C.

Meidinger, D. 2003. *Protocol for Accuracy Assessments of Ecosystem Maps.* B.C. Min. For., Forest Science Program, Victoria, BC.

Ministry of Environment, Lands and Parks. January, 1993. *BC specifications and guidelines for geomatics, Content series Volume 3, Digital Baseline Mapping at 1:20,000, Release 2.0.* Geographic Data BC, Victoria, BC.

Moon, D.E. 1999. *Problem analysis on data quality assessment issues.* BC Min. Environ., Lands and Parks, Resources Inventory Committee, TEM Alternatives Task Force, Victoria, BC. Draft. Standards for Predictive Ecosystem Mapping – Inventory Standards

Hamilton, Dennis. 2005. *Ground Inspection Forms for the Revelstoke PEM Wildlife Project.* Nanuq Wildlife Consultanting, Nelson, B.C.

Heineman, Jean. 2003. *Pre-harvest Silvicultural Prescriptions for Cutblocks in the Revelstoke TSA.* Revelstoke Community Forest Corporation. Revelstoke, BC.

Olivotto, G. and D. Meidinger. 2001. *Development of EcoYield – A Conceptual Model for Timber Supply Analysis Using Predictive Ecosystem Mapping and Site Index-Ecosystem Relationships, EcoNote 2001-01.* B.C. Min. For. Research Branch, Victoria, B.C.

Resources Inventory Committee. 1996. *Standard for digital terrain data capture in British Columbia. Version 1.* Terrain Data Working Committee. Victoria, BC.

Resources Inventory Committee. 1998. *Provincial site series mapping codes and typical environmental conditions.* Ecosystems Working Group.

Resources Inventory Committee. 1998. *Standard for terrestrial ecosystem mapping in British Columbia.* Terrestrial Ecosystems Task Force, Ecosystems Working Group. Victoria, BC.

Resources Inventory Committee. 1999. *Standards for Predictive Ecosystem Mapping – Inventory Standard.* Terrestrial Ecosystems Mapping Alternatives Task Force. Victoria, BC.

Resources Inventory Committee. 2000. *Standards for Predictive Ecosystem Mapping – Digital Data Capture Standard*. Terrestrial Ecosystems Mapping Alternatives Task Force. Victoria, BC.

Resources Inventory Committee. 2004. *Standards for Predictive Ecosystem Mapping – Digital Data Capture Standard Version 1.0, Errata No. 1*. Min. Agriculture and Lands, Resource Information Branch. Victoria, BC.

Resources Inventory Committee. 2000. *Standard for Digital Terrestrial Ecosystem Mapping (TEM) Data Capture in British Columbia. Version 3*. Terrestrial Ecosystems Task Force, Ecosystems Working Group. Victoria, BC.

Resources Inventory Committee. 2004. *Standard for Digital Terrestrial Ecosystem Mapping (TEM) Data Capture in British Columbia. Version 3, Errata No. 1.0*. Min. Agriculture and Lands, Resource Information Branch. Victoria, BC.

Appendix 1: Statistics – All Calculations and Data Sets

The following is only one example of the Internal QA datasets. All of the datasets have not been printed out due to the large size of these files. Please refer to the rest of these datasets in the file found on the accompanying DVD as "PEM_4316_val" & "PEM_4316_iqa"

Appendix 2: Scoring Matrices

The following are the scoring matrices for the Revelstoke PEM project. These are used during the scoring process of the Quality Assessment or Accuracy Assessment. If the PEM label correctly matches the ground label, a full point (1) is given. If the PEM label is not the same as the ground label, this matrix helps to identify which site series are Acceptable Adjacent ecosystem units which are then given half scores.

ICHmw2

	01	02	03	04	06	07	08	09	10	AV	RT	WG	WS	US	LA	RI	IS	ES	GL	RZ	UR
01	1		1/2	1/2																	
02		1	1/2								1/2										
03	1/2	1/2	1																		
04	1/2			1	1/2	1/2	1/2														
06				1/2	1	1/2	1/2														
07				1/2	1/2	1	1/2	1/2													
08				1/2	1/2	1/2	1	1/2					1/2				1/2				
09						1/2	1/2	1	1/2												
10								1/2	1				1/2								
AV										1	1/2		1/2	1/2				1/2	1/2		
RT		1/2								1/2	1							1/2			
WG												1	1/2		1/2						
WS						1/2		1/2	1/2	1/2			1	1/2			1/2				
US										1/2			1/2	1							
LA												1/2			1						
RI																1	1/2				
IS						1/2							1/2			1/2	1				
ES										1/2	1/2							1		1/2	1/2
GL										1/2									1		
RZ																		1/2		1	1
UR																		1/2		1	1

ICHwk1

	01	02	03	04	05	08	09	10	AV	RT	WG	WS	US	LA	RI	IS	ES	GL	RZ	UR
01	1		1/2	1/2																
02		1	1/2							1/2										
03	1/2	1/2	1																	
04	1/2			1	1/2	1/2														
05				1/2	1	1/2														
08				1/2	1/2	1	1/2					1/2				1/2				
09						1/2	1	1/2												
10							1/2	1				1/2								
AV									1	1/2		1/2	1/2				1/2	1/2		
RT		1/2							1/2	1							1/2			
WG											1	1/2		1/2						
WS						1/2		1/2	1/2		1/2	1	1/2			1/2				
US									1/2			1/2	1							
LA											1/2			1						
RI															1	1/2				
IS						1/2						1/2			1/2	1				
ES									1/2	1/2							1		1/2	1/2
GL									1/2									1		
RZ																	1/2		1	1
UR																	1/2		1	1

ICHvk1

	01	02	03	04	07	08	09	10	AV	RT	WG	WS	US	LA	RI	IS	ES	GL	RZ	UR
01	1		1/2	1/2	1/2															
02		1	1/2							1/2										
03	1/2	1/2	1	1/2																
04	1/2		1/2	1																
07	1/2				1	1/2														
08					1/2	1	1/2	1/2				1/2				1/2				
09						1/2	1	1/2				1/2								
10						1/2	1/2	1				1/2	1/2							
AV									1	1/2		1/2	1/2				1/2	1/2		
RT		1/2							1/2	1							1/2			
WG							1/2				1	1/2		1/2						
WS						1/2	1/2	1/2	1/2		1/2	1	1/2			1/2				
US									1/2			1/2	1							
LA											1/2			1						
RI															1	1/2				
IS						1/2						1/2		1/2		1				
ES									1/2	1/2							1		1/2	1/2
GL									1/2									1		
RZ																	1/2		1	1
UR																	1/2		1	1

ESSFvc — * At high elevations, the 03 becomes the zonal unit. The boundary of this occurrence is imprecise so the 01 is considered equal and the 06 and 08 are now given a 1/2 credit.

	01	02	03	05	06	08	09	KR	HM	AV	RT	WG	WS	US	LA	RI	IS	ES	GL	RZ	UR
01	1		1/2 / 1*	1	1/2																
02		1	1/2					1/2			1/2										
03	1/2 / 1*	1/2	1	1/2	1/2*	1/2*															
05	1		1/2	1	1/2																
06	1/2		1/2*	1/2	1	1/2	1/2														
09					1/2	1/2	1		1/2	1/2											
08			1/2*		1/2	1	1/2						1/2				1/2				
KR		1/2						1	1/2	1/2											
HM						1/2		1/2	1	1/2											
AV						1/2	1/2	1/2	1/2	1	1/2		1/2	1/2				1/2	1/2		
RT		1/2								1/2	1							1/2			
WG										1/2		1	1/2		1/2						
WS							1/2			1/2		1/2	1	1/2			1/2				
US										1/2			1/2	1							
LA												1/2			1						
RI																1	1/2				
IS						1/2							1/2		1/2		1				
ES										1/2	1/2							1		1/2	1/2
GL										1/2									1		
RZ																		1/2		1	1
UR																		1/2		1	1

ESSFwc1

	01	02	03	07	06	09	08	KR	HM	AV	RT	WG	WS	US	LA	RI	IS	ES	GL	RZ	UR
01	1		1/2	1/2	1/2																
02		1	1/2					1/2			1/2										
03	1/2	1/2	1																		
07	1/2			1	1	1/2	1/2														
06	1/2			1	1	1/2	1/2														
09				1/2	1/2	1	1/2		1/2	1/2											
08				1/2	1/2	1/2	1						1/2				1/2				
KR		1/2						1	1/2	1/2											
HM						1/2		1/2	1	1/2		1/2									
AV						1/2		1/2	1/2	1	1/2		1/2	1/2				1/2	1/2		
RT		1/2								1/2	1							1/2			
WG									1/2			1	1/2		1/2						
WS						1/2				1/2		1/2	1	1/2			1/2				
US										1/2			1/2	1							
LA												1/2			1						
RI																1	1/2				
IS						1/2							1/2			1/2	1				
ES								1/2	1/2									1		1/2	1/2
GL								1/2											1		
RZ																		1/2		1	1
UR																		1/2		1	1

ESSFwc2 — * At high elevations, the 03 becomes the zonal unit. The boundary of this occurrence is imprecise so the 01 is considered equal and the 06 and 08 are now given a 1/2 credit.

