RARE ECOSYSTEMS OF THE BABINE RIVER WATERSHED

Project 2009-1

For:
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EXECUTIVE SUMMARY

Maintaining rare ecosystems is an objective of both the Kispiox and Bulkley LRMPs. Currently there is a lack of information available to assess whether rare ecosystems are being maintained in the Babine River watershed, an area that is governed by both plans. In fact, very little is known about the extent and abundance of rare ecosystems in the watershed. Our objective was to identify rare ecosystems in the watershed using existing data such as field reports, terrestrial ecosystem mapping projects, and predictive ecosystem mapping products. We compared data sources in terms of reliability and quality, and made recommendations about how to address knowledge gaps.

A total of 25 occurrences of eight blue-listed ecosystems were identified in the Babine River watershed. An additional 21 occurrences of seven regionally rare ecosystems are also reported for the area. This list is derived from field observations and excludes interpreted and predicted ecosystems recorded by terrestrial ecosystem mapping and predictive ecosystem mapping. The small number of rare ecosystems reported for the Babine River watershed reflects a low effort to document rare ecosystems in the area.

Existing terrestrial ecosystem mapping (TEM) projects have been primarily designed to address wildlife concerns and the resulting data is insufficient for evaluating rare ecosystems. TEM mapping with high sampling intensity can help guide ground-truthed verifications of potential rare ecosystems.

We believe that predictive ecosystem mapping (PEM) on its own is inadequate to provide reliable information about occurrences of rare ecosystems in the Babine River watershed. Accuracy and resolution issues with PEM models limit their effective use to highlighting areas with the potential for supporting rare ecosystems.

Discussions with local ecologists inform a list of areas that are a high priority for future survey efforts. Additional surveys will be needed to meet the management objective of maintaining rare ecosystems because existing data on the types, numbers, locations and extents of rare ecosystems of the Babine River watershed is insufficient and greatly under-represents the area's true diversity.

INTRODUCTION

The Babine Watershed Monitoring Framework sets priorities for monitoring activities in the Babine River watershed to assess whether land management objectives are being met. One of the main goals of the land management plans is to maintain biological diversity by conserving the distribution, abundance and function of ecosystems.

Rare ecosystems warranted particular attention because they can be more vulnerable to extirpation from disturbance events and land management practices, they can be restricted to very specific substrates, and they can have specialized conditions for establishment and persistence (Drever *et al.* 2010). Haeussler and Hetherington (2000) suggest that rare and endangered ecosystems often share certain traits: unusual climate and geology, unusual or diverse flora and fauna, and unique or complex disturbance dynamics. These characteristics also make them attractive for development. For example, naturally occurring grasslands in sub-boreal regions are often rare. These ecosystems are also often preferred range for cattle farming or recreational uses. Antique forests with prolonged ecological continuity are regularly targeted for timber harvesting.

There are two land resource management plans (LRMP) in the Babine River watershed, which differ slightly in their goals for conservation of rare ecosystems:

> The Kispiox LRMP seeks to maintain structural and functional integrity of red and blue-listed plant communities, with no reduction in functional area.
>
> The Bulkley LRMP calls for retaining representative examples of rare and endangered plant communities within Core Ecosystems. Protected areas (i.e. parks, ecological reserves) and Special Management Zones (Class 1, SMZ1) also contribute to the protection of rare and endangered ecosystems.

Currently there are no data available to assess or monitor the success of these management objectives: whether rare ecosystems are being maintained in the Babine River watershed. In fact, we know very little about the types, locations, extent and abundance of the watershed's rare ecosystems. Neither is there much known about how and why ecosystems are rare, and this strongly affects management decisions. For example, management and conservation priorities will vary if the rare ecosystem occurs as one intact, large area or if it is sparsely distributed over the Babine River watershed. Rare ecosystems are often described in terms of their geographic extent, frequency of occurrence, and size of each occurrence (Izco 1998). Plant communities found within narrow geographic ranges (or narrow ecological niches) and at low frequency in the Babine River watershed are more likely to be at risk than plant communities found at wider ranges and at higher frequency.

The objective of this report is to document all known and predicted occurrences of rare ecosystems in the area administered by the Babine River Monitoring Trust, the Babine River watershed, and to evaluate the reliability and completeness of the existing information.

We summarize information from rare ecosystem surveys, terrestrial ecosystem mapping, biogeoclimatic ecosystem classification plot data, the Vegetation Resources Inventory (VRI) database, and predictive ecosystem mapping projects that have occurred in the Babine River watershed.

The information collected from this study will help prioritize further work on rare ecosystems, and will allow further analysis of the risk and uncertainty associated with monitoring rare ecosystems.

BACKGROUND

What are Rare Ecosystems?

The terms rare ecosystem and rare plant community are used interchangeably in this report and in much of the literature, but they are not equivalent. "Ecosystem" refers to the abiotic (climate, geology, hydrology), biotic (e.g. plant and animal communities) and ecological processes on a given site. "Plant community" refers to the real assemblage of plants on a given site.

In BC, we generally use "plant associations" to describe plant communities. Plant associations (e.g. site series) are classification concepts in the Biogeoclimatic Ecosystem Classification (BEC) system (Pojar *et al.* 1987). Similar plant communities are grouped together according to rigorous classification criteria into plant associations. Plant association is therefore an abstract, classification term to describe a complex interaction of ecological and environmental processes that supports an assemblage of plants.

To complicate matters, the "ecological community" is the standard unit of vegetation used for determining ecological conservation priorities by national and international organizations such as Nature Serve (2012) and the British Columbia Conservation Data Centre (BC CDC 2012). Ecological communities are generally broader ecological units than site series, because an ecological community can occur across more than one site series. For example, cottonwood – spruce - red osier dogwood forests on active floodplains occur on large rivers across many biogeoclimatic zones and subzones. Thus, the BC CDC does not list specific site series as at-risk; however, since site series are more widely recognized in British Columbia, the BC CDC does include site series that have the potential to develop a given ecological community.

There are four definitions of rare ecosystems used by Haeussler (1998), which were originally from the Ministry of Forests working definitions of rare ecosystems:

1. Plant communities listed as "Identified Wildlife" by the Identified Wildlife Management Strategy (2004)(see Definitions section);
2. Ecological communities listed as red or blue by the BC Conservation Data Centre;
3. Ecosystems identified by regional ecologists or rare ecosystems specialists as being rare or significant; and

4. An ecosystem (site series or surrogate) that comprises less than 2% of the landscape unit and is not common in adjacent units.

For the purposes of this study, we use the term “rare ecosystem” broadly to include provincially listed and regionally significant plant communities. Listed ecosystems are occurrences of plant communities ranked as special concern, threatened, or endangered by the British Columbia Conservation Data Centre; or classified as “Identified Wildlife”. Currently, there are 15 plant communities listed as “Identified Wildlife” in BC, but none occur in our region of BC. “Regionally significant” ecosystems are considered by leading ecologists to be rare in the region and with further investigation, some may be provincially listed in the future.

In this report, we also included “sensitive ecosystems”, which are considered ecologically fragile and very vulnerable to human-caused disturbance.

Provincially Listed Plant Communities

The BC Conservation Data Centre (BC CDC) is responsible for collecting and updating information on the status and occurrence of provincially rare ecosystems (or ecological communities). Plant communities are ranked according to their inherent rarity and vulnerability to elimination using a system developed by NatureServe, an international organization of Conservation Data Centres and Natural Heritage Programs all using the same methodology to gather and exchange information on threatened elements. Red and blue lists are designed to simplify the ranking system used by the BC CDC and Nature Serve (Table 1).

The BC CDC prefers not to use the term ‘rare’ because rarity is only one factor that they use to assess the conservation status of an ecosystem (i.e. how at risk the ecosystem is to elimination). We continue to use the term ‘rare ecosystem’ in this report.

In BC, ecosystems are primarily ranked according to the number of known occurrences, but other factors including size, range, protection and threats are also considered if the information is available. There is little available information about the status (e.g. threats, etc.) of northern rare plant communities and current rankings may change with new information.

Table 1. BC Conservation Data Centre definitions of rare elements.

Provincial Rank	Definition	Rank Description	CDC Rank
S1	Critically imperiled	Extreme rarity or some other factor(s) making it especially susceptible to extirpation or extinction. Typically 5 of fewer extant occurrences.	Red
S2	Imperiled	Rarity or some factor(s) making it very susceptible to extirpation or extinction. Typically 6-20 extant occurrences.	Red
S3	Vulnerable	Rare and local, found only in a restricted range (even if abundant at some locations), or because	Blue

Table 1. BC Conservation Data Centre definitions of rare elements.			
Provincial Rank	Definition	Rank Description	CDC Rank
		of some other factor(s) making it susceptible to extirpation or extinction. Typically 21-100 extant occurrences.	
S4	Apparently Secure .	Uncommon but not rare, and usually widespread. Possible cause for long-term concern. Typically more than 100 extant occurrences	Yellow
S5	Secure	Common to very common, typically widespread and abundant, and essentially under no threat under present conditions.	Yellow
SU	Unranked	Due to current lack of available information.	
S#-S#	Range rank	A numeric range (e.g. S2S3) is used to indicate the range of uncertainty about exact status.	
SQ	Question	Question about taxonomy of the rare element.	

Regionally Significant and Sensitive Ecosystems

The current endangered and vulnerable ecosystems listed by the BC CDC are classified according to the Biogeoclimatic Ecosystem Classification (BEC) system. This system has several important limitations and excludes many plant communities that are rare. This is because BEC is a broad classification system based on forested ecosystems—it is a system developed for use in forestry management. Small-sized rare ecosystems, particularly non-forested ones, within a larger more common biogeoclimatic unit often do not get classified, nor are they found on provincial rare plant community lists. There are many non-forested ecosystems or very small landscape features that have not been formally described or ranked in terms of their conservation priority by the BC CDC. For example, avalanche tracks, herbaceous meadows, grasslands, humid cliffs, canyons, hot springs, vernal pools, seepage sites, mineral deposits, and waterfall spray zones have not been formally classified. Several of these plant communities, including many that are vulnerable, are beyond the scope or are simply too small for BEC. Additionally, BEC ecosystem descriptions are mostly based upon climax vegetation, therefore seral plant communities, including specific deciduous forests and herb meadows, are not described for most subzones.

However, there has been recent work to develop a classification system for wetlands (MacKenzie and Moran 2004), for some deciduous seral ecosystems (Williams *et al.* 2001), for subalpine woodland ecosystems (high elevation ESSF forests at the upper limit of forestry operations; Trowbridge and Banner 2004), and for alpine ecosystems, though work on the latter three is ongoing. The BC Conservation Data Centre currently lists very few threatened alpine plant communities (only two for our region). In fact, most of the plant communities currently listed by the BC CDC are forest or wetland ecosystems (e.g. 50 out of 54 ecosystems listed in our region)(BC CDC 2012).

In order to address the limitations in the lists created by the BC Conservation Data Centre, we have also included a list of regionally significant ecosystems. Most of the ecosystems on this list are plant communities identified from Haeussler's work (1998) in the former Bulkley and Kispiox Districts. In her work, she suggested many additions to the BC CDC lists of rare plant communities but few have been incorporated into the provincial lists. Haeussler's suggestions were, however, incorporated into the Bulkley State of the Forest Report (2004).

In our analysis we include sensitive ecosystems because, in many studies that have taken place in the Babine River watershed, key landscape features such as wetlands, avalanche tracks, and riparian shrub areas are not differentiated further than these broad categories. There is not enough information to determine if they are equivalent to listed or regionally significant ecosystems. Future work involving intensive surveys of unusual ecosystems will provide a more accurate list of rare ecosystems in BC, particularly in northern BC, which has received less attention. Even if these ecosystems are never formally listed as threatened by the BC CDC, their loss on the landscape may result in adverse effects to many species and to overall ecosystem health.

STUDY AREA

The Babine River watershed encompasses a large area (approximately 400 000 ha) surrounding the Babine River from its origin at the north end of Babine Lake to its confluence with the Skeena River. The Babine River drains portions of the Babine, Bait, Sicintine and Atna Ranges. It includes the watersheds of its major tributaries – the Nilkitkwa and Shelagyote Rivers, and the Shedin and Nichyeskwa Creeks.

The Babine River watershed lies within the Sub-Boreal Interior Ecoprovince and is divided into two ecosections: the Babine Upland ecosection (BAU) and the Southern Skeena Mountains ecosection (SSM) (Demarchi *et al.* 1990).

The watershed is in transition between the continental climate of the Sub-Boreal Spruce biogeoclimatic zone, and a more coastal temperate climate in the Interior Cedar Hemlock zone.

The following subzones are found within the watershed:

- Sub-Boreal Spruce Zone, Moist Cold subzone, Babine variant (SBSmc2)
- Interior Cedar-Hemlock zone, Moist Cold subzone, Nass variant (ICHmc1)
- Interior Cedar-Hemlock Moist Cold subzone, Hazelton variant (ICHmc2)
- Engelmann Spruce-Subalpine Fir Moist Cold subzone (ESSFmc)
- Engelmann Spruce-Subalpine Fir Wet Very Cold subzone (ESSFwv)
- Boreal Altai Fescue Alpine (BAFAun)

There is an east to west transition from SBSmc2 to ICHmc, and from ESSFmc to ESSFwv. The eastern portion of the watershed experiences slightly colder and drier winters and relatively warm and drier summers (Banner *et al.* 1993). The western portion is generally wetter and milder, and winters are snowier.

In general, a complex of folded and faulted sedimentary and volcanic rocks make up the landforms of the Babine River watershed. There are two types of sedimentary rocks: Skeena and Bowser Lake Groups. Skeena Group rocks are slightly younger, dating from the Lower Cretaceous period (149 to 99 million years ago), and mostly overlay rocks from the Bowser Lake Group, which date from the upper Jurassic to lower Cretaceous (199 to 99 million years). The Bowser Lake and Skeena rocks represent a long period of succession from a time when Bowser Lake was a shallow sea, connected to the Pacific Ocean (Jurassic), until it retracted and became a freshwater lake (Cretaceous)(J. Kyba 2012, *personal communication*). The Bowser Lake rocks were therefore formed from marine sediments whereas the Skeena rocks were formed from lacustrine deposits. The rocks are very similar, being a continuation of the same sediment deposition. They are mostly greywacke, siltstone, mudstone, conglomerate, marl and minor coal (Aldrick 2007, Carter and Kirkham 1969).

Intrusive volcanic rocks are upper Cretaceous to early Jurassic in origin, and are mostly quartz monzonite, granodiorite, quartz diorite, porphyritic and fine-grained equivalents.

The study area was heavily glaciated over many thousands of years. The most recent ice age was the Fraser Glaciation, which began 25,000 to 30,000 years ago and ended between 9,300 and 11,000 years ago (Clague 1984). During the height of the glaciation, the Skeena Mountains were buried by ice to an elevation of 1800 m to 2150 m. Ridgelines above 1800 m are sharp and pointed, while rounded peaks and ridges occur below 1800 m.

There is abundant evidence of glaciation and deglaciation in the study area including U-shaped valleys, drumlins, eskers, meltwater channels, glacially smoothed bedrock with glacial striations, and extensive morainal and glaciofluvial deposits (Oden 2001).

Steep slopes in the study area are mostly bedrock bluffs and outcrops, and the surficial material in these areas, is primarily colluvium when present. On gentle slopes, morainal deposits and organics tend to occur. Lower and mid slopes and valley bottoms are covered by deep morainal and glaciofluvial deposits, as well as fluvial sediments in some cases. Colluvial deposits may occur on lower slopes at the mouths of gullies and near bedrock outcrops.

METHODS

The objective of this project was to document known occurrences of rare ecosystems and to evaluate the reliability and completeness of existing rare ecosystem information. To meet this objective we collated lists of rare ecosystems with the potential of occurring in the study area from provincial and regional sources. We gathered all available vegetation data sources pertaining to the area, analyzed the data to determine the prevalence of rare ecosystems, and assessed the reliability of the data sources. We mapped known occurrences and predicted occurrences of rare ecosystems, and identified high priority areas for further investigation. We consulted with regional ecologists to refine and enhance the list of potential rare ecosystems included in this study, and to inform recommendations for addressing knowledge gaps.

We first compiled a list of rare ecosystems with the potential of occurring in the Babine River watershed. We determined which red and blue-listed ecosystems were likely to occur in the watershed, and produced a second list of other rare or unique ecosystems that are not currently tracked by the BC CDC.

The BC Conservation Data Centre (2012) listed 54 blue and red-listed plant communities in the Skeena - Stikine Forest District (includes former Bulkley, Cassiar and Kispiox Districts), a large region spanning northwards to the Yukon border (Table 2). There are 42 blue-listed plant communities and 12 red-listed communities. Twenty-three listed plant communities have a very low likelihood of occurring in the Babine River watershed because they contain plant species or environmental features that do not occur in the watershed (A. Banner and W. MacKenzie, *personal communication* 2012; Haeussler 1998). Gray-shaded ecosystems have highest potential of occurring in the study area.

