Predictive Ecosystem Mapping (PEM)
&
Mountain caribou and Grizzly bear Habitat Ratings
for the
Purcell Wilderness Conservancy Provincial Park

Phase 2: Field Sampling Results

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EXECUTIVE SUMMARY

In 2001, preliminary Predictive Ecosystem Mapping (PEM) and PEM-based species-habitat models for grizzly bear, mountain caribou and least chipmunk were completed for the Purcell Wilderness Conservancy Provincial Park study area (Hamilton et al 2001). Follow-up field sampling in summer of 2002 was conducted to verify both the preliminary PEM classification (site series/ecosystem units) and wildlife habitat ratings. The sampling plan was designed to maximize the amount of ecological and habitat data that could be collected within the constraint of a limited budget. The objectives of this second phase of the project were:

1. to field check the preliminary Predictive Ecosystem Mapping (PEM) classifications;
2. to assess field-based habitat ratings for grizzly bear and mountain caribou; and,
3. to revise preliminary PEM and preliminary grizzly bear and mountain caribou species-habitat models based on field sampling results.

Based on PEM fieldwork, a number of incorrect classifications were identified on the preliminary maps. Changes were subsequently made to preliminary ecological assumptions and to attributes and ratings in knowledge tables specific to each biogeoclimatic unit in the study area. Changes were based on fieldwork findings as well as on the review of preliminary maps and air photos where field sampling was limited or lacking in some of the units. The addition of new attributes and changes to attribute ratings correspond to new or updated input data and/or revised ecological assumptions.

The seasonal habitat ratings assigned during field sampling were consistent with the preliminary habitat ratings. No additional changes to the grizzly bear and mountain caribou species-habitat models are recommended based on field sampling results. Provincial-standard wildlife habitat ratings provided an efficient and cost effective method for defining mountain caribou and grizzly bear habitat with the Purcell Wilderness Conservancy Provincial Park study area. The ratings accommodated broad local knowledge of caribou and grizzly bear habitat use and behaviour, and the subsequent rating tables were linked to PEM and other map coverages to illustrate the location of grizzly bear and caribou habitat on the landscape.

The method used to develop the wildlife habitat mapping is one of the few available that addresses both habitat suitability and capability, captures broad local knowledge and uses empirical data (where available) to test and adjust ratings. Most important, the maps can be updated easily if additional studies warrant changes to base map coverages (e.g., PEM) or to the species-habitat models.

In general, more field surveys would be useful for confirming ecological relationships between map attribute data, ecosystem units, wildlife habitat ratings and for providing field data that could be used to further adjust the ecological knowledge base, delineate “difficult to predict” ecosystems, and improve the reliability of the PEM mapping.

INTRODUCTION

In 2001, Preliminary Predictive Ecosystem Mapping (PEM) and species-habitat models for grizzly bear (*Ursus arctos*), mountain caribou (*Rangifer tarandus*) and least chipmunk (*Tamias minimus*) were completed for the Purcell Wilderness Conservancy Provincial Park (Hamilton et al 2001). Follow-up field sampling in summer of 2002 was conducted to verify the preliminary PEM classification (site series/ecosystem units) and wildlife habitat ratings. The sampling plan was designed to maximize the amount of ecological and habitat data that could be collected within the constraint of a limited budget. The objectives of this second phase of the project were:

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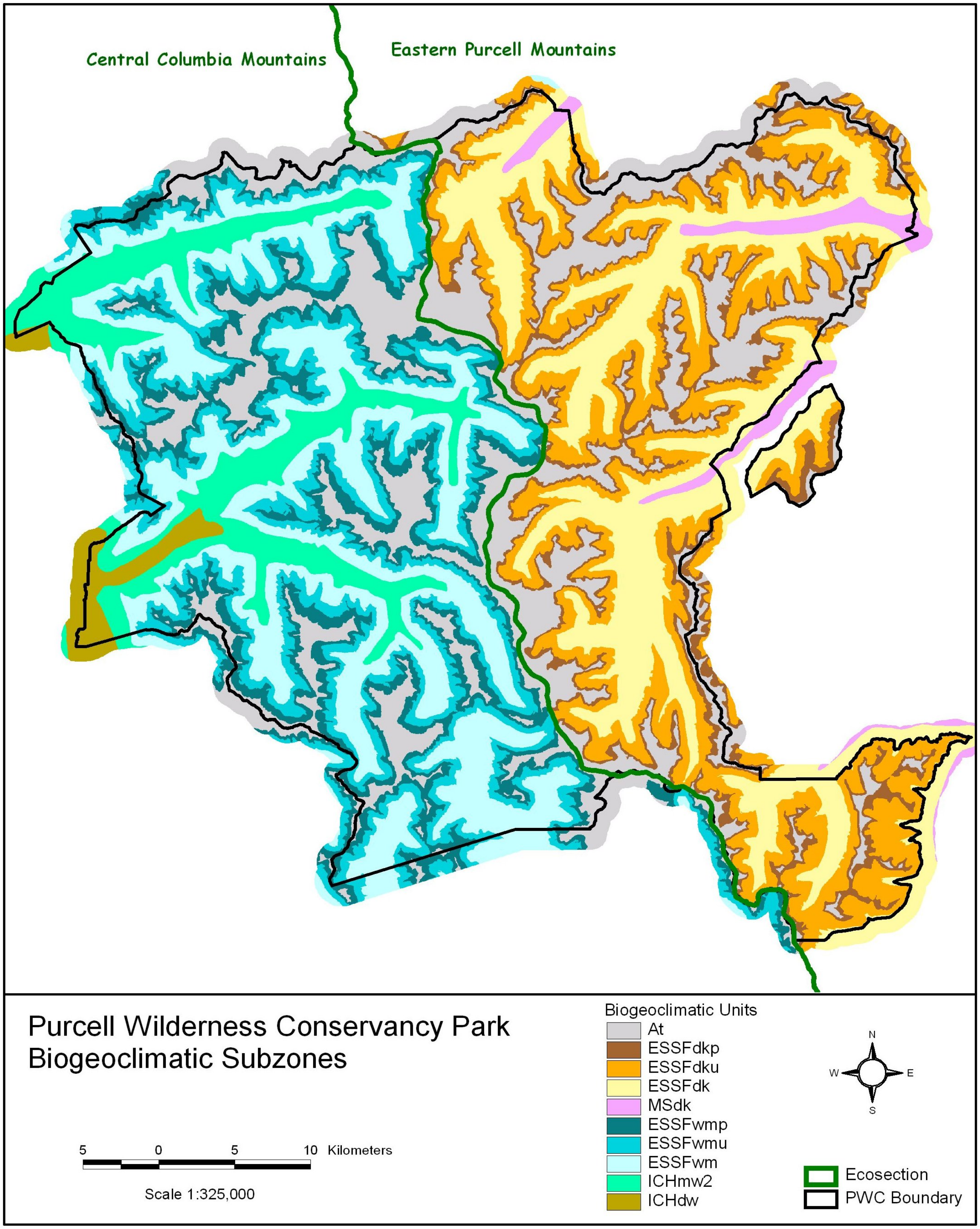
3. to revise preliminary PEM and preliminary grizzly bear and mountain caribou species-habitat models based on field sampling results.

The Purcell Wilderness Conservancy Provincial Park study area, stratified by ecosections and biogeoclimatic units, is illustrated in Figure 1. An ecological description of the study area is detailed in the Phase 1 report (Hamilton et al 2001).

Figure 1: Purcell Wilderness Conservancy Provincial Park Study Area



METHODS

INITIAL PEM METHODS

The methods used to conduct the preliminary predictive ecosystem mapping for the study area were detailed in the Phase 1 report for the Purcell Wilderness Conservancy Provincial Park (Hamilton et al 2001).

PEM ENHANCEMENTS

During this second phase of the project, there were several enhancements made to the preliminary PEM methodology. These included new input layers and expansion of the ecosystem database associated with the initial PEM mapping. The GIS enhancements included:

- Avalanche chutes were manually digitized from a Landsat image. Image classification of Landsat for avalanche chutes is an imprecise method to delineate chutes. Manual delineation ensured that over and under classification, typical of automated methods, was avoided.
- Decile ranking for the site series attributes to capture closely scored PEM results.
- Acquisition of 1:50,000 geology maps to enhance the calcareous bedrock layer for site series identification in the MSdk.
- Eight new input layers
    - Avalanche chute run-out
    - Non-forested meadow, heath, tundra (from satellite classification)
    - PL leading and SX <= 20%, ageclass > 4
    - PA in top two species (>= 30%)
    - LA alpine larch in top two species (>=30%)
    - Spruce in top two species (>= 30%)
    - PA (or PF) anywhere in stand
    - Crown closure class <=1 and ageclass > 3

PEM Database Enhancement

To enhance the attributes of the PEM, the database was expanded from one site series to a “TEM-like” decile structure to accommodate up to three site series allocated by the PEM process. Site series scores that were tied or within 75% of the highest score were summed and equalized to a value of 100 (or, units of 10 in TEM deciles terms). For example, if two site series had scores of 20, each would be assigned a rank value of five, or 50/50. If the score of two site series was 40 and 30, the rank values would be rounded to six and four. In the case of a three-way tie, the ranks would be set for each three - this is the only case were the sum of ranks would not equal 10.