	01	02	03	06	07	08	09	KR	HM	AV	RT	WG	WS	US	LA	RI	IS	ES	GL	RZ	UR
01	1		1/2 1*	1/2	1/2																
02		1	1/2					1/2			1/2										
03	1/2 1*	1/2	1		1/2*	1/2*															
06	1/2			1	1	1/2	1/2														
07	1/2		1/2*	1	1	1/2	1/2														
08			1/2*	1/2	1/2	1	1/2		1/2	1/2											
09				1/2	1/2	1/2	1						1/2				1/2				
KR		1/2						1	1/2	1/2											
HM						1/2		1/2	1	1/2		1/2									
AV						1/2		1/2	1/2	1	1/2		1/2	1/2				1/2	1/2		
RT		1/2								1/2	1							1/2			
WG									1/2			1	1/2		1/2						
WS						1/2				1/2		1/2	1	1/2			1/2				
US										1/2			1/2	1							
LA												1/2			1						
RI																1	1/2				
IS						1/2							1/2			1/2	1				
ES								1/2	1/2									1		1/2	1/2
GL								1/2											1		
RZ																		1/2		1	1
UR																		1/2		1	1

ESSFwc4	* At high elevations, the 03 becomes the zonal unit. The boundary of this occurrence is imprecise																			
	so the 01 is considered equal and the 06 and 08 are now given a 1/2 credit.																			
	01	02	03	05	06	08	07	KR	HM	AV	RT	WG	WS	US	LA	RI	IS	ES	GL	RZ	UR
01	1		1/2 1*	1/2	1/2																
02		1	1/2					1/2			1/2										
03	1/2 1*	1/2	1		1/2*	1/2*															
05	1/2			1	1	1/2	1/2														
06	1/2		1/2*	1	1	1/2	1/2														
08			1/2*	1/2	1/2	1	1/2		1/2	1/2											
07				1/2	1/2	1/2	1						1/2				1/2				
KR		1/2						1	1/2	1/2											
HM						1/2		1/2	1	1/2		1/2									
AV						1/2		1/2	1/2	1	1/2		1/2	1/2				1/2	1/2		
RT		1/2								1/2	1							1/2			
WG									1/2			1	1/2		1/2						
WS						1/2			1/2			1/2	1	1/2			1/2				
US									1/2				1/2	1							
LA												1/2			1						
RI																1	1/2				
IS						1/2							1/2			1/2	1				
ES									1/2	1/2								1		1/2	1/2
GL									1/2										1		
RZ																		1/2		1	1
UR																		1/2		1	1

ESSFwcp, wcw, vvp, vcp																	
	01	02	04	06	HE	AG	AW	KR	HM	AV	RT	LA	RI	IS	ES	GL	RZ	UR
01	1		1/2	1/2														
02		1	1/2					1/2			1/2							
04	1/2	1/2	1															
06	1/2			1	1/2	1/2	1/2		1/2	1/2					1/2			
HE				1/2	1	1/2		1/2	1/2		1/2							
AG				1/2	1/2	1												
AW				1/2			1		1/2				1/2					
KR		1/2			1/2			1	1/2	1/2	1/2							
HM				1/2	1/2		1/2	1/2	1	1/2								
AV				1/2				1/2	1/2	1	1/2				1/2	1/2		
RT		1/2		1/2				1/2		1/2	1				1/2			
LA					1/2							1						
RI													1	1/2				
IS			1/2										1/2	1				
ES										1/2	1/2				1		1/2	1/2
GL										1/2						1		
RZ															1/2		1	1
UR															1/2		1	1

Appendix 3: Map Legend

The following is the legend of the Site Series that were mapped in this PEM project. The legend shows the colors that were used on the PEM maps to represent these site series. For the non-forested units, a hatched pattern within the equivalent color scheme is used to distinguish these from the forested ecosystem units.

Those ecosystem units what were lumped for reasons explained earlier in this report, are shown in smaller font and behind a forward slash "/". The primary ecosystem unit number is used to represent the lumped units as well. This Map Legend provides a quick visual of which map labels have lumped units within them. This is intended to prevent User's misunderstandings about the mapped ecosystem units, without having to read the report. The Map Legend is also included in the template for the printed hardcopies of the PEM maps.

This file is also found on the accompanying DVD as "Pem_4316_mleg"

Table 11 -Revelstoke PEM – Map Entities Legend

– All Site Series Mapped in each BEC Subzone

	Standardized Map Legend	ICHmw2	ICHwk1	ICHvk1	ESSFvc	ESSFwc1	ESSFwc2	ESSFwc4	ESSFwcp	ESSFwcw	ESSFvcp	ESSFvvp	ATun	ATunp	ESSFvv
	ridges	02	02	02	02	02	02	02	02	02	02	02	02	02	02
	crests	03	03	03	03	03 /04	03	03	04	04	04	04	04	04	04
	dry														
	Circum-mesic			04											
Solid Color for Forested Ecosystem Units	zonal	01 /01MS 01YC	01	01 /05	01 /04	01 /05	01 /04, 05	01 /04	01 /05	01 /05	01 /05	01 /05	01 /05	01 /05	01 /05
	Circum-mesic				05										
	fresh	04 /05	04 /06												
	toes	06		07 /06		07	06	05							
	stream	07	05 /07		06 /07	06	07	06	06*	06*	06*	06*	06*	06*	06*
	fluvial	08	08		08*	09*	08*	08*							
	Horse-tail	09	09	08	09	08 /10	09 /10	07							
	Swamp forest	10	10	09											
	Bog wood-land														
	Bog forest			10											
	Other														

* These are now the meadow forest ecosystem units near or within the parkland boundaries.

Cross-hatched Pattern for Non-Forested Units

Standardized Map Legend	ICHmw2	ICHwk1	ICHvk1	ESSFvc	ESSFwc1	ESSFwc2	ESSFwc4	ESSFwcp	ESSFwcw	ESSFvcp	ESSFvvp	AT	ATun	ESSFvv
								AG /94	AG /94	AG /94	AG /94	AG /94	AG /94	AG /94
	US	US						HE /82, 83, 92	HE /82, 83, 92	HE /82, 83, 92	HE /82, 83, 92	HE /82, 83, 92	HE /82, 83, 92	HE /82, 83, 92
				KR /82	KR	KR	KR	KR /03	KR /03	KR /03	KR /03	KR /03	KR /03	KR /03
				HM /92	HM	HM /92	HM /92	HM /93, 95	HM /93, 95	HM /93, 95	HM /93, 95	HM /93, 95	HM /93, 95	HM /93, 95
	WG	WG	WG	WG	WG	WG	WG	AW /96	AW /96	AW /96	AW /96	AW /96	AW /96	AW /96
	WS	WS	WS	WS	WS	WS	WS							
	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA	LA
	RI	RI	RI	RI	RI	RI	RI	RI	RI	RI	RI	RI	RI	RI
	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS
	AV	AV /75, 76	AV /74, 75, 76, 77, 78	AV	AV /62	AV /74, 75, 76, 77, 78, 79	AV /75, 76	AV /76, 77	AV /76, 77	AV /76, 77	AV /76, 77	AV /76, 77	AV /76, 77	AV /76, 77
	RT /72, 73, 74, 75, 76	RT /72, 73, 74	RT /72, 73	RT /72, 73	RT /72	RT /72, 73	RT /72, 73, 74	RT /72, 73, 74, 75	RT /72, 73, 74, 75	RT /72, 73, 74, 75	RT /72, 73, 74, 75	RT /72, 73, 74, 75	RT /72, 73, 74, 75	RT /72, 73, 74, 75
	GL	GL	GL	GL	GL	GL	GL	GL	GL	GL	GL	GL	GL	GL
	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES
	RZ	RZ	RZ	RZ	RZ	RZ	RZ	RZ	RZ	RZ	RZ	RZ	RZ	RZ
	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR	UR

Appendix 4: PEM Entities Legend

The following is a description of the site series mapped in this PEM project. The revised BEC classifications for the Revelstoke TSA were created by Dennis Lloyd et. al. 2004-05 (see Appendix 9). This file is also found on the accompanying DVD as "Pem_4316_ent".