Table 2. Plant communities listed by the BC CDC for the Skeena-Stikine Forest District.

Scientific Name	English Name	Biogeoclimatic unit*	BC List	Likelihood of occurrence [1]
Abies amabilis - Thuja plicata / Gymnocarpium dryopteris	Amabilis fir - western redcedar / oak fern	CWHms/04 CWHws/04	Blue	Very low, coastal species.
Alnus incana / Cornus stolonifera / Athyrium filix-femina	Mountain alder / red-osier dogwood / lady fern	ICHmc2/Fl05 ICHmc1/Fl05 *SBSmc2/Fl05*	Blue	Dynamic floodplains - Likely
Alnus incana / Equisetum arvense	Mountain alder / common horsetail	*SBSmc2/Fl01*	Blue	Likely on sluggish portions of floodplain.
Amelanchier alnifolia / Elymus trachycaulus	Saskatoon / slender wheatgrass	*SBSmc2/81 ICHmc1/81 ICHmc2/81*	Red	Possible as isolated south exposures. Shallow to richer bedrock.
Betula nana / Carex aquatilis	Scrub birch / water sedge	SBSmc2/Wf02 ICHmc2/Wf02	Blue	High
Calamagrostis purpurascens Herbaceous Vegetation	Purple reedgrass Herbaceous Vegetation	BAFA CMA MHmmp	Red	Low, would be most easterly extent of this ecosystem.
Carex lasiocarpa / Drepanocladus aduncus	Slender sedge / common hook-moss	SBSmc2/Wf05 ICHmc2/Wf05 ICHmc1/Wf05	Blue	High
Carex limosa - Menyanthes trifoliata / Drepanocladus	Shore sedge - buckbean / hook-mosses	SBSmc2/Wf08	Blue	High

Table 2. Plant communities listed by the BC CDC for the Skeena-Stikine Forest District.				
Scientific Name	English Name	Biogeoclimatic unit*	BC List	Likelihood of occurrence [1]
spp.				
Carex limosa - Menyanthes trifoliata / Sphagnum spp.	Shore sedge - buckbean / peat-mosses	ICHmc1/Wb13	Blue	Moderate
Carex sitchensis - Oenanthe sarmentosa	Sitka sedge - Pacific water-parsley	CWH/Wm50	Blue	Very low. Coastal wetland.
Carex sitchensis / Sphagnum spp.	Sitka sedge / peat-mosses	CWH/Wf51	Red	Very low , coastal wetland
Eleocharis palustris Herbaceous Vegetation	Common spike-rush Herbaceous Vegetation	*SBSmc2/Wm04*	Blue	Moderate - high
Eleocharis quinqueflora / Drepanocladus spp.	Few-flowered spike-rush / hook-mosses	ESSFmc/Wf09 SBSmc2/Wf09	Red	High
Equisetum fluviatile - Carex utriculata	Swamp horsetail - beaked sedge	SBSmc2/Wm02	Blue	High
Eriophorum angustifolium - Carex limosa	Narrow-leaved cotton-grass - shore sedge	ESSFmc/Wf13	Blue	High
Larix laricina / Carex aquatilis / Tomentypnum nitens	Tamarack / water sedge / golden fuzzy fen moss	BWBS/Wb06 SBSwk2/Wb06	Blue	Very low. Tamarack does not occur in area.
Larix laricina / Menyanthes trifoliata - Carex limosa	Tamarack / buckbean - shore sedge	BWBS/Wf18	Blue	Very low. Tamarack does not occur in area.
Menyanthes trifoliata - Carex lasiocarpa	Buckbean - slender sedge	*SBSmc2/Wf06*	Blue	High
Myrica gale / Carex sitchensis	Sweet gale / Sitka sedge	CDF/Wf52 CWH/Wf52	Red	Very low, coastal ecosystem.
Picea engelmannii x *glauca - Betula papyrifera / Oplopanax horridus*	Hybrid white spruce - paper birch / devil's club	ICHmc2/54	Blue	High
Picea glauca - Picea mariana / Ledum groenlandicum / Aulacomnium palustre	White spruce - black spruce / labrador tea / glow moss	BWBS/Ws15	Blue	Low, boreal ecosystem
Picea glauca / Ribes triste / Equisetum spp.	White spruce / red swamp currant / horsetails	BWBS/110	Blue	Low. Boreal ecosystem.
Picea mariana / Equisetum arvense / Sphagnum spp.	Black spruce / common horsetail / peat-mosses	SBSmc2/Wb09	Blue	Moderate

Table 2. Plant communities listed by the BC CDC for the Skeena-Stikine Forest District.				
Scientific Name	English Name	Biogeoclimatic unit*	BC List	Likelihood of occurrence [1]
Picea mariana / Gaultheria hispidula / Sphagnum spp.	Black spruce / creeping-snowberry / peat-mosses	*SBSmc2/Wb01*	Blue	High
Picea mariana / Lysichiton americanus / Sphagnum spp.	Black spruce / skunk cabbage / peat-mosses	ICHmc2/Ws09	Blue	Moderate in ICH
Picea mariana / Menyanthes trifoliata / Sphagnum spp.	Black spruce / buckbean / peat-mosses	ICHmc2/Wb11	Blue	Moderate in ICH
Picea mariana / Vaccinium vitis-idaea / Sphagnum spp.	Black spruce / lingonberry / peat-mosses	BWBS/Wb03	Blue	Very low. Boreal.
Picea sitchensis / Lysichiton americanus	Sitka spruce / skunk cabbage	CWHwm/09	Blue	Very low. Coastal
Picea sitchensis / Rubus spectabilis Wet Maritime	Sitka spruce / salmonberry Wet Maritime	CWHwm/05	Blue	Very low. Coastal ecosystem
Picea sitchensis / Rubus spectabilis Wet Submaritime 2	Sitka spruce / salmonberry Wet Submaritime 2	CWHws2/07	Blue	Very low. Coastal ecosystem.
Pinus albicaulis / Cladonia spp. - Dicranum fuscescens	Whitebark pine / cladonia lichens - curly heron's-bill moss	ESSFmk/02 ESSFmk/03 *ESSFmc/02*	Blue	Low, except if whitebark found in ESSFmc then high likelihood.
Pinus contorta / Arctostaphylos uva-ursi	Lodgepole pine / kinnikinnick	CWHws1/02 CWHws2/02	Red	Very low. Coastal ecosystem
Pinus contorta / Carex aquatilis / Sphagnum spp.	Lodgepole pine / water sedge / peat-mosses	*ICHmc2/Wb07*	Blue	Moderate in ICH
Pinus contorta / Carex pauciflora / Sphagnum spp.	lodgepole pine / few-flowered sedge / peat-mosses	ESSFmc/Wb10 SBSmc2/Wb10	Blue	High
Pinus contorta / Juniperus communis / Oryzopsis asperifolia	Lodgepole pine / common juniper / rough-leaved ricegrass	SBSdk/02 *SBSmc2/02*	Blue	Similar site might occur in very dry habitats in SBSmc2. Dry outwash, south facing.
Poa glauca ssp. *rupicola* Herbaceous Vegetation	Glaucous bluegrass Herbaceous Vegetation	BAFA/00	Blue	Nearest occurrence to far north of study area. Analogous sites may occur.

Table 2. Plant communities listed by the BC CDC for the Skeena-Stikine Forest District.

Scientific Name	English Name	Biogeoclimatic unit*	BC List	Likelihood of occurrence [1]
Poa secunda ssp. *secunda - Elymus trachycaulus*	Sandberg's bluegrass - slender wheatgrass	*SBSmc2/82* *ICHmc2/82*	Red	Possible on isolated south slopes in ICHmc and SBSmc2
Populus balsamifera (ssp. *balsamifera*, ssp. *trichocarpa*) - *Picea* spp. / *Cornus stolonifera*	(Balsam poplar, black cottonwood) - spruces / red-osier dogwood	*SBSmc2/Fm02* *ICHmc2/Fm02* *ICHmc1/Fm02*	Red	Very high
Populus balsamifera ssp. *trichocarpa - Abies lasiocarpa / Oplopanax horridus*	Black cottonwood - subalpine fir / devil's club	ICHm1/Fm03 ICHmc2/Fm03	Blue	Moderate
Populus balsamifera ssp. *trichocarpa - Alnus rubra / Rubus spectabilis*	Black cottonwood - red alder / salmonberry	CWHws2/08	Blue	Very low. Coastal.
Pseudotsuga menziesii / Pleurozium schreberi - Hylocomium splendens	Douglas-fir / red-stemmed feathermoss - step moss	IDF SBSdk	Blue	Very low, no Douglas fir in study area
Salix bebbiana / Calamagrostis canadensis	Bebb's willow / bluejoint reedgrass	SBSdk/Ws03 BGxw1/Ws03	Blue	Low to Moderate
Salix drummondiana / Calamagrostis canadensis	Drummond's willow / bluejoint reedgrass	*SBSmc2/Fl05*	Blue	High
Salix exigua Shrubland	Narrow-leaf willow Shrubland	BGxh3/Fl06 BGxw1/Fl06	Red	Low – on very large river systems
Salix lucida ssp. lasiandra / Cornus stolonifera / Equisetum spp.	Pacific willow / red-osier dogwood / horsetails	BWBS/Fl03	Red	Low
Salix maccalliana / Carex utriculata	MacCalla's willow / beaked sedge	*SBSmc2/Ws05*	Blue	High
Scheuchzeria palustris / Sphagnum spp.	Scheuchzeria / peat-mosses	ICHmc2/Wb12 SBSmc2/Wb12	Blue	High
Trichophorum alpinum / Scorpidium revolvens	Hudson Bay clubrush / rusty hook-moss	SBSmc2/Wf10	Red	High
Trichophorum cespitosum / Campylium stellatum	Tufted clubrush / golden star-moss	ICHmc2/Wf11 *SBSmc2/Wf11*	Blue	High
Tsuga heterophylla - Picea sitchensis / Hylocomium splendens	Western hemlock - Sitka spruce / step moss	CWHwm/02	Blue	Very low. Coastal ecosystem.
Tsuga heterophylla - Pinus contorta / Pleurozium schreberi	Western hemlock - lodgepole pine / red-stemmed feathermoss	CWHws1/03 CWHws2/03	Blue	Very low. Coastal ecosystem.

Table 2. Plant communities listed by the BC CDC for the Skeena-Stikine Forest District.				
Scientific Name	English Name	Biogeoclimatic unit*	BC List	Likelihood of occurrence [1]
Tsuga heterophylla / Arctostaphylos uva-ursi / Cladonia spp.	Western hemlock / kinnikinnick / clad lichens	ICHmc1/02 ICHmc2/02	Blue	High
Tsuga heterophylla / Rubus chamaemorus / Sphagnum spp.	Western hemlock / cloudberry / peat-mosses	ICHmc2/Wb04	Red	Moderate to high
Tsuga heterophylla / Sphagnum girgensohnii	Western hemlock / common green peat-moss	CWHwm/08	Blue	Very low. Coastal ecosystem.

*Biogeoclimatic unit refers to subzone and site series combinations that may host the listed plant community. Italics in this column refer to analogous site series that may support the listed plant community but are not yet known by the BC CDC to do so.
[1]Likelihood of occurrence in Babine River watershed was determined by interviewing regional experts and by examining ranges of the plant communities and plant species.

In addition to the provincially listed ecosystems, we included ecosystems that Haeussler (1998) proposed for conservation status assessment and listing by the BC CDC, based on their threats and restricted distributions in the region (Table 3). Included in this table are other regionally significant ecosystems recommended for conservation or special consideration by other ecologists. Gray-shaded ecosystems have not been formally described.

Table 3. Regionally rare plant communities potentially occurring in the Babine River watershed.				
Scientific name	Ecosystem Name	Suggested List	Bio-geoclimatic units	Notes
Abies lasiocarpa - Pinus contorta - Cladonia	Subalpine fir -lodgepole pine – Cladonia	was Blue#	ESSFwv/02	If white bark pine is present, then equivalent to listed ESSFmk/02.
Abies lasiocarpa - Pinus contorta - Juniperus communis - Cladonia spp.	Subalpine fir - lodgepole pine - juniper - lichen	was Blue#	ESSFmc/02	If white bark pine is present, then equivalent to listed ESSFmk/02.
Amelanchier alnifolia - Agropyron trachycaulon	Saskatoon - slender wheat grass scrub steppe	Red	ICHmc2/81*	Equivalent to red listed SBSdk/81

Table 3. Regionally rare plant communities potentially occurring in the Babine River watershed.				
Scientific name	Ecosystem Name	Suggested List	Bio-geoclimatic units	Notes
Calamagrostis canadensis - *Poa* spp.	Blue-joint fowl - bluegrass wet floodplain grassland	Further surveys required	SBSmc ICHmc	Uncertain of conservation. Part of floodplain mosaic.
Carex spp. - *Equisetum* spp.	Sedge - horsetail semiaquatic backchannels	Further surveys required	SBSmc ICHmc	Uncertain of conservation. Part of floodplain mosaic.
Danthonia intermedia grassland	Timber oatgrass dry grassland	Red in SBSmc2 and SBSdk; Blue in ESSF?	SBSdk SBSmc2 ESSFmc ESSFwv	Xeric to submesic grassland community. Found on fluvial deposits.
Dryas drummondii - *Astragalus alpinus*	Yellow mountain avens - alpine milk vetch sand and gravel bars	Further surveys required	SBSmc ICHmc	Uncertain of conservation rank. Part of floodplain mosaic.
Heracleum maximum - *Geum macrophyllum* - *Bromus* spp.	Cow parsnip -large leaved avens - stinging nettle - brome lush meadows	Blue	SBSmc2 ICHmc	Lush meadow community is significant at low elevations.
Juniperus scopulorum - *Amelanchier alnifolia*	Rocky mountain juniper savanna-steppe	Red	ICHmc2/81	Equivalent to red listed SBSdk/81; more Juniper in this variation.
Picea glauca x sitchensis - *Betula papyrifera* - *Oplopanax horridus* - *Athyrium felix-femina*	Hybrid spruce - paper birch - devil's club - lady fern	Blue	ICHmc2/05	ICHmc2/05 is similar to listed CWHws2/07. Seral version (54) is listed.
Picea mariana - *Picea glauca x sitchenis* - *Betula nana* - *Carex* spp.	Black spruce - hybrid white spruce - scrub birch -sedge	Blue/Red	ICHmc2/08	Peatland ecosystems are rare in ICHmc, This is the SW extent of black spruce.
Picea mariana - *Pinus contorta* - feathermoss	Black spruce - Lodgepole pine - Feathermoss	was Blue#	SBSmc2/03	Upland black spruce forests are rare in the region.
Populus tremuloides- *Betula papyrifera* - *Corylus cornuta* - *Cornus stolonifera*	Trembling aspen - paper birch - beaked hazelnut - red osier dogwood	Blue	ICHmc2/53	Blue listing suggested for highly productive sites with birch dominating.
(Populus tremuloides) - *Prunus serotina* - *Prunus pennsylvanica* -*Corylus cornuta*	(Trembling Aspen)-wild cherry- beaked hazelnut scrub or woodland	Red	ICHmc2/53 ICHmc2/52	Subset of the site series that develops after repeated fire. Anthropogenic.

Table 3. Regionally rare plant communities potentially occurring in the Babine River watershed.				
Scientific name	Ecosystem Name	Suggested List	Bio-geoclimatic units	Notes
Pteridium aquilinum - Heracleum maximum - Fritillaria camschatcensis	Bracken - cow parsnip - riceroot meadow	Red	ICHmc2	SE extent of bracken fern occurs in Skeena region. Rare version of cow parsnip meadow.
Salix exigua - Elaeagnus commutata	Sandbar willow - wolf willow sand and gravel bars	Further surveys required	SBSmc2 ICHmc	Uncertain of conservation value. Similar to Fl06, which is red-listed by the BC CDC.
Salix scouleriana - Oplopanax horridus$	Scouler's willow - devil's club seral association	Further surveys required	SBSmc2 ICHmc2	Very large willows, found on north-facing aspects. Similar to Scouler's willow - thimbleberry but wetter.
Spiraea douglassi - Thalictrum occidentale - Valeriana dioica	Hardhack - Meadow rue-Valerian fluvial shrub/meadow	Red	ICHmc2	Submesic to mesic meadow component is very rare.
Thuja plicata - Betula papyrifera$	Western redcedar - paper birch seral forests	Further surveys required	ICHmc2/53?	North-facing version of this seral association.
Thuja plicata - Picea glauca x engelmanni - Oplopanax horridus - Lysichiton americanum	Western redcedar-hybrid white spruce - devil's club - horsetail-skunk cabbage	was Blue#	ICHmc2/07	Productive variations on former stream channels are very rare.
Tsuga heterophylla - Menziesia ferruginea - Lysichiton americanum	Western hemlock-azalea-skunk cabbage	was Blue#	ICHmc1/06	Very similar to ICHcm2/07 but without cedar.
Various species	Canyon walls and rock cliffs	Unknown	All zones	Those with unique bedrock geology, microclimate and species composition are most highly valued.
Various species	Mesic (montane) forb meadows	Red in SBSmc2, ICHmc. Blue in ESSF	All zones	Level inactive fluvial deposits with fine-textured capping over gravels, often south-facing.
Various species	Water falls	Unknown	All zones	Spray zone communities. Coastal species inland.
Various species	Beaches and shores	Unknown	All zones	Beach and shore

Table 3. Regionally rare plant communities potentially occurring in the Babine River watershed.				
Scientific name	Ecosystem Name	Suggested List	Bio-geoclimatic units	Notes
				ecosystems on lakes are very rare in northern BC.
Woodsia spp. - Polypodium spp. - Artemisia spp.	*Woodsia - Polypodium - Artemisia* canyon walls	Red	ICHmc1 ICHmc2	Steep, rocky walls and cliffs with warm aspects at low elevations.