It should be noted that the instances of more than one ranked site series do not indicate a decile representation of site series on the ground. Rather, the ranking provides an indication of what other site series might occur at a site and how much confidence one should assign to a given area. If a resulting polygon has two site series with a split 5 rank it means that the knowledge base was not able to separate the attributes leading to the assignment of site series. Therefore both site series should be considered in the analysis since both have equal likelihood of actually being present on the ground.

Table 1: Sample of PEM database structure:

ECO_SEC	*BGC_ZONE*	*BGC_SUBZON*	*BGC_VRT*	*SRNK_1*	*SITE_S1*	*SITEMC_S1*	*SRNK_2*	*SITE_S2*	*SITEMC_S2*	*SRNK_3*	*SITE_S3*	*SITEMC_S3*	*SITE_MOD*
CCM	ICH	dw	0	6	66	WS	4	02	DO	0			j
CCM	ICH	dw	0	10	02	DO	0			0			q
CCM	ICH	dw	0	10	02	DO	0			0			w
CCM	ICH	dw	0	10	02	DO	0			0			z
CCM	ICH	dw	0	10	44	TA	0			0			w
CCM	ICH	dw	0	10	66	WS	0			0			j
CCM	ICH	mw	2	3	01	HF	3	02	RC	3	04	RF	k
CCM	ICH	mw	2	3	05	HO	3	08	CS	3	09	BS	j
CCM	ICH	mw	2	3	02	RC	3	03	DF	3	04	RF	w
CCM	ICH	mw	2	5	02	RC	5	03	DF	0			z
CCM	ICH	mw	2	5	04	RF	5	02	RC	0			k
CCM	ICH	mw	2	5	04	RF	5	02	RC	0			q
CCM	ICH	mw	2	6	77	AC	4	01	HF	0			k

INITIAL CLASSIFICATION AND MAPPING OF ECOSYSTEMS

The methods used to complete the initial classification and mapping of ecosystems are described in the Phase 1 report.

WILDLIFE METHODS

Methods used to develop individual species accounts and assign preliminary habitat ratings to PEM polygons are included in the Phase 1 report. Phase 2 included field-based habitat ratings for mountain caribou and grizzly bear in accordance with provincial wildlife habitat ratings standards (RIC 1999).

FIELD SAMPLING METHODS

Rationale for Field Sampling

Field sampling was recommended in the initial Phase 1 report to assess the accuracy of the preliminary PEM mapping and to “ground truth’ the preliminary wildlife habitat ratings.

As no standardized ecological sampling (PEM 1999) has been conducted in the study area, fieldwork provided a means for validating the ecological knowledge base and assessing the initial mapping. Sampling also provided the opportunity to confirm the ecological relationships between input attribute data and ecosystem units (site series), to check and refine biogeoclimatic unit boundaries, and to "train" the knowledge base to local ecological conditions in the study area. Field data was also used to assess the accuracy of the preliminary species-habitat models.

Field sample planning

Field sample planning was conducted to clarify the sampling approach and objectives, develop the sampling design and select sample areas. It also involved organization and scheduling of fieldwork. The approach to field sampling and providing deliverable products was based on a limited budget and an attempt to maximize the amount of ecological and habitat data that could be collected in the field.

The development of the sampling design was guided by access considerations, the objective to sample a diversity of sites within the study area, and the results of the preliminary ecosystem classification and mapping. An attempt was made to distribute sampling throughout the study area and in a variety of strata in order to sample a range of ecosystems and seral (structural) stages, but the availability of cost efficient access and a limited budget strongly influenced where sample areas were located. Areas where the classification was suspect and where ecosystem complexes were assumed to occur on the landscape were target areas for more detailed sampling. Areas of important caribou habitat were also targeted for more intensive field surveys as the caribou is a red-listed species in B.C. and a species recovery plan is presently being prepared for the South Purcell caribou sub-population. A stratified, selective sampling design was used to locate field surveys in areas that were recommended for more concentrated sampling in order to investigate mapping problem areas and critical habitats (Hamilton et al 2001).

Sample area selection was initiated by interpreting air photos and/or color-themed forest cover maps in conjunction with the initial PEM and caribou and grizzly bear habitat capability maps. On the maps and air photos, sample areas were identified and prioritized according to ease of access and specific objectives to sample a range of site conditions, representative ecosystems and structural stages, "difficult to predict" ecosystems, ecosystem complexes, important caribou habitat and rare ecosystems/ habitats. Once potential sample areas were located based on access considerations and the ability to meet sampling objectives, sample lines (transects) and sample points (plots) were identified. The proposed timeframe for completing the field sampling was 5-6 days.

Vehicle-Hiking Access Sample Areas

West side of park		
Upper Dewar Creek	1 day	(ESSFwm)

East side of park		
Upper Buhl Creek	1-2 days	(ESSFdk, dku, dkp)
Dutch Creek	1 day	(MSdk, ESSFdk)
Upper Toby Creek	1 day	(MSdk, ESSFdk)
Findlay Creek	1 day (alternate area)	(MSdk, ESSFdk)

Helicopter-Hiking Access Sample Areas

West side of park

Mid Carney Creek	1 day	(ESSFwmu, wm, ICHmw2)
Mid Fry Creek	1 day (alternate area)	(ESSFwmu, wm, ICHmw2)
Upper Hamill Creek	1 day (alternate area)	(ESSFwmu, wm, ICHmw2)

Field Procedures

Field sampling took place in early to mid-September, 2001. A two-person crew consisting of an experienced plant ecologist and a wildlife biologist trained in wildlife habitat rating standards (RIC 1999) carried out the field sampling. The sampling was conducted using field traverses and point inspections. Strip mapping was done along sample lines to map terrain features, site moisture conditions and forest cover types. Information on biogeoclimatic and ecosystem unit boundaries was also recorded on strip maps and significant wildlife sign and important habitats were noted.

An attempt was made to locate plots in homogeneous types on the landscape. Each plot location was accurately identified on an air photo or field map. All attributes used in the ecological knowledge tables, as well as data required to confirm the ecological classification of the ecosystem unit being sampled, were recorded on standardized Ecosystem Field Forms or Ground Inspection Forms. Attribute data were collected according to standards as defined in the "Field Manual for describing terrestrial ecosystems" (RIC 1999). Data collected at plots included full site descriptions and partial soil (including terrain) and vegetation descriptions. At most sample points, percent cover values for dominant and indicator vegetation species were recorded for the 20X20m plot areas in addition to important information on site, soil and terrain features. Caribou and grizzly bear habitat was evaluated at sample points and the habitat data and ratings were recorded on standard Wildlife Habitat Assessment field forms, in accordance with provincial standards for conducting wildlife habitat ratings (RIC 1999).

DATA SUMMARY METHODS

Ecological field data were summarized according to the map attributes used as input data and correlated to field and predicted ecosystem classifications in order to assess the accuracy of the preliminary mapping and validate the ecological knowledge base. Revisions to preliminary ecological assumptions and the knowledge tables based on field findings were summarized in a field sampling results table. The revised knowledge tables were used to rerun the PEM program and produce a more accurate ecosystem map of the study area. Habitat assessment field data for caribou and grizzly bear were summarized.

REPORTING METHODS

This report includes a section on enhancements made to the preliminary PEM methods, documentation of the field sampling methods and a summary of sampling results. It also includes an accuracy assessment of the preliminary mapping, wildlife species accounts and habitat ratings, and describes revised assumptions and adjustments made in both the ecological knowledge tables and the wildlife rating tables. Revised PEM and wildlife capability and suitability maps were also produced and as a cost saving measure were included as part of the database submitted with this report.

RESULTS AND DISCUSSION

FIELD SAMPLING RESULTS

Although there is no minimum field sample size requirement for PEM, a minimum number of 30 samples can be used as a validation data set to check the accuracy of the predictive models developed for each biogeoclimatic unit in the project area (RIC 1999). The data set contains ecological data on the suite of attributes used in the knowledge tables and a known outcome (classification of site series/ecosystem unit and site modifier) for each plot. In order to meet the minimum sample size for a validation set, the goal during field sampling was to complete five to six sample point inspections per day in addition to strip mapping the sample lines. That level of productivity would provide a total of 30 plots completed over the proposed five to six day field session.