Table 12 - Revelstoke PEM Entities Legend – Forested Ecosystem Units

Map Legend	Site_S	SiteMC_S	SeralAssoc	Former BEC unit	Ecosystem Name	SMR[4]	Landscape Parameters that identify this unit
ICHmw2							
Ridges	02	Not Regis-tered		Kam 02	FdPl – Falsebox – Pinegrass	SX	**Ridge top forests** – these occur rocky ridge crests, very steep slopes (>80%) on south and west-facing slopes, and north hyper-steep (>100%) slopes; stand is unproductive, stunted and open; reindeer lichens and rock mosses are abundant; soil is very shallow and the bedrock is exposed.
Crests	03	Not reg'd		Kam 03	FdCw – Falsebox – Prince's pine	SM	**FgT, Crest and very steep forests** – occur on glaciofluvial flats, crests such as eskers and hill tops; shallow to deep soils, no exposed bedrock (or rare); also on steep south slopes 65 – 80% and north slopes 80 – 100%.
Zonal	01	Not reg'd	/01 MS, 01 YC	Kam 01 01YS	HwCw – Falsebox – Feathermoss $FdHwCw – Falsebox – Twinflower $FdHwCw – Nudum	M	**Zonal forests** – occur on flat to moderately steep slopes on all aspects
Fresh	04 /05	Not reg'd		Kam 04	CwHw – Oakfern CwHw – Lady fern – Oakfern	M - SHG	**High Fluvial Benches and Upper Toe of Slope forests** – occur on moist, high benches along major rivers that do not receive annual flooding; also on the uphill sides of toes of slopes that are slightly moister than mesic. Note that this unit is zonal in the ICHwk1 so will appear more prominently near this boundary. The 05 unit is lumped here since it has a very narrow range of existence occurring in small draws typically nested within the 04 unit.
Toes	06	Not reg'd		Kam 05	CwHw – Devil's club – Lady fern	SHG	**Lower Toe of Slope forests** – occur on slopes <10% with richer soils and slight moisture seepages; commonly in draws, adjacent to the stream-edge units, and along lakeshores.
Streams	07	Not reg'd		Kam 05	Act – Devil's club	SHG - HG	**Stream-edge forests** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off.

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[4] Soil Moisture Classes are: SX = Subxeric, SM = Submesic, M = Mesic, SHG = Subhygric, HG = Hygric, SHD = Subhydric

Fluvial	08	Not reg'd		Kam 05	Act – Thimbleberry - Sarsaparilla	HG - SHD	**Fluvial forests** – occur on floodplain benches (<10% slopes) next to large streams or rivers; mainly deciduous stands of Cottonwood, Spruce and Cedars; these benches are typically flooded during the spring.
Horsetail Flats	09	Not reg'd		Kam 06	CwHw – Horsetail	HG - SHD	**Horsetail flats** – occur on flat benches next to wetlands, lakes and streams where water is moving very slowly through clayey soils; these are generally productive stands due to the soil moisture and nutrient quality; the abundance of Horsetail and Lady Fern distinguish this unit.
Swamp Forest	10	Not reg'd		Kam 07	CwHw – Skunk Cabbage	HD	**Swamp forests** – occur on flat slopes at the toes of colluvial slopes or along wetland edges where the soil is clayey; the soils are saturated most of the year – open pockets of muck intermingle with the hummocks of vegetation; Skunk Cabbage is a prominent species indicating this unit.
ICHwk1							
Ridges	02	Not reg'd		Kam 02	HwCw – Azalea – Feathermoss	SX	**Ridge top forests** – these occur rocky ridge crests, very steep slopes (>80%) on south and west-facing slopes, and north hyper-steep (>100%) slopes; stand is unproductive, stunted and open; the herb layer is very sparse; reindeer lichens and rock mosses are abundant; soil is very shallow and the bedrock is exposed.
Crests	03	Not reg'd		Kam 03	HwCw – Falsebox – Feathermoss	SM	**FgT, Crest and very steep forests** – occur on glaciofluvial flats, crests such as eskers and hill tops; shallow to deep soils, no exposed bedrock (or rare); also on steep south slopes 65 – 80% and north slopes 80 – 100%.
Zonal	01	Not reg'd		Kam 01	CwHw – Oak fern	M	**Zonal forests** – occur on flat to moderately steep slopes on all aspects
Fresh	04 /06	Not reg'd		Kam 01	CwHw – Lady fern – Oak fern BlSxw – Thimbleberry – Oak fern	M - SHG	**High Fluvial Benches and Upper Toe of Slope forests** – occur on moist, high benches along major rivers that do not receive annual flooding; also on the uphill sides of toes of slopes that are slightly moister than mesic. The 06 unit is lumped here since it occupies the same topographical positions as the 04 unit but in cold-air drainages which are uncommon and not separated out in this map.
Streams	05 /07	Not reg'd		Kam 05	CwHw – Devil's club – Lady fern Sxw – Devil's club – Lady fern	SHG - HG	**Stream-edge and Lower Toe of Slope forests** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off; these are also the lower toe of slope forests that receive consistent soil moisture rich in nutrients. The 07 unit is lumped here since it is the toe of slope and stream-edge unit in cold-air drainages which are uncommon and not separated out in this map.
Fluvial	08	Not reg'd		Kam 05	Act – Dogwood – Thimbleberry	HG - SHD	**Fluvial forests** – occur on floodplain benches (<10% slopes) next to large streams or rivers; mainly deciduous stands of Cottonwood, Spruce and Cedars; these benches are typically flooded during the spring.

Horsetail Flats	09	Not reg'd		Kam 06	CwHw – Horsetail	HG - SHD	**Horsetail flats** – occur on flat benches next to wetlands, lakes and streams where water is moving very slowly through clayey soils; these are generally productive stands due to the soil moisture and nutrient quality; the abundance of Horsetail and Lady Fern distinguish this unit.
Swamp Forest	10	Not reg'd		Kam 07	CwHw – Skunk cabbage	HD	**Swamp forests** – occur on flat slopes at the toes of colluvial slopes or along wetland edges where the soil is clayey; the soils are saturated most of the year – open pockets of muck intermingle with the hummocks of vegetation; Skunk Cabbage is a prominent species indicating this unit.
ICHvk1							
Ridges	02	Not reg'd		Kam 02	HwCw –Feathermoss	SX	**Ridge top forests** – these occur rocky ridge crests and hyper-steep (>100%) slopes of all aspects; stand is unproductive, stunted and open; the herb layer is very sparse; reindeer lichens and rock mosses are abundant; soil is very shallow and the bedrock is exposed.
Crests	03	Not reg'd		Kam 03	HwCw – Azalea – Feathermoss	SM	**Crest and FgT forests** – occur on crests and hill tops, and glaciofluvial flats; shallow to deep soils, no exposed bedrock (or rare)
Circum-mesic	04	Not reg'd		Kam 04	CwHw – Oak fern	SM - M	**Steep Slope Forests** – occur on steep (>80%) slopes of all aspects; due to higher rainfall in this subzone, these slopes are slightly moister than crest forests.
Zonal	01 /05	Not reg'd		Kam 01	CwHw – Devil's club – Lady fern CwHw – Spiny wood fern – Oak fern	M	**Zonal forests** – occur on flat to moderately steep slopes on all aspects. The 05 unit is lumped here since it is the very narrow band at the transition between the 01 and 04. It is typically in the slope class with zonal, but can also occur in the slope class with 04.
Toes	07 /06	Not reg'd		Kam 01	Sxw – Devil's club Sxw – Thimbleberry – Oak fern	SHG	**Lower Toe of Slope and Stream-edge forests** – occur on lower toe of slope forests that receive consistent soil moisture rich in nutrients; also occur next to streams (not rivers) on flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off. The 07 is listed as the primary unit since it is very common and dominates the valley bottoms in this subzone. The 06 is lumped here since it is the toe of slope unit at higher elevations near the ESSF subzone (in fact, it is the zonal in ESSF).
Horsetail Flats	08	Not reg'd		Kam 05	Sxw – Dogwood – Horsetail	HG - SHD	**Horsetail flats** – occur on flat benches next to wetlands, lakes and streams where water is moving very slowly through clayey soils; these are generally productive stands due to the soil moisture and nutrient quality; the abundance of Horsetail and Lady Fern distinguish this unit.
Swamp Forest	09	Not reg'd		Kam 06	CwHw – Skunk cabbage	HD	**Swamp forests** – occur on flat slopes at the toes of colluvial slopes or along wetland edges where the soil is clayey; the soils are saturated most of the year – open pockets of muck intermingle with the hummocks of vegetation; Skunk Cabbage is a prominent species indicating this unit.