#Blue-listed ecosystems in 1998 but in 2012, they are no longer listed. Haeussler (1998) reported that they were worthy of listing.
$Recommended by A. Banner (2012, *personal communication*)

We then summarized existing information about rare ecosystems in the study area. Current sources of information for rare ecosystems in the Babine River Watershed consist of one rare ecosystem inventory, the B.C. Ministry of Forests' biogeoclimatic ecosystem classification (BEC) database, the BC Ministry of Forests' Vegetation Resources Inventory (VRI) database, terrestrial ecosystem mapping projects (including historical mapping of ecosystems), predictive ecosystem mapping projects, bedrock geology maps, plant distributions, and other reports from a variety of sources.

Using all of these sources of information, we compiled lists and maps of known occurrences of rare ecosystems for the Babine River watershed. All datasets were projected into UTM 9N, NAD 83 for mapping and querying. Mapping was conducted using ARCVIEW GIS (version 9.3).

There are many instances when not enough detail was provided to determine whether an ecosystem fit the description for a rare plant community on the BC CDC or regionally rare lists. For example, in most of the mapping projects conducted in the study area, wetlands were often characterized simply as non-forested wetlands or fens (the most common type in this area) rather than a specific wetland plant community because these projects were completed before the wetland classification was developed. Most of the mapping projects were undertaken to assess wildlife habitat, and a designation of non-forested fen provides sufficient information for habitat mapping, but not for rare ecosystem determination. Other ecosystems such as avalanche tracks and herb meadows were delineated, but species composition was not provided, therefore it was not possible to assign them to a distinct plant association. And yet these communities—wetlands, avalanche tracks and herb meadow—are all potentially rare and sensitive to disturbance.

We thought that it was important to include this wider group of sensitive and understudied ecosystems to make the most complete use of existing data. Sensitive ecosystems are defined as plant communities that are susceptible to damage or disruption by external factors, and particularly human-caused effects (RISC 2006). Examples include wetlands and riparian areas that are very vulnerable to changes in the hydrological regime. Including sensitive ecosystems allowed us to capture potentially rare ecosystems that have been mapped, but that do not have enough information to determine which plant association they belong to.

We compared the reliability and quality of the data from all vegetation mapping projects conducted in the Babine River watershed. For example, ground-truthed mapping projects have higher reliability than predictive ecosystem mapping projects because plant communities are actually recorded in the field rather than predicted by modeling. We also discussed weaknesses and strengths of the existing information and of mapping methods, and we have made recommendations about what can be assessed with the available data. A comparison was made between predicted and known occurrences of rare ecosystems. We discussed how this impacts rare ecosystem detection and conservation in the Babine River watershed.

Using this analysis, we made recommendations about areas within the Babine River watershed that may require further inventory or have high potential for supporting rare ecosystems. We also made a priority list for future work on rare ecosystem inventories in the Babine River Watershed.

To facilitate our evaluation of the area's potentially rare ecosystems and to prioritize areas for future work, we have held interviews with ecologists who have extensive knowledge of rare ecosystems in the region: Jim Pojar, Will MacKenzie, Allen Banner, and Sybille Haeussler. We have also studied relevant geology maps to prioritize field-based rare ecosystem surveys.

RESULTS

Rare Ecosystem Inventory

Rare ecosystem surveys are performed with the specific goal of identifying provincially rare and sensitive ecosystems in a given area, using standardized methods (RISC 2006, de Groot and Bartemucci 2003). This type of inventory ranks highest in reliability and quality of data because the surveyor is focusing on anomalies in the study area, not the most common ecosystems.

Rare ecosystem surveys have not been completed in the Babine River Corridor Park (de Groot and Bartemucci 2003), nor have they been done specifically for the Babine River watershed (de Groot 2004).

Haeussler (1998) surveyed rare ecosystems and collected field data from three locations within the Babine River watershed. Only a very small portion of the Babine River watershed was surveyed, specifically, two adjacent sites in the Nilkitkwa River valley and one site at the confluence of the Skeena and Babine Rivers. This was part of a large project to inventory and assess rare ecosystems in the southeastern Skeena Region (including the former Bulkley and Kispiox Forest Districts). The majority of her project occurred in the SBSdk subzone along the Bulkley River.

Haeussler (1998) documented six rare ecosystems within the Babine River watershed, two that are currently blue-listed by the BC Conservation Data Centre and four that were recommended for listing by her study. Fluvial meadows found in the Nilkitkwa River valley appeared to be extensive (approximately 10 meadows were observed), though only two were fully surveyed.

Table 4. Rare ecosystems in the Babine River watershed identified in field surveys by Haeussler (1998).

Subzone/Site series	Plant community	List	Location	Notes
ICHmc2/02(51) to /81	Western hemlock – Kinnikinnick –Cladonia lichens; Saskatoon – slender wheat grass	Blue	Confluence of Skeena and Babine Rivers	Grading to ICHmc2/81 but poor 81. Some ICHmc2/51.
ICHmc2/54	Hybrid white spruce – paper birch – devil's club	Blue	Confluence of Skeena and Babine Rivers	Grading to ICHmc2/06 (also rare). Small area.
ICHmc2/53	Hybrid spruce – paper birch – thimbleberry -hazelnut	*Blue**	Confluence of Skeena and Babine Rivers	Very nice representation of pure paper birch stand.
ICHmc2/52	Trembling aspen – paper birch – red osier dogwood	*Blue**	Confluence of Skeena and Babine Rivers	Small unit in with ICHmc2/53 (above). Birch dominated.
SBSmc2 and ESSFmc	Fluvial *Ranunculus*-dominated meadows	*Blue**	Nilkitkwa River, near Mero and Barbeau Creeks	There are approximately 10 similar meadows nearby.
ESSFmc/02	Subalpine fir – lodgepole pine –juniper - lichen	*Blue**	Confluence of Nilkitkwa and Barbeau Creek	This is a large, extensive park-like expanse of this ecosystem.

Orange-shaded ecosystems are blue-listed by the BC Conservation Data Centre (2012).
*Represents ecosystems that have been proposed for listing by Haeussler (1998). Italics refer to her suggested conservation rank.

Terrestrial Ecosystem Mapping Projects in the Study Area

Six Terrestrial Ecosystem Mapping (TEM) projects have occurred within the Babine River watershed. Most of the projects were undertaken with the purpose of characterizing habitat suitability and availability for wildlife, specifically for bears (Table 5). The projects cover most of the Babine River watershed except for approximately one-third of the watershed to the north and a few sections at the southern and eastern edges (Map 1).

Table 5. Terrestrial Ecosystem Mapping projects done within the Babine River watershed.					
Surveyors	Location	Purpose	Rare Ecosystems found	Year	Source of information
Lea and Kowall	Babine River corridor	Bear habitat	yes	1992	Digital map data and report
Madrone	Big Slide area (6000 ha area at Babine River-Thomlinson Creek Confluence)	Wildlife habitat and terrain stability	yes	1994	Report
Oikos	Upper Nilkitkwa River drainage	Wildlife habitat	yes	1998	Digital mapping data
Turney and Blume	Tommy Jack Pass area (190 polygons, 13 463 ha)	Wildlife habitat	yes	2000	Digital map data and report
D. Wellwood	Southern Park Access area, near Nilkitkwa Lake (70 polygons, 1449 ha)	Wildlife habitat	yes	2007-8	Report and plot cards
MOF BEC database	Mapsheets 93L and 93M north of 55°N	Various purposes	yes	1975-2012	Digital ecosystem data

TEM provides visually interpreted ecosystems (BEC site series or groups of site series) in polygons based upon air photo interpretation in association with geomorphology, topography, and soils information. The resulting terrestrial ecosystem maps are therefore representations of the landscape. As representations, TEM projects are described in terms of their accuracy, which is sometimes improved by lumping ecosystems that are difficult to separate. While improving the accuracy, lumping ecosystems reduces the resolution (the level of detail) of the mapping. As a consequence smaller, rare ecosystems tend to be absorbed into larger, more common ecosystems.

Scale is an important factor in terrestrial ecosystem mapping projects. Small-scale mapping (e.g. 1: 50 000) generally results in maps with less detail, and polygons are larger and tend to include more than one ecosystem. Ecosystems that are small (less than several hectares in size) are often not recognized and are therefore not mapped. The scale 1:20,000 is commonly used for TEM projects. At this scale 1 cm on a map represents 200 m on the ground. This scale is suitable for many purposes including forestry management and habitat mapping for large mammals, but it is too coarse to recognize ecosystems smaller than 1 hectare.

We have listed the goals of each project because these inform the resulting data and may cause limitations, though efforts are often made to use the products of these projects, GIS maps, to evaluate additional resources. For example, in the Babine River watershed several mapping projects have been undertaken with the goal of assessing bear habitat. Using the results of these TEM projects to evaluate rare ecosystems presents a number of problems because bear habitats and rare ecosystems are different ecological parameters occurring at different scales and in different locations within the same landscape.

The accuracy of TEM is often determined by field-checking a percentage of the polygon determinations. Ecosystem surveys range from very detailed ecological information derived from “full plots”, to a brief description in “ground inspection forms” and to very rapid “visual checks”. There are standards in place for the sampling intensity (percentage of polygons verified) and the ratio of full plot : ground inspection : visual checks. Sampling level 4 is recommended for most mapping projects where 15-25% of the polygons are verified and the ratio of plot types is 5:20:75 (RIC 1998).

Terrestrial ecosystem mapping projects that have high levels of sampling intensity and field verification provide useful information for identifying rare ecosystems. Information about the area and distribution of ecosystems is provided, and when plot data is available, detailed ecological descriptions support the mapping. However, TEM projects are not always completed at the sampling level (4) that is recommended for most mapping, and very few are completed at the level of sampling recommended in the standards for sensitive ecosystem inventories (RISC 2006). Standards set for sensitive ecosystem inventories (SEI) recommend a scale of up to 1:1000, 76-100% polygon inspection, and a ratio of 2 full plots: 98 ground inspection forms : 0 visual checks (RISC 2006).

BABINE RIVER BIOPHYSICAL HABITAT MAPPING

Lea and Kowall (1992) completed a map of biophysical habitat units (different classification system than the BEC system) of the Babine River corridor and adjacent map sheets. They mapped 251 836 ha in the Babine River watershed. The goal of this project was to assess grizzly bear habitat availability, not to assess rare ecosystems. The mapping was done at a small scale (1:50 000) and we have found little documentation to support their ecosystem classification methods, which are less detailed than terrestrial ecosystem classification methods. For example, there were no quantitative vegetation or soils descriptions available in the biophysical habitat unit descriptions. There were, however, lists of dominant plant species for each habitat unit and seral stage.

There is uncertainty in how these broad units relate to provincially-listed and regionally rare plant communities. All we can deduce from this classification is whether the units described have potential to support rare plant communities. In Table 6, we have ranked potentially rare habitat units according to their likelihood of supporting rare ecosystems: orange shading being high, gray shading being moderate likelihood. Map 2 shows the distribution of habitat units that have moderate to high likelihood of supporting rare ecosystems. Because Lea and Kowall (1992) mapped up to three habitat units (as deciles) per polygon, more than one rare ecosystem can co-occur in polygons. When this happened, we mapped the more dominant rare ecosystem (i.e. the ecosystem that covered largest percentage of the polygon). As a consequence, Map 2 may over-represent rare ecosystems that occur with common ecosystems, and may under-represent rare ecosystems that occupy very small areas in association with other rare ecosystems (for more information, see discussion of composite polygons in Nilkitkwa TEM study [below]).

Table 6. Babine River biophysical habitat units that may support rare plant communities.				
Biophysical habitat unit	Area (ha)	Subzone/Site series	Notes	Likelihood of supporting rare ecosystems
Sitka alder – cow parsnip avalanche chutes (AC)	1811 ha	ICHmc1 ESSFmc ESSFwv	At low elevation, avalanche chutes are rare (ICHmc). Lush meadows at toe slope are similar to those proposed for blue listing (Haeussler 1998).	Low likelihood for supporting rare ecosystems on current BC CDC and regionally rare lists.
Black spruce – Labrador tea – Sphagnum bogs (BS)	1760 ha	ICHmc2 SBSmc2	Acidic peat bogs are rare in these subzones. Black spruce attains its southwest extent in study area. Sparsely treed peatlands may be extremely rare in the ICHmc (Haeussler 1998)	Moderate
Sitka alder – spiny wood fern seepage area (AF)	5478 ha	ICHmc1 SBSmc2 ESSFmc ESSFwv	Lush vegetation on steep, cool slopes. Rich seepage.	Low
Hybrid spruce – black twinberry floodplain forests (ST)	2964 ha	ICHmc1 SBSmc2	Floodplain forests are rare in SBSmc2 and in ICHmc1. Could be equivalent to ICHmc1/06 or Fm02.	Moderate
Thimbleberry – cow parsnip meadows (TC)	16 ha	ICHmc2 SBSmc2	Very lush and diverse, on fluvial fans. Similar to fluvial meadow complexes proposed for listing by Haeussler (1998) and de Groot (2006).	High
Sedge – Sitka valerian moist meadows (SV)	3578 ha	ESSFmc ESSFwv AT	Uncertain of rarity. Low level of inventory and classification of these ecosystems.	Low
Willow – dwarf blueberry shrub carr (WB)	118 ha	SBSmc2	Cold air drainage, valley bottom associations. Uncertain of rarity.	Low
Willow – sedge wetlands (WS)	156723 ha	ICHmc1 ICHmc2 ESSFwv ESSFmc	Not enough ecological information to determine if these contain rare elements.	Low
Trembling aspen – Douglas maple south-facing forest (AM)	12495 ha	SBSmc2	Seral aspen forest. No classification of seral association in SBSmc2. Subset may be rare.	Low
Trembling aspen – paper birch -	1090 ha	ICHmc2	Birch-dominated ICHmc2 seral associations	High

Table 6. Babine River biophysical habitat units that may support rare plant communities.				
Biophysical habitat unit	Area (ha)	Subzone/Site series	Notes	Likelihood of supporting rare ecosystems
beaked hazelnut fluvial or morainal forests (AH)			(ICHmc2/52 and /53) were considered to be rare by Haeussler (1998).	
Paper birch – red osier dogwood moist fluvial fans (BD)	485 ha	ICHmc2	Maybe equivalent to blue-listed ICHmc2/54. Pure stands of birch are uncommon and potentially very rare.	High
Paper birch – falsebox south aspect forests (BF)	1051 ha	ICHmc2	Seral birch-dominated forests. May be regionally rare seral associations (ICHmc2/52 and /53)	Moderate
Black cottonwood – red osier dogwood floodplains (CD)	118 ha	ICHmc SBSmc2	Likely these floodplains support rare ecosystems. The following blue listed ecosystem could occur (ICHmc1/06, ICHmc2/05 and SBSmc2/Fm02) in the habitat unit.	High
Lodgepole pine – soopolallie fluvial terrace (LS)	693 ha	ICHmc1 ICHmc2	These sites may be equivalent to ICHmc1/02 and ICHmc2/02, which are blue listed.	High
Lodgepole pine – dwarf blueberry, coarse textured (LB)	7869 ha	SBSmc2	Very dry sites may include sites similar to SBSdk/02 forests (blue-listed)	Low
Lodgepole pine – black huckleberry ecosystems with coarse soils (PH)	685 ha	ESSFmc	Very dry sites may include ESSFmc/02 recommended for blue listing by Haeussler (1998)	Moderate
Horsetail swamps (HO)	309 ha	ICHmc1	May include ICHmc1/06, which was recommended for blue listing.	Moderate-high
Rock outcrops, with steep warm aspects			Not enough ecological information to determine if outcrops contain unusual species, bedrock geology, or seepage. Very little known about rarity of outcrops.	Low for currently listed or regionally rare

Orange-shaded biophysical habitat units have high likelihood of supporting rare ecosystems; gray-shaded ones have moderate likelihood.