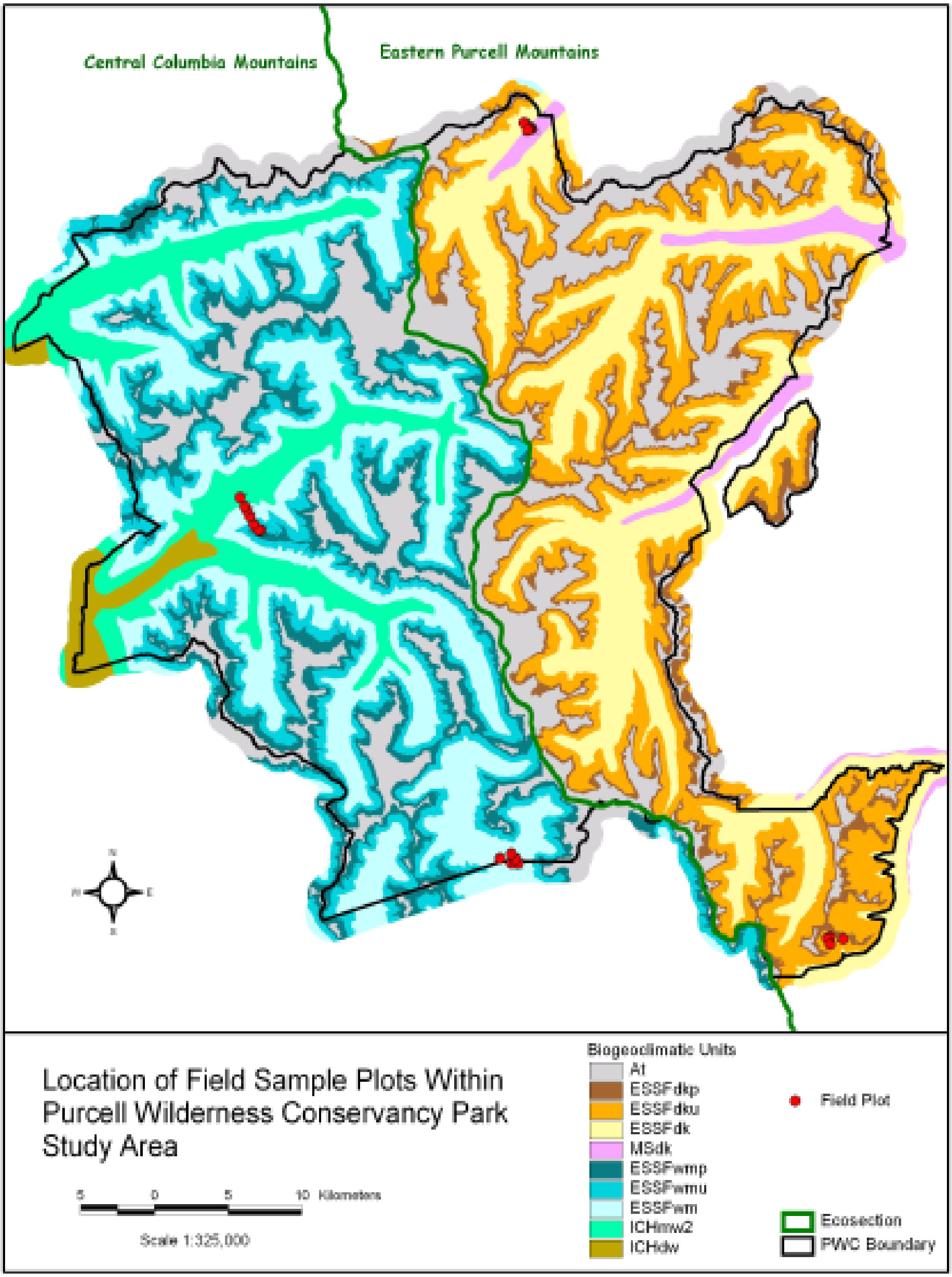
Figure 2 shows the location of sample points within the study area. A total of 24 sites were sampled in four of the proposed sample areas including Toby Creek and Buhl Creek in the east, and Dewar Creek and mid Carney Creek in the west Purcell Mountains. The goal to sample 30 sites during five to six days of fieldwork was not achieved because the field session had to be reduced to four days due to the limited budget and the high cost of accessing the interior of the study area. The cost of helicopter access for one day of sampling in the Carney Creek area used up approximately one quarter of the entire budget available for field sampling, data analysis/summary, reporting writing and the production of revised PEM maps.

Of the 24 sites sampled, 16 plots were described using Ecosystem Field Forms and 8 were described using Ground Inspection Forms. In the Toby Creek, Dewar Creek and mid Carney Creek sample areas, plots were located along sample lines that were strip mapped. Terrain and vegetation information recorded on strip maps was also useful for assessing the accuracy of the initial mapping and the validity of the preliminary ecological assumptions used to develop the knowledge base. All wildlife habitat ratings were recorded using the Wildlife Habitat Assessment (WHA) field form (RIC 1999).

Accuracy Assessment of Preliminary PEM Mapping

A number of inconsistencies were identified between the preliminary mapping and site identification in the field. Of the 24 sites sampled, ecosystem classification at seven sites matched the PEM map units. Four sample sites were considered transitional between two ecosystem units. For each of those sites, the map unit corresponded to one of the transitional units, so four more map units were considered acceptable predictions. Another site unit differed from the map unit only with respect to the aspect modifier and one site sampled was predicted incorrectly because a biogeoclimatic unit boundary was mapped at the wrong elevation. An avalanche run-out zone sampled on a gentle toe slope was incorrectly mapped as an avalanche chute. This inconsistency led to the observation that inaccurate delineation of avalanche chutes and run-out zones on the PEM maps occurred throughout the study area due to a problem with the predictive modeling process to differentiate between the two units. In all other cases, the sites sampled were predicted to be ecologically adjacent ecosystem units, with respect to soil moisture or nutrient regimes, to the actual units identified in the field.

Figure 2: Location of field sample points in the Purcell Wilderness Conservancy Park Study Area



The ecological field data corresponding to map attribute input data were correlated to site ecosystem classification and map predictions to validate the ecological knowledge base and assess the accuracy of the preliminary mapping. Fieldwork findings provided evidence that mapping inconsistencies between predicted map units and site classification occurred because of incorrect ecological assumptions, incomplete or missing input attribute data and inherent limitations of some of the input data.

Due to a lack of ecological data for the study area, it was difficult to make assumptions about what ecosystems would occur in specific landscape positions, particularly toe slopes and concave shaped terrain. Preliminary assumptions about ecological relationships between topographic features and ecosystem units had to be revised and ratings changed in the knowledge tables to improve the accuracy of the PEM mapping. Adjustments to rating values were most often made for the slope, aspect and terrain (surface shape) attributes, although changes to tree species composition and proximity to water were also important. Tree species composition attributes and revisions to the crown closure class/age class attributes were also required to help differentiate ecosystem units.

Incomplete or missing input data resulted in other mapping problems. One site in the east part of the study area was found to be incorrectly mapped because of incomplete bedrock geology input data for the “calcareous rock” map attribute. Another mapping inconsistency occurred because of missing elevation input data that was required to separate two ecosystem units in the west using the biogeoclimatic unit boundary attributes. Fieldwork findings indicated that closely related ecosystems that occur on level floodplain sites could not be accurately differentiated using the current ecological knowledge base. Ecosystems on the flat, fluvial sites correspond to texture and drainage of the underlying parent materials and terrain or soil input data necessary to help delineate those ecosystems were not available for the study area.

Some sites were not mapped correctly due to limitations of the input data. The Digital Elevation Model (DEM) did not have the resolution to delineate small topographic units within larger map units (i.e. a concave shaped site within a larger unit classified as having a straight slope). Also, field sampling indicated that small forest cover units included within larger timber types with different tree species composition were often not delineated in the forest cover input data. Sites are mapped based on the ecological assumptions being applied to the larger topographic or forest cover units; therefore, small units that were not delineated during the classification process were predicted incorrectly. It would be necessary to improve the resolution of the DEM or the accuracy of the forest cover typing to improve the accuracy of the PEM mapping.

A review of satellite (landsat) imagery and fieldwork findings confirmed that areas of avalanche paths were being over-classified and areas of meadows and heath in the upper subalpine and parkland zones were being under-represented on the PEM maps. This situation indicated a problem with the preliminary classification of satellite input data. Non-vegetated morainal units, typically associated with recent deglaciation at high elevations, were also over-classified on the preliminary PEM maps. It was determined that the units included large areas of vegetated morainal deposits that had not been excluded from the classification.

A summary of field sampling results is included in Table 2.

Table 2: Purcell Wilderness Conservancy Park – Predictive Ecosystem Mapping (PEM) Project Field Sampling Results

Location	Plot No.	BEC Unit	Map Unit (Site Series)	Preliminary Ecological Assumption(s)	Field Site Identification		Comments & Revised Ecological Assumptions	Revisions to Ecological Knowledge Base (Attributes & Ratings)
					Soil Moisture/ Nutrients[1]	Ecosystem Unit (Site Series)		
Toby Creek	T1-1	MSdk	SS (01)	Moist (subhygric) sites corresponding to the SS (05) ecosystem occur on gentle (5-25%) toe slopes and within 50 m of stream channels.	5/C-D	SS (05)	_	_
	T1-2	MSdk	SGk (01)	Significant (25-50%) slopes in toe slope positions &/or with concave surface shape and Sx as leading species correspond to the SG unit on mesic sites.	4/C	SGw (01)	The site sampled had a southeast aspect of 145º, which is in the range of warm aspect (135º-180º). The larger map unit identified during the PEM process was classified as having a cool aspect of <135º.	_
	T1-3	MSdk	LPw (04)	Significant slopes with warm aspects and straight surface shape would correspond to the LP(04) unit on submesic sites.	3/C	SGw (01)	The SG (01) unit occurs on submesic sites with significant warm aspect slopes and straight surface shape where Sx is a co-dominant (>=30%) species in the stand	- increase the rating of significant slope (25-50%) and warm aspect attributes for the SG (01) unit - add the attribute "Sx in top two species of stand (>=30%)" and rate for the 01 & moister site series - add the attribute "Pl leading species, Sx <=20%, age class > 4 (80 years)" and rate for the LJ & LP units to help differentiate the LP (04) unit that lacks Sx in mature forests from the SG (01) unit
	T1-4	ESSFdk	FGw	Submesic sites occur on significant slopes with warm aspects and straight surface shape.	3/C	MSdk-SGw (01)	The MSdk/ESSFdk boundary was mapped too low on warm aspects and has been moved to a higher elevation based on updated information from the MoF Regional Ecologist. Other assumptions were revised as for plot T1-3 to predict the SGw unit.	- revisions as for plot T1-3