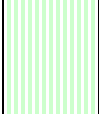|							
Bog Forest	10	Not reg'd		Kam 06	Sxw - Bulrush	HD	**Bog Forest** – occur on wetland benches and floodplains of very slow moving water; peat lands of sphagnum mosses or sedges develop over high water tables; tree stands are stunted and sparse.
ESSFvc							
Ridges	02	Not reg'd		Kam 02	BlHm – Black huckleberry – Clad lichen	SX	**Ridge top forests** – these occur rocky ridge crests and hyper-steep (>80%) slopes of all aspects; stand is unproductive, stunted and open; the herb layer is very sparse; reindeer lichens and rock mosses are abundant; soil is very shallow and the bedrock is exposed.
Crests	03	Not reg'd		Kam 03	BlHm – Black huckleberry – Heron's-bill moss	SM	**Crest and very steep forests** – occur on crests and hill tops, and on steep slopes (65 – 80%) on all aspects; shallow to deep soils, no exposed bedrock (or rare). The 03 unit becomes zonal at higher elevations (around 1680 m) in this subzone.
Zonal	01 /04	Not reg'd		Kam 01	BlHm – Rhododendron – Oak fern BlHm – Rhododendron – Heron's-bill moss	M	**Zonal forests** – occur on flat to moderately steep slopes (<65%) on all aspects. The 04 is lumped here since it is the slightly drier version of zonal and occurs throughout the subzone, particularly on south slopes, where the ICHmw2 boundary is nearby, and near the parkland boundary; the rhododendron is slightly less than the 01 and oak fern drops out. We were unable to identify a topographic or soil pattern that predicted this unit.
Circum-mesic	05	Not reg'd		Kam 01	BlHm – Valerian – Oak fern	M - SHG	**Zonal forests at the boundary of ICHwk1** – occur on flat to moderately steep slopes (<65%) on all aspects. This unit is dominant at the boundary of ICHwk1, and then merges sporadically with 01 at 1500 m elevation.
Streams	06 /07	Not reg'd		Kam 04	BlHm – Lady fern – Spiny wood fern BlHm – Devil's club – Lady fern	SHG - HG	**Stream-edge and Toe of Slope forests** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off; these are also the toe of slope forests that receive consistent soil moisture rich in nutrients. The 07 unit is lumped here since it is the toe of slope and stream-edge unit at the ICHwk1 boundary and quickly disappears.
Fluvial	08*	Not reg'd		Kam 05	BlHm – Arrow-leaved groundsel – Valerian	HG - SHD	**Meadow Forests** – occur at higher elevations in this subzone where the forests are interspersed with pockets of moist herbaceous meadows (sometimes called parkland forests); occur on flat to moderately steep slopes of all aspects.
Horsetail Flats	09	Not reg'd		Kam 05	BlHm – Horsetail	HG - SHD	**Horsetail flats** – occur on flat benches next to streams where water is moving very slowly; or on wetland benches and floodplains of very slow moving water; peat lands of sphagnum mosses or sedges develop over high water tables; tree stands are stunted and sparse; the abundance of Horsetail distinguishes this unit.
ESSFwc1							

Ridges	02	Not reg'd		Nel 02	PlBl – Rock-moss – Clad lichens	SX	**Ridge top forests** – these occur rocky ridge crests and hyper-steep (>80%) slopes of all aspects; stand is unproductive, stunted and open; the herb layer is very sparse; reindeer lichens and rock mosses are abundant; soil is very shallow and the bedrock is exposed.
Crests	03 /04	Not reg'd		Nel 02	PlBl – Huckleberry – Haircap moss Bl – Rhododendron – Five-leaved bramble	SM	**Crest and very steep forests** – occur on crests and hill tops, and on steep slopes (65 – 80%) on all aspects; shallow to deep soils, no exposed bedrock (or rare). The 04 is lumped here since it is the crest and steep slope unit at higher elevations (in fact, is the 03 unit in ESSFwc4).
Zonal	01 /05	Not reg'd		Nel 01	Bl – Rhododendron – Oak fern Bl – Oak fern – Foam flower	M	**Zonal forests** – occur on flat to moderately steep slopes (<65%) on all aspects. The 05 is lumped here since it is the zonal unit at the boundary of ICHwk1, and then merges sporadically with 01 in the lower half of this subzone. Because this subzone is so narrow, it was not possible to identify the consistent elevation at which the 01 and 05 separate.
Toes	07	Not reg'd		Nel 03	B. – Devil's club – Lady fern	SHG	**Stream-edge Toe of Slope forests at lower elevations** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off; these are also the toe of slope forests that receive consistent soil moisture rich in nutrients.
Streams	06	Not reg'd		Nel 03	Bl – Lady fern – Spiny wood fern	SHG - HG	**Stream-edge Toe of Slope forests at higher elevations** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off; these are also the toe of slope forests that receive consistent soil moisture rich in nutrients.
Fluvial	09*	Not reg'd		Nel 03	Bl – Mountain hairgrass – Leatherleaf saxifrage	HG - SHD	**Meadow Forests** – occur at higher elevations in this subzone where the forests are interspersed with pockets of moist herbaceous meadows (sometimes called parkland forests); occur on flat to moderately steep slopes of all aspects.
Horsetail Flats	08 /10	Not reg'd		Nel 04 05	Bl – Horsetail Bl - Bluejoint	HG - SHD	**Horsetail flats** – occur on flat benches next to streams where water is moving very slowly; or on wetland benches and floodplains of very slow moving water; peat lands of sphagnum mosses or sedges develop over high water tables; tree stands are stunted and sparse; the abundance of Horsetail distinguishes this unit. The 10 unit is lumped here since it intersperses with the 08 unit under the same topographic and forest cover features.

ESSFwc2

Ridges	02	Not reg'd		Kam 02	Bl – Huckleberry – Heron's-bill moss	SX	**Ridge top forests** – these occur rocky ridge crests and hyper-steep (>80%) slopes of all aspects; stand is unproductive, stunted and open; the herb layer is very sparse; reindeer lichens and rock mosses are abundant; soil is very shallow and the bedrock is exposed.
Crests	03	Not reg'd		Kam 04	Bl – Rhododendron Heron's-bill moss	SM	**Crest and very steep forests** – occur on crests and hill tops, and on steep slopes (65 – 80%) on all aspects; shallow to deep soils, no exposed bedrock (or rare).

Zonal	01 /04, 05	Not reg'd		Kam 01	Bl – Azalea – Oak fern Bl – Valerian – Oak fern Bl – Devil's club – Lady fern	M	**Zonal forests** – occur on flat to moderately steep slopes (<65%) on all aspects. The 04 is lumped here since it is the zonal unit at the boundary of ICHwk1, and the 05 is the zonal at the boundary of the ICHvk1, both of which merge sporadically with 01 in the lower half of this subzone.
Toes	06	Not reg'd		Kam 06	Bl – Lady fern – Oak fern	SHG	**Stream-edge Toe of Slope forests at lower elevations** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off; these are also the toe of slope forests that receive consistent soil moisture rich in nutrients.
Streams	07	Not reg'd		Kam 07	Bl – Valerian – Arrow-leaved groundsel	SHG – HG	**Stream-edge Toe of Slope forests at higher elevations** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off; these are also the toe of slope forests that receive consistent soil moisture rich in nutrients.
Fluvial	08*	Not reg'd		Kam 09	Bl – Dwarf blueberry – Peat-moss	HG – SHD	**Meadow Forests** – occur at higher elevations in this subzone where the forests are interspersed with pockets of moist herbaceous meadows (sometimes called parkland forests); occur on flat to moderately steep slopes of all aspects.
Horsetail Flats	09 /10	Not reg'd		Kam 08 10	Bl – Horsetail – Peat-moss Bl – Bluejoint	HG – SHD	**Horsetail flats** – occur on flat benches next to streams where water is moving very slowly; or on wetland benches and floodplains of very slow moving water; peat lands of sphagnum mosses or sedges develop over high water tables; tree stands are stunted and sparse; the abundance of Horsetail distinguishes this unit. The 10 unit is lumped here since it intersperses with the 09 unit under the same topographic and forest cover features.
ESSFwc4							
Ridges	02	Not reg'd		Nel 02	Bl – Huckleberry – Heron's-bill moss	SX	**Ridge top forests** – these occur rocky ridge crests and hyper-steep (>80%) slopes of all aspects; stand is unproductive, stunted and open; the herb layer is very sparse; reindeer lichens and rock mosses are abundant; soil is very shallow and the bedrock is exposed.
Crests	03	Not reg'd		Nel 03	Bl – Rhododendron Heron's-bill moss	SM	**Crest and very steep forests** – occur on crests and hill tops, and on steep slopes (65 – 80%) on all aspects; shallow to deep soils, no exposed bedrock (or rare). The 03 unit becomes zonal at higher elevations (around 1650 m) in this subzone.
Zonal	01 /04	Not reg'd		Nel 04 01	Bl – Rhododendron – Oak fern Bl – Valerian – Oak fern	M	**Zonal forests** – occur on flat to moderately steep slopes (<65%) on all aspects. The 04 is lumped here since it is the zonal unit at the boundary of ICHwk1, which then merges sporadically with 01 in the lower half of this subzone.
Toes	05	Not reg'd		Nel 05	Bl – Lady fern – Oak fern	SHG	**Stream-edge Toe of Slope forests at lower elevations** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off; these are also the toe of slope forests that receive consistent soil moisture rich in nutrients.