There was a diversity of habitat units mapped at the Babine and Skeena River confluence. Habitat units mapped as cottonwood – red osier floodplain ecosystems were interpreted to be very rare in the mapped area (118ha)(Map 2). Hybrid spruce floodplains were interpreted to be more frequent than cottonwood sites along major rivers, while paper birch fluvial fan forests were found mostly at the Babine – Skeena River confluence (Map 2). Thimbleberry - cow parsnip meadows (not mapped) occupy only 16 ha in two polygons in the Nichyeskwa Creek drainage in association with the Cottonwood – red osier floodplain sites.

There were abundant Willow – sedge wetlands mapped (approximately 157000 ha, Table 6) in this study but not enough ecological information was given to distinguish rare subsets of these wetlands.

UPPER NILKITKWA RIVER DRAINAGE TERRESTRIAL ECOSYSTEM MAPPING

Oikos Ecological Services (1998) mapped 24, 616 ha in the Upper Nilkitkwa River drainage in the northeast region of the Babine River watershed using standard terrestrial ecosystem mapping methods. They mapped two 1:20,000 mapsheets (93H086, 93H076), the standard scale used in most TEM projects. The scale of mapping used in the Upper Nilkitkwa River TEM is better suited to detecting rare ecosystem occurrences than the Lea and Kowall study, but both projects were completed in order to provide information about wildlife habitat use and availability, not rare ecosystems, and both share limitations in this regard. For example non-forested, alpine and wetland ecosystems were only broadly differentiated, perhaps because they are not considered important for wildlife habitat, however several of these ecosystems are potentially rare.

Unfortunately, there does not appear to be a report that describes in detail the methods and ecosystems used in this mapping project. Eight full plots, 130 ground inspections and 298 visual checks were done, resulting in 5-14% of polygons being surveyed. This is below the recommended level for most mapping projects, and results in low reliability (Level 5, RIC 1998). This low reliability extends to the detection of rare ecosystem.

Despite the low sampling level, two rare forested ecosystems and one rare meadow community were identified during the Upper Nilkitkwa TEM project (Table 7)(Map 3). There were also several ecosystems that may potentially support rare ecosystems but not enough information was provided to correlate with rare or regionally rare ecosystems (Table 8)(Map 4). Some of the plots were entered into the BEC database (VPro), which we have examined more closely in another section of our report. However, much of the map is based solely on air photo interpretation and quick visual checks, so we cannot say with 100% certainty that rare ecosystems mapped from the data provided by the Upper Nilkitkwa TEM occur across all polygons in which they were mapped. There are also problems with accurately mapping rare ecosystems when there are complexes of ecosystems within polygons. In the Upper Nilkitkwa TEM, three site series may occupy one polygon (i.e. three deciles). For example, if the rare ecosystem is believed to occur on 10% of the polygon, it is not possible to know where in the polygon, how it is distributed in the polygon, nor how accurate the estimation is. A very large polygon may be highlighted as containing a given rare or sensitive ecosystem, but in reality most of the polygon is a more common ecosystem.

Table 7. Rare ecosystems in the Upper Nilkitkwa River TEM project.				
Plant community	Subzone/ Site series	Location	Rank*	Notes
Black spruce – lodgepole pine – feathermoss (BM)	SBSmc2/03	1313 ha 157 polygons	*Blue*	Black spruce is at southwest extent of its range in the Babine River watershed. Was listed in past.
Subalpine fir – lodgepole pine – juniper – *Cladonia* lichens (LC)	ESSFmc/02	212 ha 48 polygons	*Blue*	Was listed in past. White bark pine occurrence would be significant.
Rich herbaceous fluvial or montane meadows (Cow parsnip – large-leaved avens)(CA)	SBSmc2 ESSFmc ESSFwv	49 ha (23 polygons 134 ha (47 polygons) 7 ha (3 polygons)	*Blue*	Same as described by Haeussler (1998)

*Represents ecosystems that have been proposed for listing by Haeussler (1998). Italics refer to her suggested conservation rank.

Table 8. Sensitive ecosystems and possible rare ecosystems in the Upper Nilkitkwa River TEM project.			
Plant community	Mapping unit	Extent	Notes
Alder – lady fern avalanche chutes	ESSFmc ESSFmcp ESSFwv	216 ha 11.3 ha 1.1 ha	Very little work done on the classification of avalanches. Low elevation chutes have especially high conservation value.
Non-forested fens and marshes (*Carex* dominated)	SBSmc2 ESSFmc ESSFwv	861 ha 1464 ha 32.5 ha	A number of listed wetlands occur in study area.
Drummond's willow – mountain alder riparian sites	SBSmc2 ESSFmc	21.3 ha 12.1 ha	Found on active floodplains, may contain minor components of blue listed Drummond's willow – blue-joint reedgrass (Fl05).
Labrador tea – Sphagnum non-forested bogs	SBSmc2 ESSFmc	0.8 ha 3.7 ha	Acidic peat bogs are uncommon in the SBSmc2 (Banner *et al.* 1993)
Willow-twinberry carrs	SBSmc2 ESSFmc ESSFwv	195.4 ha 222.5 ha 16.7 ha	On active floodplains and may contain rare sub-components.
Wet seepage meadows	BAFAun ESSFmcp ESSFwvp	0.4 ha 23.3 ha 27.9 ha	Uncertain of their conservation value. Subset of these may be rare or unique.
Active floodplain forests – Hybrid white spruce – Horsetail and Hybrid white spruce – Oak fern.	SBSmc2	42.8 ha	No SBSmc2 floodplain site series are included in BEC. These are SBSmc2/10 and /06 site series occurring on active floodplains.

Map 3 illustrates the distribution of rare ecosystems in the Nilkitkwa River drainage but does not accurately reflect the area occupied by the rare ecosystems due to composite polygons. Polygons in this TEM project were composed of up to three different ecosystems, and the proportion occupied by each ecosystem was estimated as a percentage of the polygon (referred to as deciles). Therefore, we summed areas occupied by each rare ecosystem in each polygon (partitioning total polygon area by estimated deciles) to get total area occupied by a given ecosystem in the project area. However, we were unable to visually illustrate the partitioning of polygons in the maps.

For example, herbaceous meadows appear extensive in the upper Nilkitkwa in the map, but absolute area was quite low (190 ha). Non-forested fens and marshes (*Carex* fens on map) also appear to dominate the Nilkitkwa TEM study area (Map 4) but a much smaller area (1357 ha) was interpreted to support these ecosystems. Map 4 shows which polygons contain but non-forested fens and marshes, but not how much of the each polygon contain these wetlands. Active floodplain spruce forests (not mapped), Drummond's willow – alder riparian sites, wet seepage meadows, and Labrador tea – Sphagnum bogs occupy small areas and few polygons in the Nilkitkwa TEM study area.

BIG SLIDE STUDY

Madrone (1994) mapped 6000 ha on the south side of the Babine River, covering an area near its confluences with Thomlinson and Gail Creeks. This study was undertaken using an early version of the current BEC system (before Banner *et al.* 1993 was complete). The study area was transitional between the SBSmc2 and ICHmc1, and the ESSFmc and ESSFwv subzones. The mapping was done at a scale of 1:20 000, and 55 full plots plus additional partial plots and visual checks were completed. The mapping was constrained to using an existing terrain classification, with the goal to visit each terrain unit, unstable ones in particular, and to providing wildlife interpretations.

Three rare forested ecosystems were identified during mapping: two are currently blue-listed and one additional ecosystem is recognized as regionally significant (Table 9).

Table 9. Rare ecosystems in the Big Slide TEM project.

Plant community	Subzone/Site series	Rank	Location	Notes
Western hemlock – lodgepole pine - kinnikinnick – Cladonia lichens	ICHmc1/02	Blue	2 polygons, occupying very small extent.	Called Dry Pine Climax forest in the report. Young and mature seral stages.
Black cottonwood – red osier dogwood floodplain	ICHmc1/Fm02 or ICHmc1/05.	Blue	2 polygons. Thomlinson Creek floodplain at confluence, and in next small drainage to west.	Active floodplains.
Black cottonwood – cow parsnip	ICHmc1/un	Unranked	3 polygons in the Thomlinson Creek valley	Found on steep southeast facing slopes. Uncertain of its conservation value. Polygons were not visited.

There were other ecosystems that Madrone (1994) considered to be of high conservation value but were not characterized in enough detail to determine whether these are rare in the region or province (Table 10). Madrone (1994) recommended that these ecosystems be considered high value areas for biodiversity conservation, and be linked together with undisturbed corridor systems.

Table 10. Sensitive and possible rare ecosystems in the Big Slide TEM project.

Plant community	Biogeoclimatic unit	Extent	Notes
Non-forested sedge-dominated fens and marshes	ICHmc1/SBSmc2/ ESSFmc/ESSFwv	Very uncommon and small. 7 tiny polygons.	Some small purely herbaceous wetlands in mosaic with willow-dominated wetlands
Forested wetlands	ICHmc1/SBSmc2	Scattered, uncommon and small.	May be equivalent to SBSmc2/07 in part, but other forested wetlands types included.
Sitka alder – cow parsnip avalanche chutes	ESSFwv	Far west of study area. 2 small polygons.	Cool aspect. Sites were not sampled. Herb meadows at base of chutes may be similar in composition to fluvial meadows.
Aspen dominated sub-mesic forests	ICHmc1/01b Maybe Atki	3 polygons in Thomlinson Creek valley	Steep slopes with thin colluvial veneer. South and west facing slopes.
Willow – alder – devil's club seral shrub communities	ICHmc1 SBSmc2 ESSFmc	Numerous polygons	Uncertain of conservation value. More detail is required.

TOMMY JACK PASS

Turney and Blume (2000) mapped 6065 ha in the extreme northwestern portion of the Babine River watershed. An additional area was mapped to the north of the Babine River watershed, beyond the Babine Watershed Monitoring Trust monitoring area. The objective of this study was to map suitable habitat for grizzly bear and mountain goat. The Tommy Jack Pass study area lies within the ESSFwv (including wvp) and BAFA biogeoclimatic subzones. Air photo interpretation of ecosystems was done using standard methods (1: 20 000 scale), but no field verification of the final ecosystem map was done. Full ecosystem plots were not completed, but dominant plant species and mapping notes were listed in field notes along wildlife transects (visual inspection forms were completed). In total 87 polygons were mapped in the Babine River watershed (190 for the entire project).

One regionally rare forested ecosystem was identified in the Tommy Jack Pass study (Table 11)(Map 5). Dry Subalpine fir – lodgepole pine – Cladonia (ESSFwv/02) forests were mapped along the east-facing slopes of Mt Tommy Jack. Here the area appears quite large but other ecosystems are included in the mapped polygons. Only 284 ha of ESSFwv/02 were mapped but no white bark pines were observed (Turney 2012, *personal communication*). ESSFwv/02 sites, which contain white bark pines, have higher conservation value due to the global decline of white bark trees and its recent addition (June 2012) to the Species at Risk Act (SARA).

We cannot confirm from the descriptions of non-forested plant communities in the report whether additional rare ecosystems were present. However, we cannot rule out the potential for them to occur – there were many reported wetlands and meadows that have potential to support rare plant communities (Table 12)(Map 6). Approximately 17% of the Tommy Jack Pass study area was mapped as sensitive ecosystems.

Table 11. Rare ecosystems in the Tommy Jack Pass study.

Subzone/Site series	Plant community	List	Location	Notes
ESSFwv/02	Subalpine fir – lodgepole pine – Cladonia lichens	**Blue*	284 ha 13 polgyons	Very dry sites in the ESSFwv are rare in the landscape. White bark pine sites have very high conservation value.

*Represents ecosystems that have been proposed for listing by Haeussler (1998). Italics refer to her suggested conservation rank.

Table 12. Sensitive ecosystems and possible rare ecosystems in the Tommy Jack Pass study.

Plant community	Biogeoclimatic unit	Extent	Notes
Herbaceous meadows	BAFAun ESSFwvp	186 ha 118 ha	May be similar to montane meadows that Haeussler (1998) proposed for blue listing.
Alder – fern avalanche chutes	ESSFwvp	14 ha	Only one polygon.
Water sedge fens	ESSFwv	44 ha	May contain rare subsets
Willow – water sedge fens	ESSFwv	536 ha	May contain rare subsets
Wet seepage meadows	BAFAun ESSFwvp	21 ha 93 ha	May contain rare subsets

Herbaceous meadows and wetlands observed in the Tommy Jack Pass were noted as being unusual and possibly rare ecosystems (Turney 2012, *personal communication*). Cold-air drainage and geomorphological processes may drive these gently rolling complexes of wetlands and meadows.

SOUTHERN PARK ACCESS AREA, BABINE RIVER CORRIDOR PARK

Wellwood (2008) mapped 1445 ha in the Southern Park Access area of the Babine River Corridor Park using TEM methods (1:10 000 scale). Although the overall goal was to assess bear habitat, the finer scale of mapping and description of wetland and hardwood-dominated plant communities provides reliable information for identifying rare plant communities in the study area.

Of the 70 polygons that were mapped, 53 were ground-truthed, thus representing a high percentage of field verification. Several rare and potentially rare ecosystems were found in the study area as well as two types of sensitive ecosystems (Tables 13, 14)

Table 13. Rare ecosystems in the South Park Access Area, Babine River Corridor Park.

Subzone/Site series	Plant community	List	Polygons and area	Notes
SBSmc2/Fm02	Black cottonwood – hybrid spruce – red osier dogwood	Blue	7 polygons 15.1 ha	Active floodplain sites. Equivalent to listed SBSdk/08.
SBSmc2/Fl05	Drummond's willow – blue-joint reedgrass	Blue	1 polygon 13.4 ha	Along lower Boucher Creek where it has a low gradient, pools, and beaver dams.
SBSmc2/Atha	Trembling aspen - hardhack	**Red?*	1 small polygon 2.7 ha	North shore of Babine River, upstream of Fish Weir. Sparse tree cover with shrub and herb meadows. May contain listed meadow elements.
SBSmc2/Atss	Trembling aspen – Saskatoon berry - snowberry	**Red?*	1 polygon 3.3 ha	North shore of Babine River, upstream of Fish Weir. South-facing seral aspen and shrub community. May contain listed meadow elements.

*Represents ecosystems that have been proposed for listing by Haeussler (1998). Italics refer to her suggested conservation rank.

Table 14. Sensitive ecosystems and possible rare ecosystems in the South Park Access Area, Babine River Corridor Park.

Plant community	Biogeoclimatic unit	Extent	Notes
Sedge wetlands	SBSmc2	5 polygons 9.3 ha	Occur close to major waterways, regular sediment deposition events. Not enough ecological information to determine rarity
Bog wetlands	SBSmc2	2 polygons	Occur in depressions. Not

		25.3 ha	enough ecological information to determine rarity.
Mountain alder – lady fern – skunk cabbage	SBSmc2/Ws01	3 polgyons 34 ha	May include Pacific willow – mountain alder – lady fern low bench floodplain sites recommended by Haeussler for blue listing.

Blue-listed cottonwood floodplain sites were found in four polgyons along Nichyeskwa Creek near its confluence with the Babine River, two polygons along the Babine River, between Boucher and Nichyeskwa Creeks, and one polygon on the Nilkitkwa River. The blue-listed Drummond's willow – blue-joint community was found in one polygon where Boucher Creek meets the Babine River. There were two polygons of seral deciduous ecosystems (Atss and Atha) that could support rare meadow components but further information is required.

MINISTRY OF FORESTS - BEC DATABASE

MacKenzie (2012) provided all BEC plot data for two map sheets (93L and 93M) north of 55N. We deleted all plots that were outside the Babine River watershed boundaries, and included all plots that contained rare or potentially rare plant communities. For example plots in mesic forests with low potential to harbour rare ecosystems were not included.

A total of 149 plots were completed in the Babine River watershed (Map 7a) and 39 plots may potentially include sensitive, regionally rare, or listed plant communities. There were seven plots of three rare wetland ecosystems (wb10, wf02 and wf08), and a further 11 plots of regionally rare ecosystems (Table 15)(Map 7b).

Table 15. Rare and sensitive ecosystems identified from the Ministry of Forests BEC plot data.

Plant community	Site series	Plots	Notes
Subalpine fir (pines – whitebark or lodgepole) – crowberry - lichen	ESSFmcp/02 or ESSFmcw/02	105107 105116 105124 105137	Sites that include white bark pine have highest conservation value.
Lush forb meadows as part of ESSF woodland and parkland forests.	ESSFmcw/04 ESSFmcw/05	105129 105135	Uncertain of conservation value in ESSF. Subsets of these meadows may be same as ones proposed by Haeussler (1998) for blue listing.
Rhododendron albiflorum sites	ESSFmcw/01	105106 105118	Haeussler (1998) suggested that *Rhododendron albiflorum* sites in the region were significant – at NW extent, western N. America endemic.
Mountain hemlock sites	ESSFmc1/01	105118	Mountain hemlock reaches its northeastern extent in study area. More plots, but this one to east of study area. See Map 16 for more information about mountain hemlock distribution in study area.