Location	Plot No.	BEC Unit	Map Unit (Site Series)	Preliminary Ecological Assumption(s)	Field Site Identification		Comments & Revised Ecological Assumptions	Revisions to Ecological Knowledge Base (Attributes & Ratings)
					Soil Moisture/ Nutrients[1]	Ecosystem Unit (Site Series)		
	T1-5	ESSFdk	FGw	The FGw (03) unit would occur on dry (subxeric-submesic) sites on steep (51-70%), warm aspect slopes underlain by <u>non-calcareous</u> soils	(2)-3/C	FSw	The site vegetation corresponds to the FSw (04) unit that occurs in similar topographic positions as the FGw (03) unit but is typically underlain by <u>calcareous</u> soils. The site vegetation may be corresponding to soil parent materials derived from an underlying phyllite-schist bedrock type with medium to high nutrient status.	Bedrock geology data was revised for the eastern part of the park by adding another geological map unit to the "calcareous rock" attribute input data. That resulted in the Toby Creek sample area being included in a map unit classified as being underlain by calcareous parent materials.
Toby Creek	T1-6	MSdk	AC	Avalanche tracks with gentle slopes (<=25%) &/or toe slopes correspond to moist avalanche run-out zones.	5/D	AR	The computer process to differentiate AC & AR units did not function properly. Avalanche paths have since been delineated by hand on the satellite (landsat) imagery of the park. Avalanche run-out zones (AR) are now identified as avalanche tracks located in valley bottom slope positions having slopes <=35%. Avalanche chutes (AC) are avalanche tracks that are located above the valley bottoms and/or have slopes >35%.	- change the "avalanche" attribute in the knowledge tables to "**avalanche chute**" and add an "**avalanche run-out zone**" attribute
Buhl Creek	B1-1	ESSFdku	LM	A crown closure class of <=1 (<=15%) with an age class > 1 (>20 years old) could be used to differentiate the LM unit with very open stands from other ecosystem units containing alpine larch (La)	3/C	LG	Crown closure class <=1 and age class >1 can correspond to young stands of other ecosystem units where tree growth is slow in the cold, dry climate of the ESSFdku. Alpine larch in the top two species of the stand is useful for differentiating the larch-dominated ecosystems from others in the ESSFdku subzone. The LH and LG units on submesic to mesic sites can occur on gentle convex surface shapes	- Rate ecosystems for low crown closure in older stands by using the new attribute "**crown closure <=1, age class >3**" - Rate the larch dominated stands (LM, LH, LG) for the new attribute "**La in top two** species of stand **(>=30%)**" - Increase ratings of convex and convex-ridge attributes for the LH & LG units and adjust ratings for all other units occurring on dry to mesic sites

Location	Plot No.	BEC Unit	Map Unit (Site Series)	Preliminary Ecological Assumption(s)	Field Site Identification		Comments & Revised Ecological Assumptions	Revisions to Ecological Knowledge Base (Attributes & Ratings)
					Soil Moisture/ Nutrients[1]	Ecosystem Unit (Site Series)		
	B1-2	ESSFdku	FGw	Sites on significant slopes with straight or concave surface shapes and with Se or Bl leading correspond to the FG unit. The HG unit only occurs on significant slopes that are in toe slope positions.	4-(5)/C-D	(FGw) - HGw	This site is transitional between the FG and HG ecosystem units. The site is classified as having a straight slope but it is very close to a toe slope map unit. Based on the site location and a transitional site classification, the predicted FGw unit is acceptable. The HG unit may also occur on significant slopes with concave surface shapes that are not in toe slope positions.	- Rate the HG unit for significant slopes (25-50%) and warm and cool aspect attributes.
Buhl Creek	B1-3	ESSFdku	LG	Submesic to mesic sites on gentle (5-25%) slopes with both La and Se in the stand differentiates the LG from the LH unit that lacks Se	3-(4)/C	LG	_	- Give a slightly higher rating to LH for the new attribute "**La in top two (>=30%)**" so that LH will be predicted over the LG unit when no Se is present in the stand
	B1-4	ESSFdku	HG	Straight surface shape was not a significant ecological attribute for differentiating ecosystems on dry to mesic sites from those on moist sites. It was also assumed that La did not occur in the FG unit dominated by Se and Bl.	4/C	FG	There is a higher probability of straight surface shape being associated with ecosystems on dry to mesic sites than with those on moist sites. Alpine larch (La) can be a minor to associate species in the FG unit.	- Increase the rating of "**straight slope**" for the units associated with dry to mesic sites to help differentiate them from the HG unit on moist toe &/or concave shaped slopes. - Give a rating for "**La anywhere in stand**" to the FG unit
Dewar Creek	D1-1	ESSFwm	FA (01)	On gentle terrain (5-25% slope) the mesic FA unit has a higher probability of occurring on sites with straight surface shape while the moist to wet FQ unit has a higher probability of occurring on sites with concave surface shape. It was also assumed that the FA unit would have a higher probability of occurring on gentle (10-25%), warm	4-(5)/C	FA – FQ (01 – 04)	This site is transitional between the mesic FA unit and the moist FQ unit. The preliminary assumptions based on surface shape are probably sound. The concave surface shape observed at the site corresponds to the FQ unit. However the larger map unit was classified as having a straight surface shape, in which case the FA map unit is correct as predicted. Both the FA and FQ units can occur on gentle warm aspect slopes.	- Delete the FA rating for the "warm aspect slope 10-25%"

Location	Plot No.	BEC Unit	Map Unit (Site Series)	Preliminary Ecological Assumption(s)	Field Site Identification: Soil Moisture/ Nutrients[1]	Field Site Identification: Ecosystem Unit (Site Series)	Comments & Revised Ecological Assumptions	Revisions to Ecological Knowledge Base (Attributes & Ratings)
				aspect slopes than the FQ unit.				attribute so that differentiation between the FA & FQ units can be determined by surface shape alone.
	D1-2	ESSFwm	FAw (01)	Submesic to mesic sites on significant (25-50%)slopes with straight surface shapes, deep soils and without Pl as the leading species correspond to the FA unit.	3-(4)/C	FAw (01)	_	_
Dewar Creek	D1-3	ESSFwm	FRw (02)	Submesic sites on steep (51-70%) slopes with Pl leading correspond to either the FR (02) or RA (03) units depending on elevation. It was assumed that the RA unit occurred within 150m vertical of the ICHmw2/ ESSFwm boundary (1500m+) and the FR unit occurred above 150m vertical of the boundary.	3/B-C	RAw (03)	In the Dewar Creek drainage, the ICHmw2/ESSFwm boundary is below the minimum 1500m elevation assumed. However, the occurrence of Hw and understory vegetation species indicate that the RA (03) unit still occurs up to an approximate elevation of 1650 m as specified in the ecological field guide.	- Revise the ICHmw2/ESSFwm boundary attribute to include and elevation cut-off (1650m) to differentiate the FR and RA units in the Dewar Creek area and the adjacent drainage to the west.
	D1-4	ESSFwm	FQk (04)	Sites on significant slopes (25-50%) with concave surface shape would correspond to the mesic FA unit. Significant toe slopes would correspond to the FQ.	4/C	FAk – (FQk) (01 – (04))	The concave site sampled is close to a toe slope map unit and is transitional between the FAk and FQk units. Therefore, the initial assumptions are probably sound based on the field findings.	_
	D1-5	ESSFwm	FAw (01)	Significant slopes with straight surface shape correspond to the FA unit on mesic sites.	(3)-4/C-(D)	FAw (01)	_	_

Location	Plot No.	BEC Unit	Map Unit (Site Series)	Preliminary Ecological Assumption(s)	Field Site Identification		Comments & Revised Ecological Assumptions	Revisions to Ecological Knowledge Base (Attributes & Ratings)
					Soil Moisture/ Nutrients[1]	Ecosystem Unit (Site Series)		
	D1-6	ESSFwm	FH	Level fluvial sites within close proximity to streams (<=100m) would correspond to the FH ecosystem unit	5/C	FQ (04)	The FQ unit can occur along water channels on flat fluvial sites that are underlain by coarse-textured parent materials. FH may be more typical on fine to medium textured fluvial deposits, while FQ would more likely occur on coarse-textured materials. The FH and FQ ecosystems cannot be accurately differentiated on level fluvial sites without terrain &/or soil data. As a consequence, areas predicted as FH units may also include FQ habitat.	- No revisions are recommended based on the field findings. Terrain &/or soil mapping digital data would improve the knowledge base and facilitate the differentiation of the moist to wet FQ and FH ecosystem units.
mid Carney Creek	C1-1	ESSFwmu	FB	Sites on gentle toe &/or concave shaped slopes would correspond to the moist FB unit.	(3)-4/C	FR	The site sampled was located on a gentle convex knoll within a concave shaped cirque basin and is slightly drier than the surrounding terrain. The Digital Elevation Model (DEM) used in the PEM mapping process does not have the resolution to delineate a localized topographic unit within the larger concave shaped area.	No revisions to the knowledge table based on this plot. (see revisions for plot C1-2)
	C1-2	ESSFwmu	FB	as for C1-1	4-(5)/C-D	FR – (FB)	This site represents a mesic FR unit transitional to a moist FB unit. The site is classified as occurring on a gentle toe slope, so the FB map unit predicted is acceptable for the transitional site. Based on field findings, it is assumed that the FR unit will occur on gentle concave slopes and the FB unit is more likely to occur on gentle concave slopes in toe slope positions.	- Decrease the rating of slope class 2 (6-25%) for the FB unit and increase the rating of concave slope for the FR unit to predict FR on gentle terrain with concave surface shape and FB on gentle slopes with concave surface shape and toe slope attributes.