Streams	06	Not reg'd		Nel 05	Bl – Valerian – Arrow-leaved groundsel	SHG - HG	**Stream-edge Toe of Slope forests at higher elevations** – occur next to streams (not rivers); these are flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off; these are also the toe of slope forests that receive consistent soil moisture rich in nutrients.
Fluvial	08*	Not reg'd		Nel 06	Bl – Valerian – Subalpine daisy	HG - SHD	**Meadow Forests** – occur at higher elevations in this subzone where the forests are interspersed with pockets of moist herbaceous meadows (sometimes called parkland forests); occur on flat to moderately steep slopes of all aspects.
Horsetail Flats	07	Not reg'd		Nel 06	Bl – Horsetail	HG - SHD	**Horsetail flats** – occur on flat benches next to streams where water is moving very slowly; or on wetland benches and floodplains of very slow moving water; peat lands of sphagnum mosses or sedges develop over high water tables; tree stands are stunted and sparse; the abundance of Horsetail distinguishes this unit.
ESSFwcp, wcw, vcp, vvp, & ESSFvv, & ATun, unp (Note that the following ecosystem units are based on the ESSFwcw revised BEC classification)							
Ridges	02	Not reg'd		n/a	Bl – Rhododendron – White mountain-heather	SX	**Ridge top forests** – these occur rocky ridge crests and hyper-steep (>80%) slopes of all aspects; stand is unproductive, stunted and open; the herb layer is very sparse; reindeer lichens and rock mosses are abundant; soil is very shallow and the bedrock is exposed.
Crests	04	Not reg'd		n/a	Bl – Rhododendron – Heron's-bill moss	SM	**Crest and very steep forests** – occur on crests and hill tops, and on steep slopes (65 – 80%) on all aspects; shallow to deep soils, no exposed bedrock (or rare).
Zonal	01 /05	Not reg'd		n/a	Bl – Huckleberry – Valerian Bl – Rhododendron – Valerian	M	**Zonal forests** – occur on flat to moderately steep slopes (<65%) on all aspects. The 05 is lumped here since it is the zonal unit at the boundary of lower ESSF's, which then merges sporadically with 01 in the lower half of this subzone.
Streams	06*	Not reg'd		n/a	Bl – Valerian – Arrow-leaved groundsel	SHG - HG	**Stream-edge, Toe of Slope and Meadow forests** –occurs in all three topographical and forest cover features. ▪ Stream edge forests – occur next to streams on flat benches that receive continual moisture from the stream and are commonly flooded during the spring run-off. ▪ Toe of slope forests that receive consistent soil moisture rich in nutrients. ▪ Meadow forests - forests are interspersed with pockets of moist herbaceous meadows (sometimes called parkland forests) that occur on flat to moderately steep slopes of all aspects.

Table 13 - Revelstoke PEM Entities Legend – Non-Forested Ecosystem Units

Map Legend	Site_S	SiteMC_S	SeralAssoc	Ecosystem Name	SMR	Landscape Parameters that identify this unit
	n/a	AG		Alpine Grasslands	SM – M	Alpine Grasslands dominated by grasses and dryland sedges
	n/a	US		Upland Shrub	M	Upland shrub patches due to disturbances such as seepages, soil movement or harvesting. These are drier than the shrub wetland shrub units (WS) described below.
	n/a	HE		Heathlands	SM – M	Alpine heathlands dominated by mountain heathers; krummholtz and forbs are minor components.
	n/a	KR		Krummholtz	SM – SHG	Krummholtz trees generally < 2 m tall
	n/a	HM		Herbaceous Meadows	SHG - SHD	Alpine moist meadows dominated by herbs; typically toes of slopes and draws.
	n/a	WG		Gramminoid Wetlands	HG - HD	Gramminoid dominated wetlands – water grasses and tall sedges.
	n/a	WS		Shrub Wetlands	HG - HD	Shrub dominated wetlands - Willows and Alders
	n/a	LA, RI		Lakes and Rivers		Lakes and Rivers
	n/a	IS		Island	SX - SHG	Islands dominated by pioneer vegetation or riparian willows.
	n/a	AV		Avalanche	SX - SHG	Avalanche tracks
	n/a	RT		Rock and/or Talus	X	
	n/a	GL		Glacier		
	n/a	ES		Exposed Soil		
	n/a	RZ		Roads		For polygons that were typed as roads
	n/a	UR		Urban		Urban areas, clearings, road allowances, well sites

Appendix 5: PEM Attribute Legend

The following is the legend of all the codes used in the PEM database. These codes are also used in the Knowledge Tables.

This file is also found on the accompanying DVD as "PEM_4316_dbleg"

Revelstoke PEM Database and Knowledge Table Code Legend			
March, 2006			
Category	**Value**	**Description**	**Notes:**
PERCENTAGE OF AREA ANALYSIS: (Qualifying Analysis - Applied to some features only)			
_P	1	5-20%	greater than or equal to 5% and less than 20% of the polygon area
_P	2	21- 50%	greater than 21% and less than 50% of the polygon area
_P	3	>50%	greater than 51% of the polygon area
STREAM DENSITY:			
W	0	No streams	No streams found in polygon (0 to 10 m/ha)
W	1	Low water	10 m/ha to 30 m/ha (low soil moisture influence)
W	2	Mod water	30 m/ha to 60 m/ha (moderate soil moisture influence)
W	3	High water	60 m/ha or greater (high soil moisture influence)
SLOPE:		Dry Interior:	
S	1	0 – 8%	
S	2	8 – 25%	(** aspect applies from this slope class on)
S	3	25 – 45%	
S	4	45 – 65%	
S	5	65 - 85%	
S	6	85 – 130%	
S	7	130 + %	
SF	f	Flat	slope class 1
SF	m	Moderate	slope classes 2 & 3
SF	s	steep	slope classes 4 & 5
SF	hs	Hyper-steep	slope classes 6 & 7
SFc	g	Gentle	slope classes 1 & 2
SF	vm	Very moderate	slope classes 3 & 4
SF	vs	Very steep	slope classes 5 & 6
ASPECT:			
As	0	No aspect	Aspect does not apply
As	1	Hot	91 to 235 degrees
As	2	Warm	236 to 290 degrees (actually 235.1 to 290)
As	3	Cool	291 to 90 degrees
ADJACENCY FEATURES: (50-m buffer around NP, NPBr, Rock, Alpine and OR polygons)			
Adj1	1	Adj to streams	buffers around NP and NPBr
Adj2	1	Adj to wetlands	buffers around NP and NPBr
Adj3	1	Adj to rock	buffers around Rock polygons
Adj4	1	Adj to alpine	buffers around Alpine polygons
Adj5	1	Adj to OR	buffers around Open Range polygons
Adj1+Adj2+Adj3+Adj4+Adj5 = 0			Not adjacent to any of these features
RIPARIAN BENCHES:			
Lakes (Calculated from perimeter of lakes)			
LB	1	present	0-5% slope adjacent to the lake, to a maximum distance of 100 m
LB_P	1	Low	between 5 and 20% of PEM polygon area
LB_P	2	Moderate	between 21 and 50% of PEM polygon area
LB_P	3	High	greater than 51% of the PEM polygon area
Wetlands (Calculated from perimeter of wetlands)			
WB	1	present	0-5% slope adjacent to the wetland, to a maximum distance of 100 m
WB_P	1	Low	between 5 and 20% of PEM polygon area
WB_P	2	Moderate	between 21 and 50% of PEM polygon area
WB_P	3	High	greater than 51% of the PEM polygon area