Table 15. Rare and sensitive ecosystems identified from the Ministry of Forests BEC plot data.			
Plant community	Site series	Plots	Notes
Fluvial Ranunculus meadows. Upper montane meadows	SBSmc2/ESSFmc	9611951 9628643	Upper Nilkitkwa River, possibly 10 meadows in area. Same meadow that Haeussler (1998) described. Pojar described similar montane meadow (very rich)(9628643).
Low-elevation herb meadows - Fireweed-cow parsnip-nettle	ICHmc2	116753	Kitsegas Village – human disturbance.
Black spruce – Lodgepole pine – *Vaccinium* spp. – feathermoss	SBSmc2/03	120778 NWTF25 NWTF57	Sandy fluvial deposits. Haeussler (1998) proposed this community for blue listing.
Lodgepole pine – few flowered sedge - Sphagnum	SBSmc2/wb10	9628639 9628670 9628731	Blue-listed by the BC CDC
Scrub birch – water sedge	SBSmc2/wf02	9628640 9628729	Blue-listed by the BC CDC
Carex anthoxanthea, *Caltha leptosepala* – *Tricophorum caespitosum* – star moss high elevation fen	ESSFmc/Wf12	9628720 9628724	Most inland occurrence of *Carex anthoxanthea* in BC in Babine River watershed.
Barclay's willow - arrow-leaved groundsel	ESSFmc /Sc03 SBSmc2/Sc03	9628722 9628725 9628726 965810	Caused by cold air ponding. Rolling fluvial. Wet sedge swales and dry shrubland on mounds. Unsure of conservation status of Sc03. 965810 occurs in SBSmc2.
Salix (*barclayii, pedicellaris*) – *Calamagrostis canadensis* – *Agrostis scabra* – *Polytrichum juniperinum* meadow	ESSFmc/Tm	9628721	West Nilkitkwa River. Not listed but unusual community, no other plots like it.
Barclay's willow – cottongrass - water sedge – glow moss	ESSFmc/Wf04	9628723	Floodplain shrub carr near Barbeau Creek.
Salix pedicellaris – *Menyanthes trifoliata* - *Carex limosa* – *Tomenhypnum nitens* – *Sphagnum* poor fen	SBSmc2/Wf07	9628727	North of Haul Lake. Very similar to blue-listed Wb13.
Shore sedge-buck bean – hook moss fen	SBSmc2/Wf08	9628730 9628789	Blue-listed by the BC CDC.
Park-like fluvial terrace Pine – *Vaccinium caespitosum* – lichen forest	ESSFmc/02	965753	This is same site that Haeussler described (1998) with Oikos. This fluvial forest may have higher conservation value than typic ESSFmc/02 sites.
Lodgepole pine –	SBSmc2/Wb07	9628728	Nilkitkwa River and W. Nilkitkwa

Table 15. Rare and sensitive ecosystems identified from the Ministry of Forests BEC plot data.			
Plant community	Site series	Plots	Notes
Hybrid spruce - sedge – Sphagnum fen			River confluence. Pine-dominated wetlands.
Talus and rocky slopes	ESSFmcp	CW-22 SW-9	Conservation value undetermined. Talus slopes that extend to low elevations have high conservation value.
Wet seepage subalpine and alpine meadows	ESSFmcp/BAFA	SD-2 CW-49 SW-8	Conservation value unknown. Components of these ecosystems may be rare. SD-2 seemed to be late snow-melt area (*Carex nardina*). CW-49 is dominated by *Sanguisorba canadensis* and SW-8 is dominated by *Carex nigricans*..
Slide path complex	ESSFmc	965756	Conservation value unknown. Very diverse herb layer, alder, *Ribes* spp., elderberry, and salmonberry shrubs.

Orange shading represents ecosystems listed by the BC CDC.
Gray shading represents ecosystems recommended by Haeussler (1998) for listing.
Ecosystems without shading are sensitive or unusual ecosystems in the Babine River watershed.

Map 7b illustrates the distribution of rare wetland ecosystems, and other regionally rare ecosystems. The Nilkitkwa River drainage supports many rare and sensitive ecosystems, though much more work was done in this area compared to the western part of the Babine River watershed (Map 7a).

Predictive Ecosystem Mapping

Predictive ecosystem mapping (PEM) is a mapping process that is based upon building a model using existing databases to predict ecosystems (BEC site series or groups of site series) in polygons. The accuracy of PEM is determined with field-based verification of a percentage of the project's polygons. Field data is then used to improve the predictive model until an acceptable accuracy is attained. The use of PEM to predict the occurrences of rare ecosystems is an effort to realize efficiencies using existing mapping resources.

Predictive ecosystem mapping has been completed for the Bulkley Timber Supply Area (TSA) unit (2010) and the Kispiox Forest District portion (2004) of the Babine River watershed. The two PEM projects differ greatly in their methodology and goals. The Bulkley TSA PEM was completed to aid in timber supply analyses (Timberline 2010), while the Kispiox Predictive Habitat Mapping (PHM) was developed to help make management decisions around grizzly bear habitat (Mahon *et al.* 2004). Because of their inherent differences, we will discuss the two PEM models separately in the sections below.

BULKLEY TSA PEM

The Bulkley PEM model was developed for use in conjunction with SIBEC data to analyze and review timber supply. An earlier version was completed in 2002 but did not achieve acceptable accuracy levels. A completely new PEM model was developed in 2009-10. The final PEM model (2010) had very low accuracy, attaining the minimum acceptable level (65%; Simonar and Migabo 2009). This minimum level was achieved only when the accuracy assessment team used alternate calls for site series in the field. For example, if the site series they identified on the ground was different than the model prediction, but similar (acceptable adjacent sites) to the predicted site series, the PEM's prediction was favoured.

The accuracy assessment was determined by very low sampling intensity during the audit process (54 plots for the entire Bulkley TSA), especially in some of the subzones. There is complex patterning of landscapes and ecosystems in SBSmc2 and ESSFmc, the two most dominant subzones. These subzones have site series that are hard to distinguish except on the ground by visually assessing the percent cover of herb and shrub indicator species. Banner *et al.* (2003) created PEM label interpretation tables to illustrate how PEM is unable to distinguish between certain site series. In Table 16, we listed rare site series for each BEC subzone and used PEM label interpretation tables to examine whether the site series was predicted at all, predicted on its own, or lumped with other units. Forward slashes between site series implies that (a) either site series is equally likely to occur, (b) PEM cannot discriminate between the two site series, or (c) the site series occurs as a complex. Bracketed site series are expected to occur as minor inclusions (<20%) in the dominant site series.

There are a few important implications from these tables. First, seral associations were not included in the PEM knowledge base, which means that they are lumped into site series that represent their climax condition if they were left for a long period of uninterrupted natural succession. Therefore, no seral associations will be predicted to occur in the Babine River watershed. Second, many rare ecosystems are not clearly distinguished from similar site series. For example, all ESSFmc/02 and ESSFwv/02 site series will be over represented because PEM cannot distinguish them from the 03 site series. These limitations informed our analysis of the Bulkley PEM for determining rare ecosystems.

Table 16. Interpretation of how PEM labels relate to some of the forested rare site series in the Babine River watershed (interpreted from Banner *et al.* 2003).

BEC subzone	Rare site series	PEM label	Label meaning	Notes
ESSFmc	02	02	02/03	Combines with 03
ESSFwv	02	02	02/03	Combines with 03
ICHmc1	02	02	02/(01b)	May have minor inclusions of 01b
	05	05	05(04)	May have minor inclusions of 04
	06	06	06(04)	May have minor inclusions of 04
ICHmc2	02	02	02(01b)	May have minor inclusions of 01b
	52	01	01/52/53	No seral associations predicted in PEM. Map and data show 01 site series.
	53	03	03/04/52/53	No seral associations predicted in PEM. Map and data show 03 and 04 site series

Table 16. Interpretation of how PEM labels relate to some of the forested rare site series in the Babine River watershed (interpreted from Banner *et al.* 2003).				
BEC subzone	Rare site series	PEM label	Label meaning	Notes
	54	04 or 05	03/04/05/54	No seral associations predicted in PEM. Combines with 03, 04, and 05.
	06	06	06	PEM has no problem discriminating 06 site series.
	07	07	07(05)	May have minor inclusions of 05.
	08	08	08(WE)	May be minor inclusion in wetlands (31).
SBSmc2	03	03	03	PEM has no problem discriminating 03 sit series.

Rare Ecosystems Predicted by the Bulkley PEM

The Bulkley PEM project covers 165 800 ha in the BAFA, ESSFmc, and SBSmc2 subzones within the Babine River watershed. When we queried the Bulkley PEM data, no rare ecosystems currently listed by the BC CDC were detected in the Babine River watershed study area. Part of the reason for this result is that the BC CDC does not list many forested sites in the BAFA, SBSmc2, ESSFmc and ESSFwv subzones. Little effort has been spent on the classification and study of potentially rare alpine and subalpine ecosystems in this region. The lack of listed rare ecosystems on the BC CDC list may therefore be an artifact of low levels of inventory. Furthermore, the Bulkley PEM did not include any of the middle bench floodplain forest sites (MacKenzie and Moran 2004), two of which (Fm02 and Fm03) are blue-listed by the BC CDC (2012).

When we include rare ecosystems recommended for listing, then three ecosystem types were predicted to occur in the study area: SBSmc2/03 upland black spruce sites and ESSFmc (including mcp and mcw)/02 and /03 dry subalpine fir – pine forests (Table 17).

Table 17. Rare ecosystem predicted to occur in the Bulkey TSA part of the Babine River watershed.			
Subzone/Site series	Plant community	List	Area and frequency
ESSFmc/02	Subalpine fir – lodgepole pine – juniper – Cladonia lichens	**Blue*	333 ha 193 occurrences
ESSFmcw/02	Subalpine fir - (white bark pine – lodgepole pine) – huckleberry – crowberry - lichen	**Blue*	612 ha 407 occurrences
ESSFmcw/03	Subalpine fir - (white bark pine – lodgepole pine) – huckleberry-juniper - lichen	**Blue*	1217 ha 658 occurrences
ESSFmcp/02	Subalpine fir - (white bark pine – lodgepole pine) – huckleberry – crowberry - lichen	**Blue*	1 ha 20 occurrences
ESSFmcp/03	Subalpine fir - (white bark pine –	**Blue*	14 ha

	lodgepole pine) – huckleberry-juniper - lichen		16 occurrences
SBSmc2/03	Black spruce – lodgepole pine - feathermoss	**Blue*	373 ha. 55 occurrences

*Represents ecosystems that have been proposed for listing by Haeussler (1998). Italics refer to her suggested conservation rank.

Many small occurrences of dry subalpine fir forests (ESSFmc 02, ESSFmcp 02/03, ESSFmcw 02/03) were predicted to occur along the west-facing slopes of the Bait Range and near Nichyeskwa Creek (Map 8). Many of these predicted sites may not be as dry as predicted since the Bulkley PEM has difficulty distinguishing between 02/03 sites in the ESSFmc. All sites have the potential to support white bark pine but no surveys have been undertaken (S. Haeussler, T. White, and A. Woods 2012, *personal communication*). Upland black spruce – pine – feathermoss sites were predicted to occur at the south end of the Babine River watershed, near Nilkitkwa and Haul Lakes.

Many of the non-forested ecosystems in the PEM model were grouped into categories too broad to determine if they were rare or common ecosystems. However, the non-forested ecosystems were accurately mapped based upon image interpretation (Timberline 2010). Though we could not determine if the non-forested ecosystems were rare, many are sensitive and have the potential to include rare ecosystems. Table 18 summarizes non-forested ecosystems predicted to occur in the Babine River watershed (Bulkley TSA portion).

Table 18. Non-forested sensitive and possibly rare ecosystems predicted by the Bulkley PEM to occur in the Babine River watershed.

Plant community	Biogeoclimatic unit	Extent	Notes
Herbaceous meadows	BAFAun ESSFmc ESSFmcw and p	957 ha 38 ha 1487 ha	Not all herbaceous meadows are rare; subsets may be rare.
High elevation wetlands	BAFAun ESSFmcp	11 ha 51 ha	Very few occupying a small area. Alpine was not focus of PEM model.
Wet meadows	BAFAun ESSFmcp	4 ha 129 ha	Very small area. Alpine was not focus of PEM model.
Avalanche chutes	SBSmc2/51 ESSFmc/51 ESSFmcw and p/51	3.8 ha 209 ha 655 ha	Very rare in SBSmc2.
Riparian shrub	SBSmc2 ESSFmc ESSFmcw	259 ha 45 ha 653 ha	May include listed shrub-dominated communities
Alder – willow dominated community	SBSmc2 ESSFmc ESSFmcw and p	434 ha 671 ha 11 ha	May include listed shrub-dominated communities
Non-forested wetlands	SBSmc2 ESSFmc	3828 ha 2925 ha	Includes all wetlands, subsets may be rare.

Table 18. Non-forested sensitive and possibly rare ecosystems predicted by the Bulkley PEM to occur in the Babine River watershed.			
Plant community	Biogeoclimatic unit	Extent	Notes
	ESSFmcw	1202 ha	

Map 9 presents the distribution of predicted sensitive ecosystems across the Babine River watershed. If two sensitive ecosystems were predicted to occur as a complex in a polygon, we have presented the dominant ecosystem. It is difficult to detect sensitive ecosystems that are predicted to occupy only small percentages of polygons, unless they are associated with common ecosystems (i.e. not sensitive).

Non-forested wetlands were predicted to occur frequently across the entire Bulkley portion of the Babine River watershed (Map 9). The predictive map exaggerated the area covered by wetlands because it included all polygons where wetlands are predicted to occur in association with common ecosystems in addition to all polygons where wetlands are predicted to be the dominant ecosystem. Though not as abundant as the map shows, non-forested wetlands were predicted to cover approximately 6955 ha in the Bulkley TSA part of the watershed. High-elevation wetlands, riparian shrub communities, avalanche chutes, and wet meadows were predicted to occupy far less area (Table 18).

We can also use PEM to highlight ecosystems that occupy a very small portion of the landscape. One of the definitions of rare ecosystems was an ecosystem that occupied less than 2% of the landscape unit (Haeussler 1998). In this case, "percentage of area" refers to the percent of the total area in the Babine River watershed that is included in the PEM model (Bulkley TSA portion). Table 19 lists all ecosystems that occupy less than 1% of the 165 800 ha of the Babine River watershed area. We highlight ecosystems with 1% total cover rather than 2% because most of ecosystems in the PEM model occupied less than 2% of the area. Both are arbitrary cut-off levels, not based upon ecologically dependent factors. Indeed, total cover values are directly related to the number of classes in a classification system, and the scale at which mapping is delineated.

For example the PEM model divided the ESSFmc into ESSFmc, ESSFmc woodland (ESSFmcw) and ESSFmc parkland (ESSFmcp). For the purposes of the following table, we lumped all of the ESSFmc together, because finer divisions resulted in an inflated number of ecosystems occupying less than 1% of the land base.

Table 19. Ecosystems that occupy less than 1% of the of the Babine River watershed (Bulkley TSA portion) as predicted by the Bulkley PEM.			
Ecosystem	Subzone and site series	Total area (ha)	Percentage of area
Talus	SBS mc 2	0.4	<0.001
Glacier	ESSF mc	1	<0.001
Slides	ESSF mc	2	0.001

Table 19. Ecosystems that occupy less than 1% of the of the Babine River watershed (Bulkley TSA portion) as predicted by the Bulkley PEM.			
Ecosystem	Subzone and site series	Total area (ha)	Percentage of area
Wet meadows	BAFA un	4	0.002
Avalanche chutes	SBS mc2/51	4	0.002
Lakes	BAFA un	7	0.004
Wetlands	BAFA un	11	0.007
Ponds	SBS mc2	46	0.028
Ponds	ESSF mc	47	0.028
Riparian shrubs	ESSF mc	49	0.029
Wetlands	ESSF mc	51	0.031
Talus	ESSF mc	78	0.047
Wet meadows	ESSF mc	129	0.1
River	ESSF mc	145	0.1
Krummholz	BAFA un	174	0.1
Riparian shrub	SBS mc2	259	0.2
Lakes	ESSF mc	309	0.2
Subalpine fir - huckleberry - thimbleberry	ESSF mc/05	318	0.2
Black spruce - lodgepole pine - feathermoss	SBS mc2/03	373	0.2
Lodgepole pine - huckleberry - Cladonia	SBS mc2/02	413	0.2
Alder - willow shrub community	SBS mc2	434	0.3
River	SBS mc2	553	0.3
Subalpine fir - devil's club -lady fern	ESSF mc/07	658	0.4
Alder - willow shrub community	ESSF mc	681	0.4
Hybrid spruce - scrub birch - feathermoss	SBS mc2/07	701	0.4
Avlanche chutes	ESSF mc/51	865	0.4
Subalpine fir - lodgepole pine - juniper - Cladonia	ESSF mc/02	947	0.6
Herbaceous meadows	BAFA un	957	0.6
Rock outcrops	ESSF mc	1089	0.7
Lakes	SBSmc2	1130	0.7
Subalpine fir – horsetail – glow moss	ESSFmc/09	1174	0.7
Subalpine fir –horsetail – leafy moss	ESSFmc/10	1291	0.8
Herbaceous meadows	ESSFmc	1526	0.9

The results shown in this table substantiate some of our reasons for including non-listed rare ecosystems in this project. For example, many of the ecosystems recommended by local ecologists for addition to the BC CDC list occupy very small areas in the study area (e.g. SBSmc2/03, ESSFmc/02, and herbaceous meadows).