Location	Plot No.	BEC Unit	Map Unit (Site Series)	Preliminary Ecological Assumption(s)	Field Site Identification		Comments & Revised Ecological Assumptions	Revisions to Ecological Knowledge Base (Attributes & Ratings)
					Soil Moisture/ Nutrients[1]	Ecosystem Unit (Site Series)		
	C1-3	ESSFwmu	WH	Sites with convex or convex-ridge surface shapes, shallow soils and the presence of whitebark pine (or limber pine) correspond to the dry WH unit.	2-(3)/B	WH	The presence of whitebark pine (Pa) in the timber type is the most important attribute for the WH unit. On dry sites where the WH unit lacks Pa in the stand, topographic and soil depth attributes are used to differentiate the WH from the FR unit typically found on moister sites.	- Revise ratings of slope class, surface shape and shallow soil (Cv, Mv) for WH and FR units to predict WH on significant (25-50%) slopes with convex surface shape and shallow soils and FR on significant convex slopes with deep soils.
	C1-4	ESSFwmu	WH	as for C1-3	2-3/B	WH	-	-
	C1-5	ESSFwm	FR (02)	Sites on gentle & significant straight slopes with Pl leading correspond to either the FR (02) or RA (03) unit depending on elevation.	4/C	FA (01)	This is a localized area (within a larger map unit) that has a concave surface shape, slightly moister site conditions than the surrounding area and is dominated by Bl & Se. The larger map unit is classified as having a straight slope and Pl as the leading species. Therefore the site is correctly mapped based on the assumptions being applied to the larger unit. As a result the FR (02) unit may include small areas of FA (01) habitat on moister sites where Pl is not the leading species.	No revisions to the knowledge table based on this plot. The accuracy of the PEM mapping depends on the resolution and ability of the Digital Elevation Model (DEM) to map topographic units as well as on the accuracy of the forest cover mapping in the area.
mid Carney Creek	C1-6	ESSFwm	FAk (01)	Sites on significant, straight slopes with a cool aspect, deep soils and above 1650m elevation, would correspond to the FA (01) unit regardless of tree species composition	3/(B)-C	FRk (02)	Cool aspect sites on significant straight slopes with deep soils correspond to the FR (02) or the RA (03) unit where lodgepole pine (Pl) is the leading species in the stand. The RA (03) unit occurs within 150m vertical of the ICHmw2/ ESSFwm boundary or below 1650m while the FR (02) unit occurs above 150m vertical of the BEC boundary or above 1650m.	- Increase the rating of the cool aspect attribute for the FR unit and decrease the difference in ratings between the FR/RA and FA units for the straight slope attribute. Then the Pl leading attribute will differentiate between FRk or RAk and the FAk unit on straight significant slopes with cool aspects.
	C1-7	ESSFwm	RAk (03)	Sites on significant, straight slopes with cool aspect, deep soils, Pl leading and below 1650m, correspond to the RAk unit.	3-(4)/B-C	RAk (03)	_	_

Location	Plot No.	BEC Unit	Map Unit (Site Series)	Preliminary Ecological Assumption(s)	Field Site Identification		Comments & Revised Ecological Assumptions	Revisions to Ecological Knowledge Base (Attributes & Ratings)
					Soil Moisture/ Nutrients[1]	Ecosystem Unit (Site Series)		
	C1-8	ICHmw2	RFk (04)	Sites with Douglas-fir (Fd) or western larch (Lw) leading on significant, straight slopes with cool aspects correspond to RFk. Similar sites with deep soils where Fd and Lw are not the leading species correspond to the HFk (01) unit.	3-4/C	HFk (01)	The plot sampled a localized area of HFk dominated by western hemlock (Hw) within a larger map unit identified as having Fd or Lw as the leading species, hence the RFk prediction. The resolution and accuracy of the forest cover mapping data influences the accuracy of the PEM mapping.	- No revisions to the ICHmw2 knowledge table based on this plot. The computer predicted the site correctly based on the forest cover data of Fd or Lw leading.

Mapping inconsistencies and revisions to ecological assumptions and the knowledge base to improve the accuracy of the PEM mapping are detailed in Appendix A. The revised knowledge tables are included with the project dataset and maps (submitted on Compact Disc).

Accuracy Assessment of Preliminary Wildlife Species Accounts and Habitat Ratings for Grizzly bear and Mountain caribou

A summary of the 2002 field-based habitat ratings results for grizzly bear and mountain caribou are presented in Table 3. No field-based habitat ratings were conducted for least chipmunk, which were rated for presence/absence only in the preliminary ratings tables in the Phase 1 report.

Based on a six-class habitat rating scheme, only 3 of the 68 habitat ratings derived from field sampling differ by more than one rating class from the preliminary rating table values. Thirty-three (48.5%) of the field-based habitat ratings were the same as the preliminary habitat ratings. When habitat ratings are grouped into three classes (i.e., classes 1 and 2; classes 3 and 4; and, class 5), 95.6% of the field-based ratings match those of the preliminary ratings for the same rating class groupings.

For grizzly bear, all field-based habitat ratings were within one class of the preliminary habitat ratings. Twenty-four of the 34 (70.6%) of the field-based ratings match ratings from the preliminary habitat rating table.

Table 3: Comparison of preliminary habitat ratings (2001) to field-based habitat ratings (2002) for grizzly bear and mountain caribou

Location	Plot No.	BEC Unit	Map Unit (Site Series)	Preliminary Habitat Ratings (Phase 1 Report 2001)						Suitability Ratings (2002 field ratings)					
				Caribou (6-class)				Grizzly bear (4-class)		Caribou				Grizzly bear	
				WE	WL	PL	SF	PL	SF	WE	WL	PL	SF	PL	S/F
Toby Creek	T1-1	MSdk	SS	4	5	3	4	3	3	4	5	4	5	4	3
	T1-2	MSdk	SGw	3	5	4	4	3	3	3	5	4	4	3	3
	T1-3	MSdk	SGw	3	5	4	4	3	3	4	5	4	4	3	3
	T1-4	ESSFdk	MSdk-SGw	4	5	5	5	3	3	5	5	5	5	3	3
	T1-5	ESSFdk	FSw	4	5	5	5	3	3	5	5	5	5	3	3
Buhl Creek	B1-1	ESSFdku	LG	4	5	4	3	3	3	3	5	4	3	3	2
	B1-2	ESSFdku	FGw-HGw	2	3	2	3	3	2	2	2	3	2	3	2
	B1-3	ESSFdku	LG	2	1	4	1	3	3	1	1	3	1	3	2
	B1-4	ESSFdku	FG	1	1	4	2	3	2	1	1	3	1	3	2
Dewar Creek	D1-1	ESSFwm	FA-FQ	3	3	2	3	3	2	3	2	3	3	2	2
	D1-3	ESSFwm	RAw	3	4	4	4	3	2	5	4	4	5	3	3
	D1-5	ESSFwm	FAw	3	3	2	3	3	2	3	4	1	2	2	2
	D1-6	ESSFwm	FQ	5	4	4	4	3	3	4	5	2	4	2	2
Carney Creek	C1-2	ESSFwmu	FR-FB	3	3	4	3	3	3	4	2	3	2	3	2
	C1-5	ESSFwm	FA	2	2	4	1	2	3	1	2	3	4	3	3
	C1-6	ESSFwm	FRk	3	2	4	3	3	3	2	5	4	3	3	2
	C1-8	ICHmw2	HFk	4	5	4	4	3	3	5	5	5	5	3	3

WE=early winter season
WL=late winter season
PL=spring season
SF=summer/fall seasons

CONCLUSIONS AND RECOMMENDATIONS

ECOLOGICAL KNOWLEDGE BASE & PEM MAPPING

Field sampling was conducted in the Purcell Wilderness Conservancy Provincial Park study area to provide a validation of the ecological knowledge base and to assess the accuracy of the preliminary PEM mapping. Based on fieldwork findings, a number of incorrect classifications were identified on the preliminary maps. This can partly be attributed to the lack of existing ecological data for the park available for developing and "training" the initial knowledge base. The inaccuracy of the preliminary mapping indicates that validation of the knowledge base using an independent data set is essential for assessing and improving the reliability of the initial mapping results.