Stream Low Benches: (Calculated from double-line streams)			
SLB	1	present	0-5% slope adjacent to a double-line stream to a maximum distance of 100m
SLB_P	1	Low	between 5 and 20% of PEM polygon area
SLB_P	2	Moderate	between 21 and 50% of PEM polygon area
SLB_P	3	High	greater than 51% of the PEM polygon area
Stream High Benches: (Calculated from double-line streams)			
SHB	1	present	- 0-5% slope from the edge of the SLB to a max distance of 500 m; or - 0 - 5% slope adjacent to a small rise up from the river's edge (a slope of 6-20% within 50 m from the river edge) to a max distance of 500 m
SHB_P	1	Low	between 5 and 20% of PEM polygon area
SHB_P	2	Moderate	between 21 and 50% of PEM polygon area
SHB_P	3	High	greater than 51% of the PEM polygon area
Stream Terraces: (Calculated from double-line streams)			
ST	1	present	- is a 0-10% slope adjacent to a large rise up from the river's edge – a greater than 20% slope within a 400 m distance – to a max distance of 1000 m; or - a 0-10% slope adjacent to a small rise up from the edge of the SLB or SHB – a greater than 6% slope within a 400 m distance – to a max distance of 1000m.
ST_P	1	Low	between 5 and 20% of PEM polygon area
ST_P	2	Moderate	between 21 and 50% of PEM polygon area
ST_P	3	High	greater than 51% of the PEM polygon area
GULLY BOTTOMS and GULLY BUFFERS: (on single-line streams)			
G	1	present	This is a 20-m buffer on either side of the single-line stream, and search for slope of 30% + (allows for flat-bottom gully and eliminates gully mouths)
G_P	1	Low	between 5 and 20% of PEM polygon area
G_P	2	Moderate	between 21 and 50% of PEM polygon area
G_P	3	High	greater than 51% of the PEM polygon area
GB	1	present	This is a 40-m buffer up the 30%+ slopes starting from edge of the gully bottom polygon (G)
GB_P	1	Low	between 5 and 20% of PEM polygon area
GB_P	2	Moderate	between 21 and 50% of PEM polygon area
GB_P	3	High	greater than 51% of the PEM polygon area
HILL TOPS and HILL BUFFERS (upper slope positions)**:**			
HT	1	present	Hill top is the largest outside contour line less than 1200 m in length and not a depression
HT_P	1	Low	between 5 and 20% of PEM polygon area
HT_P	2	Moderate	between 21 and 50% of PEM polygon area
HT_P	3	High	greater than 51% of the PEM polygon area
HB	1	present	40-m buffer where slope is > or = 20%, starts from edge of HT
HB_P	1	Low	between 5 and 20% of PEM polygon area
HB_P	2	Moderate	between 21 and 50% of PEM polygon area
HB_P	3	High	greater than 51% of the PEM polygon area
RIDGE TOPS and RIDGE BUFFERS (defines upper slope positions)**:**			
RT	1	present	20-m buffer around the ridge break line where slopes are > or = 30%
RT_P	1	Low	between 5 and 20% of PEM polygon area
RT_P	2	Moderate	between 21 and 50% of PEM polygon area
RT_P	3	High	greater than 51% of the PEM polygon area
RTL	1	present	Little ridge tops between 10 and 30% slopes – for Interior BEC subzones
RTL_P	1	Low	between 5 and 20% of PEM polygon area
RTL_P	2	Moderate	between 21 and 50% of PEM polygon area
RTL_P	3	High	greater than 51% of the PEM polygon area
RB	1	present	40-m buffer from edge of RT if slopes are > or = 30%
RB_P	1	Low	between 5 and 20% of PEM polygon area

RB_P	2	Moderate	between 21 and 50% of PEM polygon area
RB_P	3	High	greater than 51% of the PEM polygon area
TOES OF SLOPES			
ToS	1	present	Interface of >40% slopes above and <25% slopes below, that are within 100 m of each other
ToS_P	1	Low	between 5 and 20% of PEM polygon area
ToS_P	2	Moderate	between 21 and 50% of PEM polygon area
ToS_P	3	High	greater than 51% of the PEM polygon area
ELEVATION			
E	1		ESSFvc below 1520 m
E	2		ESSFvc between 1520 and 1680 m
E	3		ESSFvc above 1680 m
E	4		ESSFwc2 below 1440 m
E	5		ESSFwc2 between 1440 and 1770 m
E	6		ESSFwc2 above 1770 m
E	7		ESSFwc4 below 1580 m
E	8		ESSFwc4 between 1580 and 1720 m
E	9		ESSFwc4above 1720 m
E	10		ESSFwcw below 1700 m
E	11		ESSFwcw above 1700 m
TRIM 2 LANDFORM FEATURES: (These are assumed to be within a FC forested polygon and influence differently than the NP code)			
L1_P	1,2, or 3	Rock polygon	TRIM HB25400000
L2	1,2, or 3	Esker	TRIM HB10200000 (follows m/ha correlation like the Water calculation)
L3	1,2, or 3	Cliff/scarp	TRIM HB05650000 (follows m/ha correlation like the Water calculation)
L4_P	1,2, or 3	Slide	TRIM HB27900000
L5	1,2, or 3	Beaver dam	TRIM GA08450110 (follows m/ha correlation like the Water calculation)
L6_P	1,2, or 3	Flooded area	TRIM GB11350110
L7_P	1,2, or 3	Spring	TRIM
L8_P	1,2, or 3	Moraine	TRIM HB18700000
L9_P	1,2, or 3	Skree	TRIM HB26150000
L10_P	1,2, or 3	Avalanche	TRIM AVA
L11_P	1,2, or 3	Glacier	TRIM GD12300000
L12_P	1,2, or 3	Snow/ice	TRIM
L13	1,2, or 3	Ridge	TRIM HB06650100 (follows m/ha correlation like the Water calculation)
L14_P	1,2, or 3	Islands	TRIM GE14850000
L15_P	1,2, or 3	Sand Bars	TRIM GE25850000
L16_P	1,2, or 3	Pit	TRIM AG21550000
L17	1,2, or 3	Rock Bluffs	TRIM HB25000100 (follows m/ha correlation like the Water calculation)
L18_P	1,2, or 3	Depressions	TRIM
L19	1,2, or 3	Cliff drop off	TRIM HB05650100 (follows m/ha correlation like the Water calculation)
L20	1,2, or 3	Cliff drop off indefinite	TRIM HB05650200 (follows m/ha correlation like the Water calculation)
SOLAR RADIATION RANGES:			
SR	1		Full South-facing, no obstructions – Intensive solar radiation
SR	2		Warm aspects – east or west – moderate solar radiation
SR	3		Full North-facing, no variations – Cool solar radiation
BEDROCK TYPE (dominant bedrock type is assigned to the PEM polygon)			

BR	1	Rich	limestone, marble, calcareous sedimentary rocks; limestone, slate, siltstone, argillite; dolomitic carbonate rocks
BR	2	Mod - rich	chert, siliceous argillite, siliciclastic rocks; volcanic, basalt; greenstone, greenschist metamorphic rocks; orthogneissic; paragneissic; undivided metamorphic
BR	3	Moderate	mudstone, siltstone, shale fine clastic sedimentary rocks; mudstone/laminite fine clastic sedimentary rocks; undivided sedimentary rocks
BR	4	Mod - poor	coarse clastic sedimentary rocks; conglomerate, coarse clastic sedimentary rocks; quartzite
BR	5	Poor	Igneous (Intrusive) – i.e. granodiorite, quartz diorite, granite, gabbro diorite, monzonite
BR	0	Undivided	Undivided – not useful – everything from volcanic, to sedimentary, to metamorphic, to intrusive
SATELLITE IMAGERY:			
SA	1	Water	
SA	2	Snow or Ice	Snow, ice or glaciers – not present in this PEM project
SA	3	Bare	Rock cliffs or talus slopes – undifferentiated; Exposed soil for various reasons: road way, landslide, river island, etc.
SA	4	Forest	Coniferous and/or Deciduous mixes
SA	5	Parkland Forest	Open coniferous forests with meadow pockets, at or within the parkland/alpine BEC subzones
SA	6	Krummholtz	Alpine krummholtz – few upright trees
SA	7	Decidous Shrub	Deciduous shrub patches with no or few upright trees
SA	8	Grasslands	Upland gramminoid sites – including alpine grasslands
SA	9	Heathlands	Alpine meadows dominated by heathers and junipers
SA	10	Herbaceous meadows	Alpine forb-dominated meadows – verdant green
FOREST COVER CHARACTERISTICS:			
Forest Cover Base Codes:			
NP	0	Forested	Forested stands
NP	1	icefield	
NP	2	alpine	
NP	3	rock	50-m buffer around these polygons for adjacency searches
NP	7	sand	
NP	9	clay bank	
NP	10	alpine forest	
NP	11	NPBr	50-m buffer around these polygons for adjacency searches
NP	12	NP	50-m buffer around these polygons for adjacency searches
NP	13	burn	
NP	15	lakes	Merge Forest Cover and TRIM lakes
NP	18	Gravel Bar	
NP	25	River	
NP	35	wetlands	Merge Forest Cover and TRIM wetlands/depressions (TRIM marsh polygons are displayed within the wetland complexes.)
NP	42	Clearing	
NP	50	Roads	
NP	54	Urban	
NP	60	hayfield	
NP	62	meadows	
NP	63	open range	50-m buffer around these polygons for adjacency searches