The Bulkley PEM model predicts that talus and avalanche chutes are rare components in the SBSmc2. No rock outcrops were mapped by the PEM in the SBSmc2. Low-elevation, natural openings with rocky substrates are very rare in this region, and have high conservation value (Pojar 2012, *personal communication.).* Riparian shrub and permanent alder – willow communities also occupy a very small portion of the Bulkley TSA PEM portion of the Babine River watershed. Three forested communities also occupied small areas: Lodgepole pine – huckleberry – Cladonia (SBSmc2/02)), Black spruce – lodgepole pine – feathermoss (SBSmc2/03) and Hybrid white spruce – scrub birch – feathermoss (SBSmc2/07).

Wet meadows and herbaceous meadows were predicted to represent very minor components of alpine areas. Because very little effort was spent in developing PEM in the BAFA zone, this information should be viewed as preliminary and used with caution.

Even when grouping all ESSFmc ecosystems (forest, woodland and parkland), there were still many (18) ecosystems that occupied less than 1% of the land base predicted by the PEM in the Babine River watershed. There were five forested ecosystems that occupied less than 1%, one of these being the ESSFmc/02 identified by Haeussler (1998) as being rare, as well as the ESSFmc/05 and /07. While both ecosystems are uncommon in the region, the ESSFmc/05 is the least common and is restricted to warmer aspects at lower elevations with base-rich parent materials (Banner *et al.* 1993, A. Banner 2012, *personal communication*).

Ecological Exception Mapping

"Ecological exception" mapping was completed for the Bulkley TSA PEM for landscape features that PEM models have difficulty predicting (Timberline 2010). Approximately 15-30% of the landscape does not follow the ecological principles outlined in the knowledge base of the PEM model. As noted earlier, orthophoto image interpretation was done to manually map "unpredictable" portions of the land base. Often rare and sensitive ecosystems fall within the exception mapping. Ecological exceptions include areas with climate extremes or variations (e.g. cold air drainage, higher precipitation) and uncommon geomorphological processes such as coarse or fine soils, seepage, shallow soils, and specific bedrock types (Timberline 2010). The exception mapping recognized known element occurrences of rare SBSdk grasslands and steppe communities, though none fall within the Babine River watershed. This part of the PEM model uses empirical data and is not predictive. The information is much more reliable than PEM for detecting areas that may support rare ecosystems, especially for non-forested ecosystems. One weakness of the ecological exception mapping is that it does not separate the ecological exception units into biogeoclimatic zones, so we cannot query the database stratified by subzones.

Timberline (2010) mapped 32 classes of ecological exceptions in the Bulkley TSA PEM project. Approximately 26 656 ha were mapped in the Bulkley TSA portion of the Babine River watershed. Alpine and subalpine parkland ecosystems received little attention in the exception mapping since Timberline (2010) believed that these ecosystems required more detailed mapping and further classification to produce meaningful results.

The exception mapping was incorporated into the main PEM model; however, we queried the exception database on its own for 23 specific ecosystems and landscape features (Table 20). This allowed us to identify potentially rare non-forested ecosystems as well as ecosystems that are restricted to specialized habitats or substrates. The main PEM model did a poor job of identifying forested floodplains in the SBSmc2, but by querying the exceptions data, we found 850 ha of low- and mid-bench floodplain in the Babine River watershed. There were also an additional 508 hectares of shrub and herb communities on low-bench floodplains. Map 10 shows the distribution of important floodplain habitat along the Babine River, Nilkitkwa River and Nichyeskwa Creek. Fluvial fan forests were also rare in the watershed (35 ha).

The upper Nilkitkwa River drainage is an exceptional area rich in herbaceous meadows, wetlands, avalanche chutes and shrub communities. Likewise, the region surrounding Boucher Creek and the lower reach of Nilkitkwa River (at the SW corner of the watershed) supports unusual soil features, floodplain, seepage sites and wetland ecosystems.

Table 20. Areas in the Babine River watershed that may support rare ecosystems using the Bulkley TSA Ecological Exception Mapping.

Ecological exception map entity	Code*	Total area (ha)	Potential to support rare ecosystems
Soil texture and depth to bedrock			
Shallow soil (<50 cm) and exposed bedrock	11	830	Very high at low elevations
Strong bedrock controlled landform	12	23	Very high at low elevations
Fluvial/glaciofluvial, coarse textured soil	21	520	High
Esker soil, very coarse textured	22	138	High
Forested wetlands and herb/shrub ecosystems			
Herb/graminoid leading wetlands	30	5363	Moderate
Shrub leading wetlands	31	2247	Moderate
Wet meadow	32	1230	Moderate
Wet meadow - forested ecosystem complex	33	685	Moderate
Forested swamps	34	2538	Moderate
Forested bogs	35	730	Moderate
Low bench floodplain (shrubs)	36	333	High
Low bench floodplain (herbs/graminoids)	37	175	High
Permanent shrubs (e.g. species of alder, willow, etc.)	41	1296	Moderate
Mesic meadow	42	341	High
Avalanche chutes	43	1420	Low with current knowledge

Table 20. Areas in the Babine River watershed that may support rare ecosystems using the Bulkley TSA Ecological Exception Mapping.			
Ecological exception map entity	Code*	Total area (ha)	Potential to support rare ecosystems
Dry grassland	44	3	High
Rhododendron shrubs	46	48	Regionally significant
Wet seepage areas, forested			
Wet seepage (sub-hygric)	50	3523	Low to moderate at low elevations
Very wet seepage (hygric)	51	143	High
Low bench floodplain	52	753	High
Mid-bench floodplain	53	97	High
Fluvial fan	55	35	High
Black spruce	56	370	Moderate

*Codes are the original numbers given to ecological exceptions (Timberline 2010).
Orange shading refers to map entities that have high potential to support rare ecosystems.

Exceptions mapping was also valuable for highlighting how uncommon areas of coarse-textured soils, shallow soils, and exposed bedrock are in the Babine River watershed (Map 10). Landforms strongly controlled by bedrock are particularly rare: only 23 ha were mapped on the north side of Mount Horetzky. Another striking result was the very small area in dry grassland (3 ha).

PREDICTIVE HABITAT MAPPING IN THE KISPIOX FOREST DISTRICT PORTION OF THE BABINE RIVER WATERSHED

A predictive model was developed for grizzly bear habitat suitability and was named predictive habitat mapping (PHM; Mahon *et al.* 2004) to distinguish this from standard PEM methods. Many of the input layers are similar to standard PEM models. This model was not intended for timber supply review like the Bulkley PEM but it does give a realistic distribution of site series by BEC variant across the Kispiox and Cranberry Timber Supply Areas (former Kispiox Forest District). The PHM model covers approximately 255 040 hectares of the Babine River watershed. It has undergone three major revisions since 2000 and the newest model achieved and accuracy level of 80-85%. The higher accuracy may reflect more lumping of site series in this model as compared to the Bulkley PEM. In addition to site series, the PHM model also combines two subzones in the ESSF (mc and wv), as well as two ICHmc variants (ICHmc1 and 2). The grouping of subzones and variants does not greatly alter the model's ability to identify rare ecosystems, because rare ecosystems can occur across biogeoclimatic units. In Table 21 (like Table 16 previously), we have listed rare site series for each BEC subzone and used PEM label interpretation tables (Banner *et al.* 2003) to examine whether the site series was predicted at all, predicted on its own, or lumped with other units. Forward slashes between site series implies that (a) either site series is equally likely to occur, (b) PEM cannot discriminate between the two site series, or (c) the site series occurs as a complex. Bracketed site series are expected to occur as minor inclusions (<20%) in the dominant site series.

Table 21. Site interpretations of the Kispiox PHM (interpreted from Banner *et al.* 2003).

BEC subzone	Rare site series	PHM label*	Label meaning	Notes
ESSFmc	02	02/03-w	02/03	Combines with 03. Over-represents 02. Same as ESSFwv02/03-w.
ESSFwv	02	02/03-w	02/03	Combines with 03. Over represents 02. Same as ESSFmc02/03-w.
ICHmc1	02	02/01b-w	02/01b(01)	Over represents 02 because of inclusion of 01b. May be some inclusion of 01.
	05	05	05(04)	Banner *et al.* (2003) predict some inclusion of 04.
	06	06	06(04)	Banner *et al.* (2003) predict some inclusion of 04.
ICHmc2	02	02/01b-w	02/01b(01)	Over represents 02 because of inclusion of 01b. May also be some inclusion of 01 and 51.
	52	52/53/54	52/53/54	Banner *et al.* (2003) suggests that the 54 can occur in combination with 03/04/05. The PHM model may be better at separating 54 from 03/04/05 since it focuses on its deciduous content.
	53	52/53/54	52/53/54	See notes for 52
	54	52/53/54	52/53/54	Seen notes for 52
	06	06	06	PEM models pick up 06 reasonably well.
	07	07	07(05)	Minor inclusions of 05.
	08	08	08(WE)	Some inclusion of wetlands.
SBSmc2	03	03	03	PEM model picks up 03 reasonably well.

*w in this column denotes warm aspect.

Field study to verify PHM

The PHM model development included a field verification study. There were 207 field plots used to verify the model accuracy following standard TEM methods, and 117 of these plots occurred in the Babine Watershed Monitoring Trust study area. Five occurrences of two blue-listed ecosystems were recorded: four occurrences of the ICHmc2/54, and one occurrence of the SBSmc2/Fm02 (a site classified as being equivalent to listed SBSdk/08 floodplain sites)(Table 22, Map 11).

For additional sites in the Kispiox District PHM, the plot information was not sufficiently detailed to determine whether plant communities were equivalent to listed or regionally rare ecosystems (Table 23).

Table 22. Rare ecosystems observed in the field verification study of the Kispiox PHM (Kispiox Forest District portion) in the Babine River watershed.

Plant community	Biogeoclimatic unit	Plots	Notes
Cottonwood – Hybrid white spruce - red osier dogwood	SBSmc2/Fm02	PEM-069	Blue-listed by the BC CDC. This is a mid-bench floodplain with an active channel through stand. Structural stage 6.
Cottonwood – Hybrid white spruce – red osier dogwood	ICHmc2/05	PEM004 PEM021 PEM017	Blue-listed by the BC CDC.
Hybrid white spruce – Paper birch – devil's club	ICHmc2/54	PEM-021 PEM-037 PEM-017 PEM-030	Blue-listed by the BC CDC.
Western redcedar - hybrid spruce – horsetail – skunk cabbage	ICHmc2/07	PEM-018	Productive sites are recommended for blue listing by Haeussler (1998)
Subalpine fir – lodgepole pine – Cladonia lichens	ESSFwv/02	PEM-064	Multi-aged forest, structural stages 3-7.
Trembling aspen – paper birch – red osier (seral)	ICHmc2/53	PEM-018 PEM-030 PEM-028 01-16	Structural stages 5-6. Birch dominated stands are most significant.
Hybrid spruce – paper birch – thimbleberry – hazelnut (seral)	ICHmc2/52	PEM-030 PEM-019 PEM028	Structural stages 5-6. Birch dominated stands, or stands with increased fire frequency are most significant.

Orange shading represents blue-listed ecosystems; ecosystems without shading were recommended to be blue listed by Haeussler (1998).

Table 23. Sensitive and possible rare ecosystems observed in the field verification study of the Kispiox PHM (Kispiox District portion of the Babine River watershed).			
Plant community	Biogeoclimatic unit	Number of plots	Notes
Herbaceous meadows	ESSFmc ESSFwv SBSmc2	5	Subsets of these herbaceous meadows may be rare.
Wetlands	ESSFmc ESSFwv SBSmc2	11	Subsets of these wetlands may be rare.
Avalanche chutes	ICHmc1	1	Low-elevation avalanche chutes are significant.
Alder – willow ecosystems	ICHmc2 SBSmc2	7	Subsets of these ecosystems may be rare. Alder – fern sites are included here.
Scouler's willow - thimbleberry	ICHmc2	1	May include wetter areas that are similar to regionally-rare Scouler's willow – devil's club (Table 3).
Shrub meadow	SBSmc2	2	Not enough ecological information.
Shrub carr	SBSmc2	1	Not enough ecological information.
Riparian thicket	SBSmc2	1	Not enough ecological information.

Map 11 shows the distribution of four blue-listed, three regionally rare and numerous sensitive ecosystems mapped as part of the field verification study for the Kispiox PHM (Kispiox Forest District portion of the Babine River watershed). There are clusters of rare and sensitive ecosystems at the Babine and Skeena Confluence and in the Shelagyote River - Gunanoot Lake areas (Map 11).

Predicting Rare Ecosystems using PHM

The Kispiox District PHM predicted the occurrences of three blue-listed ecosystems in the Babine River watershed portion of the former Kispiox Forest District (Table 24). The Kispiox PHM had a tendency to predict numerous, small polygons. The number of element occurrences that these numerous polygons represent is much lower because the BC CDC require a minimum separation distances of one km between element occurrences (BC CDC 2012).

Floodplain ecosystems were predicted using an extra floodplain sub-model (Mahon *et al.* 2004), and the ICHmc2/06 sites were not lumped with other site series in the model (Table 21). However, only a very small area of cottonwood floodplain forest was predicted (12 polygons covering 9.6 ha), with most polygons clustered near the Babine and Skeena confluence (Map 8). It is probable that the Kispiox PHM model has a tendency to under-predict this ecosystem.

Table 24. Rare ecosystems predicted to occur in the Kispiox District of the Babine River watershed.

Plant community	Biogeoclimatic unit	Extent	Notes
Cottonwood – spruce – red osier floodplain ecosystems	ICHmc1/05 ICHmc2/06	2.2 ha (3 polygons) 7.4 ha (9 polygons)	Equivalent to blue-listed Fm02 ecosystem. Very rare in the watershed.
Western hemlock – kinnikinnick – Cladonia lichens	ICHmc1/02 ICHcm2/02	858.7 ha (1231 polygons) 34.8 ha (55 polgyons)	**Currently blue-listed.** 01b and 02 site series are lumped—some of the area shown is for 01b site types.
Western hemlock – azalea – skunk cabbage Redcedar – hybrid spruce – horsetail – skunk cabbage	ICHmc1/06 ICHmc2/07	566.3 ha 717 polygons 22.6 ha 41 polygons	Recommended for blue listing by Haeussler (1998).
Subalpine fir – lodgepole pine – juniper – lichen Warm aspect:	ESSFmc/02 ESSFmcp/02	219.9 ha 371 polygons 1.2 ha 4 polygons	White bark pine sites have high conservation value. Area shown is combined 02/03.
Subalpine fir – lodgepole pine – Cladonia lichens	ESSFwv/02 ESSFwvp/02	1027.8 ha 1595 polygons 99.3 ha 156 polygons	Grouped with 03 site series so area shown is combined 02/03. White bark pine sites have high conservation value.
Seral deciduous forests: Hybrid white spruce – paper birch – thimbleberry – hazelnut (ICHmc2/52) Trembling aspen – paper birch – dogwood (ICHmc2/53) Hybrid spruce – paper birch – devil's club (ICHmc2/54)	ICHmc1 52/53/54 ICHmc2 52/53/54	1302.3 ha 564 polgyons 811.9 ha 428 polygons	All seral associations are grouped into one label in this PEM. **ICHmc2/54 is currently blue-listed.** Subsets of ICHmc2/52 and /53 were proposed for blue listing (Haeussler 1998).

Orange shaded ecosystems are currently blue-listed (BC CDC 2012).

Lumping and overlapping of site series cause the model to predict greater areas and more polygons with rare ecosystems than actually occur. For example, the Kispiox PHM lumps the xeric blue-listed Western hemlock – kinnikinnick – Cladonia site series (ICHmc2/02) with sub-mesic forests (ICHmc2/01b). In addition, when the model predicts 01b sites, it likely includes minor amounts of mesic 01 sites.

Likewise, the Kispiox PHM groups three seral associations into one type (52/53/54) that occur in the ICHmc1 or ICHmc2. One (ICHmc2/54) of the seral associations is blue-listed, and certain variations of the other two are considered regionally rare. The seral deciduous forests occupy a large area (2144 ha) along the Babine River in the western part of the watershed (Map 8).

The following sensitive and potentially rare ecosystems were predicted to occur in the Babine River watershed portion of the Kispiox Forest District (Table 25). A proportion of these ecosystem types may contain rare ecosystems, but the extent cannot be determined using available data.