The field data set of 24 plots is less than the minimum of 30 samples recommended for the validation process and is considered inadequate for such a large study area. The minimum sample size could not be attained due to a limited field sampling budget and difficult, expensive access to the remote areas within the study area. Despite the inadequate sample size, the field sampling provided a wealth of information for validating and revising ecological assumptions, adjusting the knowledge tables and improving the accuracy of the PEM mapping for the study area.

A number of inconsistencies were found between the preliminary mapping and site identification in the field as described in the results. Of 24 sites sampled, 12 map units correlated to single or transitional ecosystem units identified on the ground while the other half of the sites were predicted to be ecologically adjacent ecosystem units compared to the field classifications. The mapping inconsistencies occurred due to incorrect ecological assumptions, missing or incomplete input attribute data and limitations of the input data.

Preliminary ecological assumptions were revised based on fieldwork findings. The revised assumptions were then used as the basis for changing attributes and ratings in the knowledge tables to improve the predictive power of the ecological knowledge base. Through the process of revising assumptions and knowledge tables, many of the mapping problems identified on the preliminary maps were eliminated. Other mapping inconsistencies were corrected by revising or adding new input data. Revisions to input data, ecological assumptions, and attributes & ratings in the knowledge tables based on fieldwork findings are summarized in Table 2 of the Results. Inherent limitations of some of the input attribute data, as discussed below, could not be resolved within the budget of this project.

Revisions to improve the PEM mapping results for the overall project area and for specific biogeoclimatic units in the study area are described in detail in Appendix A.

Avalanche paths were remapped by digitizing individual units on satellite (landsat) imagery and differentiating between chutes and run-out zones on the basis of a slope cut-off (35%) and landscape position. Landsat imagery was reclassified to more accurately predict the distribution of non-vegetated morainal units associated with recent deglaciation and non-forested vegetation units, including meadow, heath and tundra ecosystems, in the high subalpine and parkland zones in the east half of the study area.

Toe slopes were reclassified to help differentiate between mesic and moist site ecosystems on significant slopes. Significant toe slopes now include only those slopes <=35%. Toe slopes >35% are reclassified as concave slopes. Further field investigation would be useful to confirm the validity of using this slope gradient cut-off as a characteristic of toe slopes.

The very steep slope modifiers are now applied to all slopes >70% to be consistent with TEM mapping standards.

A number of changes were also made to ecological assumptions and to attributes and ratings in knowledge tables specific to each biogeoclimatic unit in the study area. Changes were based on fieldwork findings as well as on the review of preliminary maps and air photos where field sampling was limited or lacking in some of the units. The addition of new attributes and changes to attribute ratings correspond to new or updated input data and/or the revised ecological assumptions.

Biogeoclimatic unit boundary input data were revised by raising the elevation of the MSdk boundary on warm aspect slopes. The revision was based on updated information provided by the Nelson Forest Region ecologist. The “calcareous rock” attribute was also revised by adding a new bedrock geology map unit to the input data, which improved ecosystem classification and mapping in the MSdk and ESSFdk subzones.

A number of ecological assumptions about what ecosystems would occur in specific landscape positions were revised for biogeoclimatic units in order to correctly differentiate between closely related ecosystems. Predicting ecosystems on concave shaped terrain and in toe slope positions was particularly difficult for some subzones. As a result, rating values in knowledge tables were most often adjusted for the slope, aspect and surface shape attributes. Tree species composition attributes were also found to be important for predicting ecosystems although the accuracy of the forest cover mapping is suspect and could limit the accuracy of the PEM mapping results. To a lesser extent, the proximity to water attributes was also useful in the predictive mapping process.

Some of the mapping inconsistencies observed within biogeoclimatic units was due the limitations of the input data. The Digital Elevation Model (DEM) does not have the resolution to delineate small topographic units in the landscape as was indicated by DEM classifications of terrain surface shape differing from the terrain classifications determined on the ground. Forest cover input data were also observed to be inaccurate during field sampling where small stands were included in larger timber types with different tree composition. The mapping inconsistencies indicate that the accuracy of the PEM mapping depends upon the resolution and accuracy of the input data for the area, including the DEM and forest cover mapping layers.

Other mapping inconsistencies were due to a lack of input data important for differentiating between units that can occur on similar sites on the landscape. Fieldwork findings indicated that moist to wet ecosystems on level, floodplain sites cannot be accurately predicted without terrain or soil input data to provide information on soil texture and drainage characteristics that determine what ecosystems will occur. Complex units that inclued closely related ecosystems that are difficult to delineate and map, may also occur on active floodplains. In the absence of terrain or soil data, air photo interpretation in conjunction with field checking would be useful for identifying site, soil and forest cover characteristics that could help to differentiate the closely related units on flat, fluvial sites.

In general, more field surveys would be useful for confirming ecological relationships between map attribute data and ecosystem units and for providing data that could be used to further adjust the ecological knowledge base, delineate "difficult to predict" ecosystems, and improve the reliability of the PEM mapping.

WILDLIFE SPECIES ACCOUNTS AND HABITAT RATINGS

The field-based habitat ratings and preliminary rating comparison was based on a sample size of 17 field plots distributed across a relatively large project area. Nonetheless, the results confirm consistency between the preliminary ratings and those derived from field sampling. No additional changes to the grizzly bear and mountain caribou species-habitat models are recommended based on field sampling results.

Provincial-standard wildlife habitat ratings (RIC 1999) provided an efficient and cost effective method for defining mountain caribou and grizzly bear habitat with the Purcell Wilderness Conservancy Provincial Park study area. The ratings accommodated broad local knowledge of caribou and grizzly bear habitat use and behaviour, and the subsequent rating tables were linked to PEM and other map coverages to illustrate the location of grizzly bear and caribou habitat on the landscape. The seasonal habitat ratings assigned during field sampling were consistent with the preliminary habitat ratings.

Although not field-assessed as part of this project, the standardized wildlife habitat ratings approach further accommodated development of an 'expert-based'species habitat model for the red-listed least chipmunk, providing an ecological-based indication of potential habitat within the study area.

The method used to develop the wildlife habitat mapping is one of the few available that addresses both habitat suitability and capability, captures broad local knowledge and uses empirical data (where available) to test and adjust ratings. Most important, the maps can be updated easily if additional studies warrant changes to base map coverages (e.g., PEM) or to the species-habitat models.

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APPENDIX A

Revisions to the Ecological Knowledge Tables based on Fieldwork Findings

A number of revisions were made to the ecological knowledge tables based on the fieldwork findings to improve the validity of the knowledge base and the accuracy of the PEM mapping.

Revisions to Improve Mapping of the Overall Study Area

Avalanche Paths: To deal with the problem of over classification of avalanche paths using satellite (landsat) imagery, avalanche tracks were mapped by digitizing individual units on the landsat imagery of the park. Avalanche chutes and run-out zones were delineated using a slope cut-off of 35% and valley bottom landscape positions. Avalanche run-out zone (AR) units occur in valley bottom slope positions and have slopes <= 35%. Avalanche chute (AC) units have slopes >35% or occur in slope positions above the valley bottoms. To accommodate the new classification, the "avalanche" attribute in the knowledge tables was separated into "avalanche chute" and "avalanche run-out" attributes.

Non-vegetated morainal units: Non-vegetated morainal deposits (MO) are associated with recent deglaciation and are typically found in high elevations basins and upper valleys in close proximity to retreating glaciers and remnant snow fields. The MO unit was delineated using classification of landsat imagery digital data. In the preliminary PEM maps, the non-vegetated unit included large areas of vegetated morainal deposits. The distribution of the MO unit across the landscape was revised by "masking" or removing morainal deposits with vegetation from the classification.

Meadow, heath & tundra ecosystem units: Subalpine meadows and parkland meadow, heath and tundra units were not accurately delineated on the preliminary PEM maps by using the forest cover map input data. In order to correct this problem, the landsat digital data was reclassified to identify non-forested vegetation units in the subalpine and parkland zones that correspond to a narrow range of spectral signatures in the landsat data. Meadow, heath and tundra units are the areas that remain after avalanche path and wetland units with similar signatures are "masked" or removed from the non-forested area classification. Meadows correspond to non-forested areas on gentle slopes and may be in close proximity to water. Heath units typically occur on significant slopes but may also occur on gently sloping sites with drier conditions than meadows and that generally are not in close proximity to water. Tundra ecosystems occur on dry exposed convex upper slopes and ridge tops. Meadow, heath and tundra units were rated in the ESSFdku and ESSFdkp knowledge tables using the new "non-forested – meadow, heath, tundra" attribute. In the ESSFdkp table, the three non-forested units are delineated from each other by using different ratings for the slope, aspect and terrain attributes.

Toe slopes: Toe slopes are areas on the landscape that have a high rate of decreasing slope gradient and represent the flattening out inflection point of the landscape profile. Due to the rapid decrease in slope gradient at toe slopes, down slope water movement tends to be impeded in those landscape positions. Subsurface water flow often moves closer to the surface as drainage is restricted and temporary or permanent seepage within the vegetation rooting zone is often observed. Due to the impeded drainage, toe slopes are often imperfectly to poorly drained and support ecosystems associated with moist to wet site conditions. Based on this ecological relationship between slope position and site moisture, the identification of toe slopes on the landscape is important for predicting ecosystems in the PEM mapping process.