NP	64	salt water				
NP	70	NTA	No typing available			
NPD	A	Alpine		NF_DESC	NSR	Cutblock
NPD	AF	Alpine forest		NF_DESC	NCBr	Cutblock Brush
NPD	U	Urban				
NPD	SWAMP	Swamp				
NPD	NPBr	Brush				
NPD	NP	Non-productive				

Disturbance History:			**Height:** (HCTL_PR – these classes were re-programmed in the VRI database)		
ACT_B	1	Past burn	HC	1	height class 1 = 0 to 10.4m
ACT_L	1	Logged	HC	2	10.5 to 19.4 m
		Burns are also recorded in Comp1, 2 or 3 of the VRI database	HC	3	19.5 to 28.4 m
			HC	4	28.5 to 37.4 m
Species: (Species codes vary: PLI or PL; ACT or AC; E or EP)			HC	5	37.5 to 46.4 m
Sp		SP1, SP2, or SP3	HC	6	46.5 to 55.4 m
SpL		lead species - SP1 only	HC	7	55.5 to 64.4 m
SpS		Second - SP2 only	HC	8	64.5 +
SpP		Primary – 1st or 2nd species	H	vs	Very short – classes 0 - 1
Sp1_Per		% cover for each species	H	s	Short - height class 2
Sp_Pure	p	Pure >95%	H	t	Tall - height classes 4+
Crown Closure: (CRNCL_PR – these classes were re-programmed in the VRI database)			**Age:** (AGECL_PR – these classes were re-programmed in the VRI database)		
CRN	0	Crown class 0-5%	AGE	1	1 – 20 years
CRN	1	6-15%	AGE	2	21 – 40 years
CRN	2	16-25%	AGE	3	41 – 60 years
CRN	3	26-35%	AGE	4	61 – 80 years
CRN	4	36-45%	AGE	5	81 – 100 years
CRN	5	46 – 55%	AGE	6	101 – 120 years
CRN	6	56-65%	AGE	7	121 – 140 years
CRN	7	66-75%	AGE	8	141 – 250 years
CRN	8	76-85%	AGE	9	250 + years
CRN	9	86-95%	A	m	Mature - age classes 3 to 9 (this is a younger age than other PEM projects due to the lesser fire history of the area; the younger mature age is a result of excessive water saturation in the soils)
CRN	10	96-100%			
CC	v	Very open – classes 0 – 1			
CC	o	Open – classes 2 – 3			
CC	c	Closed – classes 4+			

Other Information from the VRI Database:					
COMP1 COMP2 COMP3	B, SL, ST, HE, HF, HG, ES, GL, LA, RI, RP, RZ, PN, RT, BR, TA, TB, TC, TM	Non-forest descriptors – burn, shrub layer, herb layer, exposed soil, glacier, lake, river, road, rock bare rock, talus, Treed – broad, conifer, mixed.	BCLC_L1		N, U, V
			BCLC_L2		L, N, T
			BCLC_L3		A, U
SOILMOIST1	1 to 8	Dry to wet soil moisture	BCLC_L4		EL, HE, HF, HG, RO, SI, SL, ST, TB,

SOILMOIST2 SOILMOIST3		classes		TC, TM
SOILNUTRRG	A to E	Poor to Rich nutrient classes	BCLC_L5	BP, BR. DE, LA, OP, PN, RI, RS, SP, UR
SHRUB_HT			SHRUBCWNCL	
			HERBCOVTYP	
BIOTERRAIN MAPPING FEATURES: (not used in this PEM Project)				
		Bioterrain mapping was not contracted as part of this project. There was no detriment to the accuracy of this PEM map due to the lack of this input layer.		
SOIL DESCRIPTION: (not used in this PEM Project)				
		The digital soils map is too coarse to be of use in this project (scale of 1:1,000,000)		
Post Processing to avoid Input database complications – Completed as a separate project				
TEM Structural Stage: (based on DEITF)				
TSS	3		Shrub (1 to 20 years) - corresponds to Structural Stage codes in DEITF manual	
TSS	4		Pole/sapling (20 to 40 years)	
TSS	5		Young (40 to 80 years)	
TSS	6		Mature (80 to 240 years)	
TSS	7		Old (240+ years)	
		Optional Module:	Note structural stage 2 is missing since it must be applied after the ecosystem label has been ascribed. This is a post-processing module that may not have been requested by the Client.	
TEM Seral Stage: (based on DEITF and the Biodiversity Guidebook)				
SES	NV	Non-vegetated	talus, rock, roadways, gravel pits; urban developments	
SES	DS	Disclimax	Avalanche tracks, shrub carrs, alder swales	
SES	PS	Pioneer	0 - 20 yrs for ICH, ESSF – includes wetlands, grasslands and meadows	
SES	ES	Early	21 – 50 yrs for ICH, ESSF	
SES	YS	Young	51 to 100 yrs for ICH	
			51 to 120 yrs for ESSF	
SES	MS	Mature	101to 250 yrs for ICH	
			121 to 250 yrs for ESSF	
SES	OS	Overmature	> 250 yrs for ICH, ESSF	

Appendix 6: Knowledge Tables

The following is one example of the Knowledge Tables used for the Revelstoke PEM project. We are showing only one example here since the files are too large to print out. Please refer to the digital file to view the rest of the KB's.

This file is also found on the accompanying DVD as "PEM_4316_knb"

Appendix 7: Internal Data Quality (IDQ) Report

The following is the Input Data Quality or metadata report completed by Silvatech Group Consulting.

This file is also found on the accompanying DVD as "PEM_4316_meta"

Appendix 8: Revised BEC Classification for the Revelstoke PEM

The following is an example of the revised BEC Classification (2005) provided by Dennis Lloyd, Regional Ecologist of the Southern Interior Forest Region. The rest of the BEC classifications are provided on the accompanying DVD as "Revised BEC Classifications for the B.C. Southern Interior".

http://www.for.gov.bc.ca/ftp/RSI/external/!publish/Dennis_Lloyd_BEC_Materials/

Appendix 9: Email Correspondence

The following are emails pertaining to this project, relevant to QA/AA contractors and Auditors.

Email from Corey Erwin regarding a Neatline Issue:

Hi Colleen,

As per our telephone conversation this morning....

Dividing these large PEM datasets into smaller, more manageable, units is a common practice. From a standards perspective, this is acceptable as long as the data within each, individual unit is totally seamless and meets the PEM standard (essentially creating 6 smaller complete standard PEM products). All remaining aspects of the entire project must comply with the requirements of the PEM standard.

For clarification the requirement for a seamless coverage has existed since the onset of the PEM standard. Section 5.2.3 - Spatial databases, of the PEM technical standard (April 2000), spatial deliverables #2, 3, & 4 refer to section 3 of the TEM technical standard (TEM TSD). Section 3.3.11 of the TEM TSD outlines the requirement for a seamless coverage. Granted the cross-referencing of standards is confusing but the requirement for "seamless data" is present and is also mentioned in section 5.1 of the PEM TSD Errata.

Also I would like to comment on your point about creating a database too complex to use. This is an important point. It is critical that we identify, and possibly change, areas where the requirements of the PEM/TEM standards are not meeting current project objectives and/or are resulting in extra work for mappers/clients. However, I don't think we can expect every forester and biologist, to have the skill sets necessary to query these types of complex datasets. Nor can we expect to develop a standard that will be all encompassing. The requirement to have a GIS skill set to use these datasets is one that we cannot avoid. We have the same problem in house. If you have any suggestions around changing the standard in this regard, please forward them to the TEM change mgt website.

As I stated earlier the current provincial standard requires a seamless data coverage and what you have outlined here is acceptable.

Please let me know if you have any further questions.

Corey Erwin
Vegetation Ecologist
Ecosystems Information Section
Phone: (250) 387-2031
-----Original Message-----
From: Shamaya [mailto:shamaya@junction.net]
Sent: December 10, 2003 9:55 AM
To: Erwin, Corey W SRM:EX
Cc: Graham MacGregor
Subject: question regarding seamless coverage for a PEM

Hi Corey,

We have a question for you. In our Patry PEM project, we divided the area into 6 blocks (landscape units) in order to make the data files manageable. Our AA contractor alerted our Client that the

coverages were not seamless within these blocks. We followed the edge matching protocol as per the PEM standards, but did not dissolve all the mapsheets. The Client insisted that we do this, so we did. As a consequence, there are no mapsheet labels or forest cover polygon numbers in the database.