Table 25. Sensitive and possible rare ecosystems predicted to occur in the Kispiox District portion of the Babine River watershed.

Ecosystem types	Biogeoclimatic unit	Extent	Notes
Herbaceous meadows (HM)	BAFAun	462.9 ha	Subsets of these herbaceous meadows may be rare.
Wetlands and wet meadows (WL or WM)	BAFAun ICHmc1 ICHmc2 SBSmc2 ESSFmc ESSFmcp ESSFwv ESSFwvp	67.3 ha 651.1 ha 12.5 ha 463 ha 2463.8 ha 9.1 ha 2744.3 ha 354.6 ha	Not all wetlands and wet meadows are rare but rare subsets may occur.
Avalanche chutes – cool aspect (SAc)	ICHmc1 SBSmc2 ESSFmc ESSFwv	224.3 ha 23.3 ha 721.7 ha 3666.1 ha	Very rare at low elevations.
Avalanche chutes – warm aspect (SAw)	ICHmc1 SBSmc2 ESSFmc ESSFwv	377.6 ha 73.6 ha 242.1 ha 3161.1 ha	Very rare at low elevations.
Alder – willow ecosystems (AW)	ICHmc1 ICHmc2 SBSmc2 ESSFmc ESSFwv ESSFwvp	1101.7 ha 5.5 ha 1386.2 ha 412.8 ha 1183.6 ha 6.4 ha	
Deciduous seral subalpine ecosystems (DE)	ESSFmc ESSFwv	124.0 ha 4.3 ha	Deciduous forests in the subalpine zone are unique.
Dry non-productive forests	ESSFmc ICHmc1 ICHmc2 SBSmc2	18 ha 24 ha 1 ha 20 ha	These dry sites are predicted to occur very small areas.

Table 25. Sensitive and possible rare ecosystems predicted to occur in the Kispiox District portion of the Babine River watershed.			
Ecosystem types	Biogeoclimatic unit	Extent	Notes
Mesic non-productive forests	ESSFmc ICHmc1 ICHmc2 SBSmc2	720 ha 236 ha 14 ha 278 ha	The conservation value is undetermined.
Wet non-productive forests	ESSFmc ICHmc1 ICHmc2 SBSmc2	525 ha 192 ha 12 ha 263 ha	A proportion of these sites may be rare.
Deciduous seral (DE)	SBmc2	7181 ha	This ecosystem type is represented by a large area, of which a small proportion may be rare.

The Kispiox PHM does not predict composite polygons, so sensitive ecosystems were predicted to occur in 100% of each polygon where they are mapped (Map 9). Frequent small wetlands and complexes were predicted to occur in the Damsumlo and Gunanoot Lake areas. Deciduous seral ecosystems in the subalpine were predicted to occur in approximately 130 ha and 64 polygons.

We queried the Kispiox PHM data to determine which ecosystems occupied very small percentages of the modeled area. In the Kispiox PHM, 149 out of 180 types of ecosystems occupied less than 1% of the modeled area so we examined ecosystem types that occupied less than 0.1%. Table 26 represents the ecosystem types that occupy less than 0.1% of the modeled area and are not clear-cuts or human-disturbed areas. Again, this is an arbitrary cut-off that is related to the number of classes and the scale of mapping.

Table 26. Ecosystems predicted to occupy less than 0.1% of the Kispiox District portion of the Babine River watershed.			
Ecosystem Name	PHM Habitat Label	Area (ha)	Percent or area
Warm aspect Subalpine fir - Lodgepole pine - Cladonia, Subalpine fir - huckleberry-crowberry	ESSFmcp 02/03-w	0.33	<0.001
Non-productive forests - dry	ICHmc2 NP-d	0.38	<0.001
Burned sites - dry	ESSFwvp BU-d	0.52	<0.001
Warm aspect Subalpine fir - Lodgepole pine - Cladonia, Subalpine fir - huckleberry-crowberry	ESSFmc 02/03	0.91	<0.001
Subalpine fir - huckleberry-leafy liverwort	ESSFmcp 01/04/05	1.55	0.001
Active Cottonwood - spruce - red osier dogwood floodplain sites	ICHmc1 05	2.16	0.001
Burned sites - mesic	ESSFw BU-d	3.38	0.001

Table 26. Ecosystems predicted to occupy less than 0.1% of the Kispiox District portion of the Babine River watershed.			
Ecosystem Name	PHM Habitat Label	Area (ha)	Percent or area
Deciduous seral forests	ESSFwv DE	4.32	0.002
Rock outcrop	ICHmc2 RO	4.75	0.002
Alder - willow	ICHmc2 AW	5.54	0.002
Alder - willow	ESSFwvp AW	6.41	0.003
Active Cottownwood - spruce - red osier dogwood floodplain sites	ICHmc2 06	7.37	0.003
Subalpien fir - devil's club -lady fern	ESSFmcp 07	7.48	0.003
Burned sites - mesic	ESSFwvp BU-m	7.94	0.003
Non-productive forests - dry	ESSFwvp NP-d	8.46	0.003
Warm aspect Western hemlock - lodgepole pine - kinnikinnick - Cladonia/Hemlock - stepmoss (submesic)	ICHmc2 02/01b-w	9.02	0.004
Wet meadows	ESSFmcp WM	9.10	0.004
Non-productive forests - dry	SBSmc2 NP-d	9.13	0.004
Non-productive forests - dry	ESSmc NP-d	11.34	0.004
Non-productive forests - wet	ICHmc2 NP-w	11.79	0.005
Wetlands	ICHmc2 WL	12.52	0.005
Rock outcrop	ESSFmc RO	13.86	0.005
Non-productive - mesic	ICHmc2 NP-m	15.07	0.006
Krummholz - dry	ESSFmcp PF-d	17.58	0.007
Warm aspect Subalpine fir - lodgepole pine - Cladonia/Subalpine fir - mountain hemlock - feathermoss	ESSFwvp 02/03	17.68	0.007
Hybrid spruce – paper birch – thimbleberry/Aspen – paper birch – red osier dogwood/Hybrid spruce – paper birch – devil's club	ICHmc2 52/53/54	18.60	0.007
Non-productive forests - dry	ICHmc2 NP-d	19.35	0.008
Krummholz - dry	ESSFmc PF-d	20.37	0.008
Western hemlock - skunk cabbage	ICHmc2 07	22.60	0.009
Slide or avalanche - cool aspect	SBSmc2 SA-c	23.34	0.009

Gray shading represents listed or regionally rare ecosystems.

A large number of ecosystem types occupy very small areas in the Kispiox District portion of the Babine River watershed (Table 26). Eight listed or regionally rare ecosystem types occupy less than 0.1% of the area. There were a number of non-productive forests, dry ones in particular, that occupied very small areas. These ecosystems may be similar to scrub-steppe shrub communities described by Haeussler (1998), but we do not know species composition. Non-productive areas were identified from Forest Cover data (Mahon *et al.* 2004). Slide and avalanche chutes in the SBSmc2 occupied only 23 ha, confirming the rarity of these elements at low elevations. Another very rare element appears to be dry krummholz in the ESSF, though more information about this ecosystem is required.

Vegetation Resources Inventory (VRI) Database

Like PEM and PHM, VRI is a model with inherent inaccuracies; however VRI provides information that is not available from PEM models. The Bulkley PEM collates many data layers with the main soil moisture model resulting in a site series, but it does not predict tree species composition or seral stage for a given polygon because tree species composition and stand structure change through succession. The Kispiox PHM predicts up to three dominant tree species for each polygon, which provides more detail per polygon but does not account for changes over time. To use the Kispiox PHM to monitor ecosystems over time, the VRI component of the database would have to be updated, or a succession model introduced.

Because both PEM models have some limitations in mapping mature tree species, we used the VRI database (2011) to map the occurrences of tree species in the Babine River watershed. We mapped the following tree species: western red cedar, western hemlock, mountain hemlock, amabilis fir, paper birch, trembling aspen, black cottonwood, and white bark pine (Table 27). The VRI database can differentiate cottonwood floodplain ecosystems, whereas PEM models cannot. The exception mapping identified low and mid bench floodplains but not species composition. In addition, VRI models all tree species and all seral stages, while the Bulkley PEM is unable to predict deciduous seral forests (*sensu* Williams *et al.* 2001).

In addition to identifying rare ecosystems not adequately predicted by PEM, Haeussler (1998) recommended this approach to highlight uncommon or rare forested ecosystems – those that occur at the limit of their ranges, outside of their known range, or in unusual habitats. Peripheral populations of leading tree species—those at the very edges of their ranges—are ecologically significant because they contain genomes that enable survival at the limit of environmental tolerance (Fraser 2000). The Babine River watershed is an ecological crossroads where coastal species attain their northeastern extent (e.g. amabilis fir, western hemlock and western red cedar) and where other species such as black spruce attain their southwestern extent. The VRI database also provides information about high-elevation aspen forests and birch-dominated forests, both considered rare by Haeussler (1998).

Table 27. Queries completed on tree cover data (VRI) in order to identify peripheral populations and detect rare ecosystems not adequately predicted by PEM models.

Tree species	Purpose of query
Black cottonwood (Map 12)	Identify cottonwood floodplain sites along large rivers. Identify cottonwood-leading forests in SBSmc2.
Trembling aspen (Map 13)	Identify stands of aspen in ESSF. Identify unusual seral deciduous stands.
Paper birch (Map 14)	Identify birch-leading stands across all zones. Determine rarity of birch-leading mature stands.
Amabilis fir (Map 15) Mountain hemlock (Map 16)	Identify outlying stands of these tree species. All of these four conifer species reach their northeastern extent in the Babine River watershed.

Western red cedar (Map 17) Western hemlock (Map 18)	
Black spruce (Map 19)	Identify outlying stands of black spruce. Rare to west of study area. Upland black spruce sites in SBSmc2 and black spruce bogs.
White bark pine (not mapped)	Endangered species. Identify whether it occurs in the Babine River watershed.

Maps 12 – 19 show results of the VRI analyses. No white bark pine forests were detected using VRI data; however, the model has difficultly distinguishing between lodgepole pine and white bark pine. Mountain hemlock, amabilis fir, western red cedar and western hemlock reach their northeastern extent in the Babine River watershed (Maps 15 -18, Douglas *et al.* 2002). The isolated populations of these tree species to the east of the Babine River watershed, particularly the ones with greater than 40% composition, have high conservation value. Red cedar is very rare in the Babine River watershed (Map 17). There is a very small, isolated stand of red cedar along the Nilkitkwa River, which requires field verification to ensure that it is not an error in the VRI database.

Cottonwood forests occur on floodplains along major creeks and rivers—Skeena, Babine, Shedin, Shelagyote, and Nichyeskwa—but the largest concentrations were found near the Babine and Skeena confluence (Map 12). Aspen and birch stands follow this same trend, though aspen stands are generally more abundant and larger, while birch forests are smaller and far less abundant (Maps 13, 14). The small birch-dominated stands at the Babine River confluence, along the Babine River, Shelagyote River, and Boucher Creek drainages are regionally rare.

Black spruce stands become increasingly rare to the west in the Babine River watershed, with very few and small occurrences west of the Shelagyote River (Map 19). In the eastern portion, black spruce stands are scattered and very small.

Anomalous Bedrock Geology

Because many rare ecosystems require specific substrates for establishment, we reviewed geology maps to locate anomalous bedrock such as limestone/karst, serpentine (ultra-mafic), or very acidic and mineralized bedrock. Any carbonate rock (e.g. limestone), and in particular, karst features should be identified and protected in the Babine River watershed. Currently there are no known occurrences of carbonate bedrock or karst in the watershed (J. Kyba 2012, P. Griffiths 2012, *personal communication*), but many small occurrences of carbonate rock have been mapped near Babine Lake and to the east of the study area (Stokes *et al.* 2010) in a stratum called the Cache Creek formation. Limestone and karst ecosystems are rare in the BC interior, and have very high conservation value (Stokes *et al.* 2010). Karst ecosystems are created by the dissolving action of water on carbonate bedrocks (primarily limestone and marble, but also dolostone, gypsum and halite)(Stokes *et al.* 2010).

Calcareous siltstones are likely common in the study area since the Bowser Lake and Skeena groups support this bedrock; however, calcium-loving (calcicole) plant communities have not been reported from the Babine River watershed. Haeussler (1998) and Pojar (2002) consider calcicole communities that occur on canyon walls, rock ledges, and vertical rock walls to be of high conservation value. These communities are typically characterized by diverse assemblages of ferns, and distinctive moss and liverwort species.

Ultramafic or serpentine rocks are not known to be present in the Babine River watershed, though they have been found further east.

Volcanic acidic rocks occur in the area and are referred to as the Babine and Bulkley intrusions (Ferri *et al.* 2005). These two formations are composed of upper Cretaceous and early Tertiary intrusive rocks such as, quartz-monzonite, quartz biotite, granodiorite, diorite, and feldspar. This bedrock is not necessarily indicative of acid rock drainage (ARD) in the mining context, but rather represents parent material and related soil that is weakly acidic. Acidic and nutrient-poor rocks such as these are known to support white bark pine trees in other areas. Acidic intrusions are found on Mount Thomlinson, Kitsegas Peak, Mount Horetzky, Shelagyote Peak, Shedin Peak and likely others (Carter and Kirkham 1969).

The Rocky Ridge volcanics in the study area contain basalt and basaltic andesite as well as tuff, breccia and andesite-dacite (Ferri *et al.* 2005, Macintyre 2001). Aldrick (2007) identified Rocky Ridge volcanics in a large area between French Peak and the Babine River. Basalt outcrops and flows may support rare ecosystems. For example, in neighbouring regions rare grasslands in the SBSdk are found below basalt outcrops where soils are deep and rich (Haeussler 1998).

DISCUSSION AND CONCLUSIONS

We have summarized known occurrences of rare ecosystems in the Babine River watershed from one rare ecosystem survey, five TEM projects, the Ministry of Forests BEC plot database, one PEM model accuracy study, and two predictive ecosystem mapping projects. Approximately 70% of the Babine River watershed (282447 ha out of 402435 ha) has been mapped using terrestrial ecosystem mapping (TEM) and biophysical habitat mapping methods, and the entire Babine River watershed has been mapped by predictive ecosystem mapping (PEM).

The reliability and quality of the data varies among mapping projects. For some projects there is certainty in the reported occurrences of rare ecosystems, while for other projects it is only possible to suggest sites that may support rare ecosystems.

Field-based Surveys and Terrestrial Ecosystem Mapping

Field-based ecosystem surveys have the greatest probability of identifying known occurrences of rare ecosystems and identifying threats to their persistence. In our review of existing studies, the most reliable and highest quality data comes from the only rare ecosystem survey to occur in the Babine River watershed: Haeussler's Rare and Endangered Plant Communities of the Southeastern Skeena Region (1998). But Haeussler's study only evaluated a very small proportion of the Babine River watershed. The purpose of her survey was to identify rare ecosystems and landscape features, focusing on the Bulkley River valley. Rare ecosystems were mapped, threats identified, and detailed ecological information reported.

The second highest quality of rare ecosystem data comes from the BEC database, and in particular plots data used to develop the provincial wetland classification system. Since 35 out of 54 of the ecosystems listed by the BC Conservation Data for this region are wetlands, the wetland portion of the database was helpful for identifying several rare wetland ecosystems in the Babine River watershed. In addition to wetland sites, several other ecosystem types were characterized in the BEC database (Table 15). Ecological data provided by the BEC database were very detailed but no information was available about the size of occurrences, nor conservation concerns.

In the above two types of field-based surveys, field plots were done and ecological information summarized in a systematic, quantitative manner for 100% of the area sampled. In contrast, terrestrial ecosystem mapping projects have limitations based up on the methods, scale, goals of the projects, and survey intensity level (*sensu* RIC 1998).

In our study, only one TEM project achieved a sampling intensity close to standards set in place for sensitive ecosystem inventories: the South Park Entrance Area TEM (Wellwood 2008; Table 28). The high sampling intensity resulted in data that was reliable for identifying several rare ecosystems, though the scope of the project was limited to a small study area.

Mahon *et al.* (2004) completed a TEM study to assess the accuracy of the predictive habitat mapping (PHM) model in the Kispiox Forest District. The ecological information was summarized in ground inspection forms for each polygon sampled, also achieving standards recommended for SEI mapping (RISC 2006).

The Big Slide study occurred before RIC Standards for TEM were developed (RIC 1998) and not enough information was available to calculate survey intensity level. We have included the Big Slide Study (Madrone 1994) because of the level of detail provided in the map and report is indicative of reliable data.

The three remaining TEM projects in the Babine River watershed were not ground-truthed at accepted levels for reliably identifying rare ecosystems (Table 28).

Table 28. Field-based surveys and terrestrial ecosystem mapping projects within the Babine River watershed, and an assessment of their reliability for identifying rare ecosystems.