In the preliminary PEM process, toe slopes were identified for significant slopes (slope class 3) up to a slope gradient of 50%. However, impeded water movement and restricted drainage may not occur on steeper toe slopes in slope class 3. An effective increase in site moisture may only occur on the lower gradient slopes. As a way to improve the accuracy of the PEM mapping results, it is recommended to use a toe slope cut-off of 35%. Based on this revision, landscape positions classified as toe slopes in the preliminary PEM are now only considered toe slopes if the slope gradient is <=35%. Sites previously classified as toe slopes with slopes >35% have been reclassified as concave slopes. To accommodate for this revised assumption, the toe slope=3 attribute in the knowledge tables was revised to include the 35% slope cut-off.

Very steep slopes: For the preliminary PEM mapping, the very steep slope modifiers were applied to map units with slopes > 100%. This has been revised so that the very steep modifiers are now applied to units with slopes >70% to be consistent with TEM mapping standards.

Revisions to Improve Mapping in Biogeoclimatic Units

A number of changes were made to ecological assumptions and to attributes and ratings within individual knowledge tables to improve the prediction of ecosystem units within the biogeoclimatic units of the park.

WEST PURCELL MOUNTAINS BIOGEOCLIMATIC UNITS

ICHdw

Due to the limited extent of the ICHdw subzone within the park and a very limited budget for fieldwork, field sampling to verify the mapping in the subzone was not done. As a result, no field data was collected to identify site and stand characteristics that could be used to differentiate between the RFA (01a) and RFB (01b) ecosystem units on gentle, straight slopes and the moist to wet HD (03) and RD (04) units on level, toe slope sites. After a review of the initial PEM maps, the ratings of steep slopes (51-70%) were increased for the DO and RFA units to ensure differentiation of the RFA from the RFB unit on steep cool aspect sites with concave surface shape. The difference between the “71-100%” slope class ratings for the DO and RFA units was increased to give a higher probability to the DO unit for occurring on very steep slope sites. Changes were also made to the warm aspect attribute rating for RFA and to the shallow soil (CV, Mv) attribute rating for the DO unit to predict RFAw on steep, straight warm aspect slopes with deep soils and DOw on sites with similar topographic features but shallow soils.

ICHmw2

Very limited field sampling was done in the ICHmw2 variant along the lower part of sample line C1 in the mid Carney Creek area. The one site sampled on a significant, cool aspect slope in this variant was mapped incorrectly because the stand dominated by western hemlock was included within a larger timber type classified as having Douglas-fir (Fd) or western larch (Lw) as the leading species. "Fd or Lw leading" was considered to be an important attribute for differentiating the submesic RF (04) ecosystem from the mesic HF (01) unit within the ICHmw2. The mapping inconsistency indicates that the accuracy of the PEM mapping depends upon the resolution and accuracy of the input data for the area, in this case the forest cover mapping.

On the preliminary PEM maps, the RFk (04) ecosystem unit was predicted for east facing slopes that are associated with the steep, dry warm aspect slopes on the north side of mid Carney Creek. The warm aspect slopes were predominantly classified as the DFw (03) unit. Some of the RFk map units surrounded by the warm aspect sites may correspond to the DFk unit on sunny cool aspect sites. Based on that assumption, the rating of the lodgepole pine (Pl) leading attribute for the DF unit was increased so as to predict the DFk unit on sunny cool aspects where Pl is the leading species, an important attribute for delineating the DF unit. Some of the RFk map units on sunny cool aspect sites where Pl is not leading may also be more representative of the DFk ecosystem, but that cannot be predicted using the ICHmw2 knowledge table.

Several areas of DFw were predicted on warm aspect sites that are associated with predominantly north and northwest facing slopes on the south side of mid Carney Creek. The DFw units on west facing slopes surrounded by cool aspect sites may actually be RFw units due to the influence of the surrounding terrain, but that can't be determined from the current knowledge base. More field sampling would be useful for investigating the occurrence of the DFk unit on sunny cool aspect sites and the RFw on west facing slopes and for identifying site and stand features that could be used to predict those modified ecosystems.

The moist HOk (05) units mapped along mid Carney Creek occur on significant slopes (25-50%) in toe slope positions. The HOk units may include HFk (01) habitat on the steeper, better-drained slopes of those units. Revisions to the knowledge tables to restrict toe slopes to <=35% and change toe slopes >35% to concave slopes will help to delineate HOk and HFk units on significant slopes.

Due to time constraints, the field crew was unable to sample gentle toe slopes in the ICHmw2 to determine how to differentiate between the HO (05) and RD (06) units that can both occur in those slope positions. There was also no time available to survey floodplain sites along creeks to determine what site or forest cover features might be useful for differentiating the RD (06), RH (07) and CS (08) ecosystem units that can all occur on fluvial parent materials. The current ICHmw2 knowledge table cannot differentiate between the wet RH (07) and CS (08) ecosystems on flat, fluvial sites. The moist-wet RD (06) unit can also occur on similar sites as that unit was observed on a narrow floodplain along mid Carney Creek during field surveys. As a result, the RH (07) unit predicted on the PEM maps may contain areas of RD (06) and CS (08) habitat on the active floodplain sites. Terrain or soil input data may be necessary to help differentiate and accurately map ecosystem units that occur on moist to wet fluvial sites in the ICHmw2 variant.

Cursory field observations in the vicinity of creeks in the park indicated that parent materials are typically coarse-textured along the fast flowing streams in the steep, rugged terrain of the Purcell Mountains. Coarse-textured, sandy and gravelly fluvial materials would tend to be associated with the RD (06) and RD (07) ecosystem units rather than the CS (08) unit that has a higher probability of occurring on finer-textured, silty deposits. Based on that assumption, the CS unit is considered to be limited in distribution along creeks in the narrow valley bottoms of the park. Therefore, the knowledge table was revised to reduce the amount of CS predicted on flat, fluvial sites of the ICHmw2.

ESSFwm

In the ESSFwm subzone, it was assumed that the FA (01) unit on submesic to mesic sites occurred on gentle straight slopes and the moist FQ (04) unit had a higher probability of occurring on gentle concave shaped slopes. In the Dewar Creek area, a site with a concave surface shape was classified as a transitional FA (01) – FQ (04) site and mapped by the PEM process as the FA (01) unit. The site occurred within a larger map unit classified by the Digital Elevation Model (DEM) as having a straight surface shape, so the area was mapped correctly based on the preliminary assumptions. This situation indicates that the accuracy of the PEM mapping depends on the ability of the DEM to delineate topographic units. If the model had the resolution to delineate the smaller concave shaped site, the unit would have been mapped as the FQ ecosystem.

In the Carney Creek sample area, a site identified as the mesic FA (01) ecosystem was mapped as the drier FR (02) unit. The site occurred within a localized area with a concave surface shape resulting in moister site conditions than the surrounding area and the leading tree species being subalpine fir (Bl) and Engelmann spruce (Se) rather than Pl. The localized area occurs within a larger map unit that was classified as having a straight slope and lodgepole pine (Pl) and the leading species. This mapping inconsistency also demonstrates that the accuracy of the PEM mapping depends upon the resolution and accuracy of the DEM and the forest cover mapping.

Another site identified as the FRk (02) unit was mapped as the FAk (01). This inconsistency was based on an incorrect assumption that straight, cool aspect slopes with deep soils would correspond to the FAk unit regardless of tree species composition. The assumption and the "Pl leading" attribute rating in the knowledge table were modified to predict the FRk unit in those topographic units where Pl is the leading species and the site is above approximately 1650m elevation.

The FR (02) and RA (03) ecosystem units occur on similar sites in the ESSFwm subzone but are differentiated on the basis of elevation. The RA unit occurs only below approximately 1650m while the FR unit generally occurs above the elevation. According the Nelson Forest Region ecological field guide, the ICHmw2/ESSFwm boundary occurs at 1500m or higher elevation depending on aspect. Therefore it was assumed that using a 150m vertical cut-off above the boundary would be more accurate for differentiating between the two units as the boundary shifts up and down with changing aspects. This assumption did not work in the Dewar Creek area and the drainage to the west because the ICHmw2/ESSFwm boundary in those areas is mapped below 1500m. As a result, the RA unit was not mapped as high as 1650m but during field sampling, understory vegetation species indicated that the RA unit did occur up to that elevation. To correct the mapping, a 1650m elevation boundary was added to the input data for the above mentioned drainages, and the ICHmw2/ESSFwm boundary attributes in the ESSFwm knowledge table were revised to include a 1650m elevation cut-off.

The dry FG unit, differentiated by whitebark pine in the timber type, was predicted as occurring below 1650m in the ESSFwm subzone rather than the RA (03) unit that occurs on similar sites. The FG unit should only be predicted below that elevation if whitebark pine is actually present on the sites, so the knowledge table was revised by changing the rating of the ICHmw2/ESSFwm boundary attribute for FG to provide the desired mapping results.

Field observations indicated that steeper slopes within the significant toe slope class might correspond to the mesic FA (01) rather than the moist FQ (04) unit. The previously discussed revision to the significant toe slope attribute will help to differentiate between the FA and FQ units on significant slopes.