This is now causing our databases to malfunction. I cannot locate my ground points without the forest cover polygon number and mapsheet number. I, like most other forestry folks, use the forest cover maps to locate areas of interest, then query which PEM polygons exist within the area, the PEM labels and all their attributes from within the PEM database. This is not possible with the current database. I have to do another GIS overlay to bring back the forest cover.

More importantly, we have now created a database that cannot be used by our Clients, other Foresters and Biologists. Now, they too have to go to their GIS analyst to have this overlay process completed and sit with the GIS person to do all the queries and cross-references. Previously, the Forester and Biologist could sit at their own desk and query the database without the visual plot (or use the cheap ArcExplorer program to see the plots). We've now created a database that can't be used for simple tasks in forest planning - everyone will have to line up to get the assistance of the sole GIS person in their company. This is not an effective use of time or manpower, and our Clients will be mad at us.

We searched all the PEM, TEM and Errata standards and cannot find an actual statement that the PEM maps must be a seamless coverage. Could you please let us know where this is written? Is this a mis-interpretation by the AA contractor of some point in the Standards? If it is there in the Standards, is this an unintended consequence? Can this requirement be ammended to allow us to keep the mapsheet and forest cover labels? The problems created by this requirement are no simple matter. PEM's must be user friendly for our Clients and their contractors otherwise they will not be used.

We do see the requirements in the TEM Digital Data Capture standards section 3.3.5 that the polygon label must have a "provincially unique tag" that includes at least the mapsheet and polygon number. This isn't possible if the neatlines have to be dissolved - polygons that cross a neatline have two mapsheet numbers so these must be thrown out. In previous PEM project, we complied with this TEM labelling requirement.

Have a Great Day!

Colleen F. Jones, M.A. RPBio
Shamaya Consulting - Ecological Services
5577 Silver Star Road, Vernon V1B 3P7
Phone/fax: (250) 542-3028

From: Lloyd, Dennis FOR:EX
Sent: June 23, 2005 10:27 AM
To: Jones, Colleen F SRM:EX
Subject: RE: ESSFvv?
Colleen

The ESSFvv has become the ESSFvcw or ESSFwcw, depending upon location. Geographically, where the old ESSFvv occurred elevationally above the ESSFvc it has become ESSFvcw. Where the ESSFvv occurred above the ESSFwc2 or ESSFwc4 it has become ESSFwcw. Question answered?

Dennis Lloyd
Research Ecologist
Southern Interior Forest Region
515 Columbia Street
Kamloops, B.C.
V2B 2T7
Ph: (250) 828-4129
mailto:Dennis.Lloyd@gems1.gov.bc.ca

> -----Original Message-----
> **From:**   Jones, Colleen F SRM:EX
> **Sent:**   Thursday, June 23, 2005 10:23 AM
> **To:**   Lloyd, Dennis FOR:EX
> **Subject:**   ESSFvv?
>
>
> Hi Dennis,
>
> We downloaded the most recent BEC map for the Nelson region. There is quite a bit of ESSFv v there. Was this subzone renamed to something else in your classification?
>
> Colleen
> > -----Original Message-----
> > **From:**   Lloyd, Dennis FOR:EX
> > **Sent:**   June 22, 2005 4:39 PM
> > **To:**   Jones, Colleen F SRM:EX
> > **Subject:** RE: Latest BEC linework for the former Revelstoke forest district
> >
> > Colleen
> >
> > Revelstoke National Park is in the former Nelson Forest Region, as such, the most recent mapping is on the Provincial website at research branch. Go the MoF....Research...Ecology....BGC mapping for the links. Talk to Marvin Eng if you have any questions. To the west of Revelstoke is the former Kamloops Forest Region, for which there is new mapping, it's available along with the most recent BEC classification guide materials on the following FTP site. I think most or all of the subzones you will be dealing with are shared between the former Nelson and Kamloops Region's. Our work included the data for both Regions. As such you materials for the ICHmw3, ICHwk1, ICHvk1, ESSFwc2, ESSFwc4, ESSFwc1, ESSFwcw, ESSFvc and ESSFvcw are included as a united product. Separate files for each BGC unit are located on this site, or as a compiled product for the wetbelt ESSF and ICH as a subdirectory. I can't recall, but it's possible the ICHmw1 or mw4 is located in your study area, if so you will have to use the 1992 Nelson guide for these BGC units.
> >
> > <<http://www.for.gov.bc.ca/ftp/RSI/external/!publish/Dennis%20Lloyd%20BEC%20Materials/ >>
> >
> >
> > Dennis Lloyd
> > Research Ecologist
> > Southern Interior Forest Region

---

515 Columbia Street
Kamloops, B.C.
V2B 2T7
Ph: (250) 828-4129
<u><mailto:Dennis.Lloyd@gems1.gov.bc.ca></u>

-----Original Message-----
From: Jones, Colleen F SRM:EX
Sent: Wednesday, June 22, 2005 2:27 PM
To: Lloyd, Dennis FOR:EX
Subject: Latest BEC linework for the former Revelstoke forest district

Hi Dennis,

We are beginning a PEM project in collaboration with National Parks for the Revelstoke
district area. We need to download the latest BEC coverage and would like to know if you
have the version we should use, or if it is posted somewhere for us to retrieve.

As well, do you have the revised BEC classification that you would like us to use for this
area? Can I download the veg summaries and any other descriptions you have available?

I hope your trip to Invermere went well. Thanks.

Have a great day!

Colleen F. Jones
TEM/PEM Specialist
Ministry of Sustainable Resource Management
1285 Dalhousie Drive (mailing address 1259 Dalhousie Drive)
Kamloops, B.C.   V2C 5Z5

phone: (250) 371-5292
Colleen.Jones@gov.bc.ca

From:	Lloyd, Dennis FOR:EX
Sent:	June 22, 2005 4:39 PM
To:	Jones, Colleen F SRM:EX
Subject:	RE: Latest BEC linework for the former Revelstoke forest district

Colleen

Revelstoke National Park is in the former Nelson Forest Region, as such, the most recent mapping is on the Provincial website at research branch. Go the MoF....Research...Ecology....BGC mapping for the links. Talk to Marvin Eng if you have any questions. To the west of Revelstoke is the former Kamloops Forest Region, for which there is new mapping, it's available along with the most recent BEC classification guide materials on the following FTP site. I think most or all of the subzones you will be dealing with are shared between the former Nelson and Kamloops Region's. Our work included the data for both Regions. As such you materials for the ICHmw3, ICHwk1, ICHvk1, ESSFwc2, ESSFwc4, ESSFwc1, ESSFwcw, ESSFvc and ESSFvcw are included as a united product. Separate files for each BGC unit are located on this site, or as a compiled product for the wetbelt ESSF and ICH as a subdirectory. I can't recall, but it's possible the ICHmw1 or mw4 is located in your study area, if so you will have to use the 1992 Nelson guide for these BGC units.

<http://www.for.gov.bc.ca/ftp/RSI/external/!publish/Dennis%20Lloyd%20BEC%20Materials/>

Dennis Lloyd
Research Ecologist
Southern Interior Forest Region
515 Columbia Street
Kamloops, B.C.
V2B 2T7
Ph: (250) 828-4129
mailto:Dennis.Lloyd@gems1.gov.bc.ca

-----Original Message-----

From:	Jones, Colleen F SRM:EX
Sent:	Wednesday, June 22, 2005 2:27 PM
To:	Lloyd, Dennis FOR:EX
Subject:	Latest BEC linework for the former Revelstoke forest district

Hi Dennis,

We are beginning a PEM project in collaboration with National Parks for the Revelstoke district area. We need to download the latest BEC coverage and would like to know if you have the version we should use, or if it is posted somewhere for us to retrieve.

As well, do you have the revised BEC classification that you would like us to use for this area? Can I download the veg summaries and any other descriptions you have available?

I hope your trip to Invermere went well. Thanks.

Have a great day!

Colleen F. Jones
TEM/PEM Specialist
Ministry of Sustainable Resource Management
1285 Dalhousie Drive (mailing address 1259 Dalhousie Drive)
Kamloops, B.C.   V2C 5Z5
phone: (250) 371-5292
Colleen.Jones@gov.bc.ca

Appendix 10: Forest Cover Retro-fitting Database Report

The following report was written by Eric Valdal, B.C. Integrated Land Management Bureau (Kamloops), August 31, 2005.

This report is also saved on the accompanying DVD as "PEM_4316_app10"

Appendix 11: PEM Quality Control Documentation

This report is also saved on the accompanying DVD as "PEM_4316_iqc"