A moist FQ (04) ecosystem unit was sampled on a flat, fluvial site that was predicted to be the FH unit based on the assumption that level fluvial sites within close proximity to streams correspond to the wet FH ecosystem. The drier FQ unit was associated with coarse-textured, well-drained parent materials that could not be accounted for in the knowledge table. This mapping inconsistency indicates that the moist to wet FQ and FH ecosystems cannot be accurately differentiated on flat, fluvial sites without terrain or soil input data. As a result, the FH unit mapped on level fluvial sites in the ESSFwm may include the slightly drier FQ ecosystem on coarse-textured soils. Air photo interpretation with ground checks in the field could provide a way to collect the data necessary to differentiate between those ecosystems on similar floodplain sites.

After a review of the preliminary PEM maps and field data, it was believed that the wet FH unit may have been overstated in the ESSFwm as it was mapped for all gentle (6-25%) toe slopes. The majority of gently toe slopes may actually correspond to the moist FQ unit, so the knowledge table was revised to overstate the FQ unit in those landscape positions. The rating of the attribute "toe slope=2" was increased for the FQ unit to predict FQ on gentle and significant toe slopes with slopes <= 35%. The FQ unit would also be predicted on flat toe slopes that occur more than 50m from a stream or other water body. As a result of this revision, now the FQ unit may include some FH habitat on gently sloping and flat toe slope sites. The revised knowledge table will predict the FH unit on level fluvial sites in valley bottoms and on flat toe slopes within 50m of water. The revised ecological assumptions are based on minimal sampling in the Dewar Creek area and more field investigations would be necessary to confirm the assumptions.

ESSFwmu

A FB map unit representing moist site conditions was identified in the field as being the mesic FR ecosystem. The site sampled occurred on a gentle convex knoll within a concave shaped cirque basin, so it was slightly drier than the surrounding terrain. The Digital Elevation Model (DEM) did not have the resolution to delineate the localized topographic unit within the larger concave shaped area, hence the misclassification of the site. Once again, this is and example of the accuracy of the PEM mapping being limited by the accuracy of the input data, in this case the DEM digital data.

Before field sampling, it was assumed that the moist FB unit occurred on gentle concave slopes. Based on fieldwork findings, the ESSFwmu knowledge table was revised to predict the FR unit on gentle concave shaped terrain and FB on gentle terrain with both concave surface shape and toe slope attributes. As a result of this revised assumption, the FR unit on concave shaped terrain may include some FB habitat on mesic-subhygric sites.

The WH ecosystem unit may lack whitebark pine (Pa), an important attribute for differentiating the unit, but still be more representative of dry sites than the moister FR unit. To compensate for the lack of Pa in stands on dry sites, topographic and soil depth attribute rating s were revised to predict the WH ecosystem rather than the FR unit on the dry sites. The knowledge tables were revised to predict WH on significant, convex shaped slopes with shallow soils, on steep (51-70%), convex slopes and on steep, straight slopes with shallow soils. The FR unit would be predicted on significant convex slopes with deep soils.

On level, fluvial sites in the ESSFwmu subzone, the WS unit may be overstated on the PEM maps in areas where the moist FB unit could occur on coarse-textured, well-drained fluvial materials.

ESSFwmp

No field sampling was done in this subzone and no revisions were made to the preliminary ecological assumptions or to attribute ratings specific to the ESSFwmp knowledge tables.

East Purcell Mountains Biogeoclimatic Units

MSdk

Several mapping inconsistencies were encountered in this subzone in the Toby Creek area. One of the specific mapping problems identified for the MSdk in the preliminary mapping results was how to differentiate between the LP (04) and SG (01) ecosystem units that can occur in similar topographic position on the landscape. A SGw unit sampled on a significant straight slope with warm aspect was mapped as the LPw unit based on the incorrect assumption that straight warm aspect slopes correspond to the slightly drier LPw unit regardless of tree species composition. Field findings indicated that those topographic positions correspond to the SGw unit where hybrid spruce (Sx) is the leading or second species. The knowledge table was revised to incorporate the revised assumption as described for plot T1-3 in Table 2. A new attribute was also added to help differentiate the LP (04) unit that lacks spruce in mature forests (age class >4) from the SG (01) ecosystem.

Field sampling also confirmed that the MSdk/ESSFdk boundary was mapped too low at about 1500m elevation on the warm aspect slopes above Toby Creek. The boundary has been moved to the higher elevation of 1620m after consultation with the Nelson Forest Region ecologist.

ESSFdk

Limited field sampling was done in this subzone in the Toby Creek drainage. The one site sampled was identified as the FSw (04) but mapped as the FGw (03). The site was mapped correctly based on the initial assumption and input data that the area was underlain by non-calcareous soils. However, the site vegetation corresponded to the FS unit that occurs in similar topographic positions as the FG unit but is typically underlain by calcareous parent materials that increase soil nutrient status. To overcome the mapping inconsistency, the bedrock geology input data was reviewed and revised to include another bedrock unit in the Toby Creek sample area that is classified as having the "calcareous rock" attribute. Sites in that sample area will now be classified as being underlain by calcareous bedrock and the correct ecosystem unit (FS) will be predicted on the steep warm aspect sites. A FGw unit was observed on a significant warm aspect slope underlain by granite (non-calcareous bedrock) in the ESSFdk of the Buhl Creek drainage indicating that the initial assumptions work to differentiate the FG and FS units.

The field crew did not have time to investigate other potential mapping problems in the ESSFdk previously identified in the preliminary mapping results. One of the concerns is that the current knowledge table may result in the FA (01) unit being understated on significant straight slopes in the subzone.

ESSFdku

The ESSFdku subzone was sampled in the Buhl Creek area of the park. A number of mapping problems were identified upon analyzing the field data. The "crown closure class<=1, age class >1" attribute did not work to differentiate the LM ecosystem unit, typically with very open stands, from other units in the subzone. That attribute can be associated with young stands of a number of ecosystems due to slow tree growth in the cold, dry climate of the ESSFdku. The attribute was modified by using "age class >3 (60 years)" to help differentiate the LM ecosystem with low crown closure in older stands from other units, and in particular, the LH unit that can occur on similar sites with steep cool aspect slopes.

A new attribute "La in top two species (>=30%)" was added to the knowledge table and rated for the LM, LH and LG ecosystems to help differentiate those units having alpine larch (La) as a co-dominate species from other units that may have La as an associate species. It was also determined from field sampling that the LH and LG units can occur on sites with convex surface shapes and the terrain attribute ratings were revised in the knowledge table to incorporate those fieldwork findings.

The alpine larch dominated LG and LH units may occupy similar sites in the ESSFdku but the LH unit lacks Engelmann spruce (Se), indicating slightly drier site conditions. The LH ecosystem was rated slightly higher than the LG unit for the "La in top two" attribute, so that the knowledge table will predict LH if Se is not identified in the stand. If Se occurs anywhere in the timber type, then the larch dominated stand will be predicted as the mesic LG unit or possibly the HG unit on moist sites depending on other attributes.

A site on a straight gentle slope classified as a mesic FG unit in the field was mapped as the moister HG ecosystem. This occurred because a significantly higher rating was given for La occurring in the stand of the HG unit. The knowledge table was revised to emphasize the importance of the straight surface shape attribute for differentiating between ecosystems on dry to mesic sites from the moist HG unit that typically occurs on toe and /or concave shaped slopes. Field findings also indicated that La does occur in stands of the FG ecosystem so the unit was given a rating for the attribute "La anywhere in the stand".

A site on a significant toe slope was identified as the moist HGw unit but mapped as the drier FGw unit. On investigation of the input data, it was determined that the site was classified as having a straight slope although it was very close to a toe slope map unit. The site was predicted correctly based on the straight slope classification and preliminary assumptions but the site may have been incorrectly classified as "straight" due to the limitations of the Digital Elevation Model (DEM). The site classification also indicates that significant slopes with concave surface shape may include some HG habitat on mesic-moist sites within the predicted FG units of the ESSFdku.

Moist meadows in the ESSFdku were underrepresented on the preliminary PEM maps because of inaccurate identification of the non-forested units on forest cover maps. Meadows are now mapped using revised satellite imagery input data and methods as previously described. The meadow unit (PW) has been rated as an absolute occurrence (100) for the new attribute " non-forested – meadow, heath, tundra" in the ESSFdku knowledge table.

ESSFdkp

Several changes were made to the ESSFdkp knowledge table based on field observations made during sampling in the Buhl Creek sample area. The attribute "Pa in top two species (>=30%)" was added to the table and given a high rating for the WF unit that has whitebark pine (Pa) as a co-dominant species. This revision will help to differentiate the WF unit from the EM ecosystem that can have Pa as an associate species (<=20%) in stands. The new attribute "La in top two species (>=30%) was also rated for the LM unit, that has alpine larch (La) as a co-dominant species, to help differentiate it from the EM unit that may have La as an associate species only. The warm aspect rating for LM was increased in the knowledge table so that LM would be predicted on significant, concave shaped slopes with warm aspects where La occurs as a co-dominant species.

Tundra (AW), heath (YM) and meadow (DV) ecosystems were all given an equal rating for the new attribute "non-forested – meadow, heath, tundra" that was created using satellite imagery input data. The three non-forested ecosystems are further differentiated based on ratings for slope, aspect and terrain shape attributes.

AT

No field sampling was done in the AT zone and no revisions were made to the preliminary assumptions regarding map attribute-ecosystem relationships or to the knowledge table.