Study	Scale	Sampling level	Quality of data for identifying rare ecosystem occurrences *
Rare ecosystem inventory (SE Skeena Region; Haeussler 1998)	n/a	100%	Level 1. Highest reliability and quality. Goal was to examine rare ecosystems.

MOF BEC Database	n/a	100%	Level 1. High reliability and quality. Goal was to classify wetlands and other ecosystems. Standard TEM methods.
Verification of PHM study (Mahon *et al.* 2004)	n/a	100%	Level 1-2. Ground inspection forms completed. No plot data available. Goal was to verify model predictions.
South Park Entrance area, Babine River Corridor Park (Wellwood 2008)	1:10000	62%	Level 2. Goal was to assess bear habitat.
Big Slide area, (Madrone 1994)	1:20000	unknown	Level is unknown. 55 full and additional partial plots were completed. Goal was to assess bear habitat.
Tommy Jack Pass (Turney and Blume 2000)	1:20000	0-4%	Level R. Visual inspection forms were completed. Goal was to assess wildlife habitat.
Upper Nilkitkwa River Drainage	1:20000	5-14%; 5:20:75	Level 5. Below the accepted verification standards. Standard TEM methods. Goal was to assess wildlife habitat.
Babine River Biophysical habitat mapping (Lea and Kowall 1992)	1:50000	unknown	Level R. Coarse mapping. Uncertain of how many plots were completed. Not quantitative. Goal was to assess bear habitat.

*Levels refer to *survey level intensity* following standards for TEM mapping projects (RIC 1998).

Orange shading refers to studies with high reliability for detecting rare ecosystems; turquoise shading refers to unknown survey level intensity but high quality data. Remaining studies (without shading) require further verification of rare ecosystem occurrences.

The objectives of the TEM projects reviewed during our study were to evaluate wildlife habitat (mostly bear), not to assess biological diversity or identify rare ecosystems. As a consequence, interpreting rare ecosystems from the TEM data results in determinations that are less reliable. The necessary information is incomplete.

We consider rare ecosystem occurrences from projects with high reliability (orange shaded in Table 28) to be confirmed sites that do not require verification. Rare ecosystems derived from less-reliable data sources are potential sites that require verification.

Most of the confirmed cases of rare ecosystems within the Babine River watershed are forested. This is likely is due to the fact that most studies occurred before the wetland classification system was developed, but also because most studies do not require further classification of non-forested ecosystems.

Overall, we have identified 25 occurrences of eight blue-listed ecosystems in the Babine River watershed (Table 29), and an additional 21 occurrences of seven regionally rare ecosystems (Table 30).

Table 29. Confirmed occurrences of rare ecosystems in the Babine River watershed.		
Ecosystem	Biogeoclimatic unit	Occurrences*
Western hemlock – lodgepole pine – kinnikinnick – Cladonia lichens	ICHmc1/02 ICHmc2/02	3
Hybrid white spruce – paper birch – devil's club	ICHmc2/54	5
Black cottonwood – red osier dogwood floodplain	ICHmc1/Fm02 or ICHmc1/05 or ICHmc2/Fm02 or ICHmc2/06	5
Black cottonwood – hybrid spruce – red osier dogwood	SBSmc2/Fm02	4*
Drummond's willow – blue-joint reedgrass	SBSmc2/Fl05	1
Scrub birch – water sedge	SBSmc2/Wf02	2
Shore sedge – buck bean – hook moss fen	SBSmc2/Wf08	2
Lodgepole pine – few flowered sedge - Sphagnum	SBSmc2/Wb10	3

*Includes 3 occurrences from Wellwood (2008). Seven polygons were mapped to cottonwood floodplain sites but were spatially close, so we estimated that they constitute only 3 occurrences.

Table 30. Confirmed occurrences of regionally rare ecosystems in the Babine River watershed.		
Ecosystem	Biogeoclimatic unit	Occurrences
Subalpine fir – lodgepole pine – juniper – Cladonia lichens	ESSFmc/02 ESSFmcp/02 ESSFmcw/02	5
Subalpine fir – lodgepole pine – Cladonia lichens	ESSF wv/02	1
Black spruce – lodgepole pine - feathermoss	SBSmc2/03	3
Trembling aspen – paper birch- hazelnut – red osier (birch dominated of frequent fires)	ICHmc2/52 ICHmc2/53	8
Western redcedar- hybrid spruce – horsetail – skunk cabbage	ICHmc2/07	1
Fluvial Ranunculus meadows	SBSmc2/ESSFmc	2
Mesic cow parsnip meadows	ICHmc2	1*

*This ecosystem has anthropogenic causes.

When we considered potential occurrences from TEM projects where polygons are mapped using air photo interpretation (and infrequently ground-truthed), there were 18 occurrences of three blue-listed ecosystems, and a further 322 occurrences of regionally rare ecosystems (Table 31). These occurrences are polygons (vs. plots), come from TEM projects with low survey intensity, and require field verification.

Table 31 also includes occurrences of ecosystems from studies with high survey intensity but there was not enough detail provided to assess whether the observed ecosystem is truly equivalent to rare ecosystems.

Thimbleberry – cow parsnip meadow communities, Cottonwood – cow parsnip forests, and Horsetail – swamp forests were the only types of ecosystems that were not already confirmed to occur in the Babine River watershed (Tables 29 and 30).

Table 31. Potential occurrences of rare ecosystems mapped as polygons (or partial polygons) in three TEM projects in the Babine River watershed.

Ecosystem	Biogeoclimatic unit	Conservation rank	Polygons
Western hemlock – lodgepole pine – kinnikinnick – Cladonia lichens	ICHmc1/02 ICHmc2/02	Blue	10
Hybrid white spruce – paper birch – devil's club	ICHmc2/54	Blue	4
Black cottonwood – red osier dogwood floodplain	ICHmc1/Fm02 or ICHmc1/05	Blue	4
Subalpine fir – lodgepole pine – Cladonia lichens	ESSFwv/02	*Blue*	13
Subalpine fir – lodgepole pine – juniper - Cladonia lichens	ESSFmc/02	*Blue*	51
Thimbleberry – cow parsnip meadows	ICHmc2 SBSmc2	*Blue*	2
Black spruce – lodgepole pine - feathermoss	SBSmc2/03	*Blue*	157
Trembling aspen – Saskatoon - snowberry	SBSmc2/Atss*	*Blue?*	1
Trembling aspen – hard hack	SBSmc2/Atha*	*Blue?*	1
Black cottonwood – cow parsnip forests	ICHmc1	Unknown	3
Cow parsnip – large-leaved avens meadows	SBSmc2/CA ESSFmc/CA ESSFwv/CA	*Blue?*	73 (23 in SBS)
Horsetail swamp forests	ICHmc1/06?	*Blue?*	1
Trembling aspen – paper birch – beaked hazelnut	ICHmc2/53?	*Blue?*	7
Paper birch – false box	ICHmc2/52?	*Blue?*	13

* These occurrences may include meadow components similar to red-listed SBSmc2/81, but more information is required.
Orange shading refers to listed ecosystems; un-shaded ecosystems are regionally rare; gray shaded ecosystems require further investigation.
The question mark in the "Biogeoclimatic unit" column refers to uncertainty in the site series determination because of insufficient detail. Further information is required.

TEM projects also reported many occurrences of sensitive ecosystems such as wetlands, avalanche tracks, meadows, bogs, shrub carrs, seepage areas and riparian areas that were not characterized with enough detail to determine whether or not they included rare ecosystems. This reflects a lack of classification work on these unusual ecosystem types, and also that detailed descriptions of sensitive ecosystems were beyond the scope of the TEM projects. Furthermore, of these sensitive ecosystems, only wetlands and riparian sites are currently adequately represented on the tracking list maintained by the BC CDC.

Predictive Ecosystem Mapping
Without a full inventory of rare ecosystems, or by ground-truthing all predicted rare ecosystem occurrences, it is impossible to fully evaluate how well PEM and PHM work in detecting rare ecosystems. However, we can get a general idea of how well they recognize known occurrences by comparing mapped distributions of known vs. predicted occurrences of rare ecosystems in the Babine River watershed (Map 20). There is an obvious concentration and richness of rare ecosystems near the Babine and Skeena confluence for both PEM and field-based results. For many known occurrences of regionally rare ecosystems, PEM and field-based results appear to agree (i.e. dots of known occurrences intersect predicted occurrences).

We reported 25 confirmed occurrences of 8 types of blue-listed ecosystems, while the Bulkley PEM predicted no occurrences of listed ecosystems and the Kispiox PHM predicted frequent occurrences of three blue-listed ecosystems in the Babine River watershed (Table 24, Map 20). The PEM models, therefore, could not detect 5 types of blue-listed ecosystems that were found to occur by field-based surveys and mapping. We also reported 21 occurrences of 7 types of regionally rare ecosystems; while the combined Bulkley PEM and the Kispiox PHM models predicted four types of regionally rare ecosystems. Overall, there was a lower diversity of rare ecosystems predicted by the PEM models and a higher frequency of occurrences. Both PEM models predicted very frequent and small polygons that amalgamate into much fewer element occurrences (as defined by the BC CDC 2012).

We have previously discussed some of our concerns about using PEM to identify rare ecosystems. We feel the PEM models may have limited use in pointing to areas of high potential for rare ecosystems, but only in conjunction with field verification. If a number of predicted rare ecosystems are found together in an area, then PEM may be a means of highlighting diversity hotspots in the Babine River watershed. These areas would have high priority for ground-truthing.

There is considerable uncertainty in PEM predictions. Accuracies for the models range from 65% for the Bulkey PEM to 80-85% for the Kispiox PHM. The Bulkley PEM does not lump any site series in the model, but Banner *et al.* (2003) suggested that it is limited in its ability to distinguish among closely related ecosystem units (e.g. site series that overlap on the edatopic grid). Mahon *et al.* (2004) lumped site series in the PHM model to attain higher accuracy, but lumping site series makes it difficult to determine the exact location and extent of rare ecosystems. In general, the PHM over-represents rare site series because it cannot distinguish them from more common site series.

If we look only at forested ecosystems, for which the Bulkley PEM was developed, two key problems are that it excludes seral deciduous forests and cottonwood floodplains. It is not possible to highlight areas of deciduous composition in the main model. The ecological exceptions mapping identified floodplain sites using visual interpretation, and the data were incorporated into the PEM model, but the model reassigned these same polygons site series that do not occur on active floodplains. Fortunately we were able to query the ecological exceptions database independently of the larger PEM model and map floodplains. However, we were still unable to determine the tree composition or age of the floodplain stand. The Kispiox PHM included seral ecosystems, cottonwood floodplain ecosystems and three dominant tree species in the database. All three factors made it more useful than the Bulkley PEM for detecting potentially rare ecosystems in this study.

An additional weakness of the Bulkley PEM is the use of composite polygons (up to three deciles), which in combination with the above-mentioned overlapping of site series, makes it very difficult to determine exact location and extent of predicted rare ecosystems within a polygon or area. The Kispiox PHM does not have composite polygons, but by lumping site series it predicts occurrences of rare ecosystems in polygons that are comprised of common ecosystems. All we can conclude is that rare ecosystems may potentially occur in the polygon. If we consider the site interpretation tables (Tables 16, 21), there is even more potential for rare ecosystems to be predicted in polygons dominated by common ecosystem types.

The non-forested ecosystems in both PEM models are not described with enough detail to identify rare ecosystems, and this weakness explains why the PEM models predicted lower diversity of rare ecosystems. The Kispiox PHM mapped a range of non-forested elements from TRIM and VRI databases. The Bulkley PEM used ecological exception mapping to compensate for weaknesses in the model for predicting non-forested sites. But even with this extra effort, both models only identify polygons of interest that require further investigation on the ground. For example, the ecological exceptions database identifies occurrences of eight types of wetlands - wet meadows, forested swamps, forested bogs, herb/graminoids/sedge leading, wet meadow-forest complexes, and low bench shrub and herb communities. Without more detail from ground-based surveys, or further air photo interpretation by a wetland specialist, it is not possible to distinguish rare wetland types from common ones using the database. There can be rare or common representations of virtually all of these ecosystems.

Haeussler (1998) suggested that rare ecosystem specialists could use PEM as a tool to locate non-forested shrub-thickets (maple-alder-willow), meadows, low-elevation rock cliffs or canyons, waterfalls, and wetland systems. These sites would then be high priority for TEM mapping or closer field inspection by rare ecosystem specialists. The two predictive models undertaken in the Babine River watershed can be used to highlight these ecosystems, and we have created maps of these occurrences to aid future study of rare ecosystems in the Babine River watershed (see Map 9). Again, the exception mapping database of the Bulkley PEM, which is really a sub-model using image interpretation methods, would be most appropriate for this purpose; however even then, it would not necessarily detect canyons, or waterfalls (see Map 10). The soils features of the ecological exception mapping - bedrock controlled, very shallow soils, coarse and very-coarse textured soils – are also very useful for identifying rare ecosystems that have specific substrate preferences.

Knowledge Gaps

During the course of this study, we have found several knowledge gaps in our understanding of rare ecosystems in the Babine River watershed. Overall, we know very little about the status of non-forested ecosystems and rare phases of more common forested ecosystems in the Babine River watershed, and in BC. These unclassified ecosystems may be very rare, declining and experiencing threats but there is no information available to assess them.

The BC CDC lists of rare ecosystems are comprised of formally described ecosystems, and specifically, ecosystems that have been classified using the BC Ministry of Forests Biogeoclimatic Ecosystem Classification system. Unclassified ecosystems are not listed or tracked by the BC CDC, nor is there is a large database available to assess the uniqueness, range extent, area of occupancy or degree of threat to these ecosystems either globally or regionally (Haeussler 2006). Most of the unclassified ecosystems are non-forested. Haeussler (1998) included unclassified non-forested ecosystems and rare examples of common forests during her inventory of rare ecosystems in the southern Skeena Region but none of her recommendations to the BC CDC were instated. Examples of these include canyons, riparian shrub ecosystems, herbaceous meadows, waterfalls and cliffs.

Currently, a system for classifying non-forested ecosystems is being developed for BC, though only broad site classes have been described to date (MacKenzie *et al.* 2012, *in preparation*). With this new work, a better understanding of at-risk non-forested ecosystems will be gained. . Though the process is underway, it will take some time to classify all non-forested ecosystems in sufficient detail to assess their conservation status. Further inventory and classification of non-forested ecosystems will result in additional occurrences of rare ecosystems in the Babine River watershed

In the meantime, we would like to highlight the need for further inventories of alpine and subalpine ecosystems, of upland shrub ecosystems, and of avalanche tracks in the Babine River watershed. They are key features of the Babine watershed and received very little attention. Additionally, there needs to be a mechanism in place to highlight rare versions of common site series, even of very common forested ecosystems (e.g. antique forests).

We suggest that any future inventories, regardless of whether further classification work has been completed, will use the preliminary lists in this report to detect unclassified ecosystems.

ALPINE AND SUBALPINE ECOSYSTEMS

Alpine and subalpine ecosystems have not received much attention from ecologists and land managers (Pojar and Stewart 1991). Work is underway by ecologists to create an alpine ecosystem classification system, a variation of the BEC system. Alpine ecosystems occur in a complex mosaic ruled by interrelated environmental factors such topography, exposure, wind, soil temperature, snow depths, and melt water patterning (Pojar and Stewart 1991). The mosaic of alpine ecosystems is also dependent upon bedrock, soil frost features, and sometimes permafrost.

The conservation of alpine ecosystems has not received as much priority as low-elevation ecosystems. The management of the alpine falls under multiple jurisdictions, with no one overruling comprehensive management system. Many assume that alpine ecosystems experience less development pressures and threats, and that many occur in protected areas, but climate change and mineral claims are significant threats to many alpine ecosystems. Furthermore, alpine ecosystems are much more sensitive to disturbance and take much longer to recover.

Alpine and subalpine areas of the Babine River watershed are under risk of development from mineral exploration and extraction. There are 29 active mineral claims within the Babine River watershed (Map 21), and approximately 50 further claims nearby; MINFILE 2012).

Very little is known is about what constitutes an "at-risk alpine ecosystem" in BC. There are only two alpine ecosystems listed by the BC CDC for our region *Poa glauca* ssp. *rupicola* and *Calamagrostis purpurascens* vegetation communities (BC CDC 2012). The former occurs on grassy saddles or convex areas in the alpine, where sheep and goats graze and rest, and where their manure enriches the soil, resulting in enhanced growth of herbaceous vegetation (Pojar 1986). Analogous ecosystems may exist in mountains of the Babine River watershed. They are mostly snow-free in winter, and green up quickly in spring. The BC distribution of *Calamagrostis purpurascens* follows the Coast Mountains and finding this ecosystem in the Babine River watershed would be a significant range extension (Douglas *et al.* 2002).

PEM projects in the Babine River watershed have not adequately characterized or mapped alpine ecosystems. Broad habitat classes, such as heath and grassland, meadow, krummholz, rock, and glacier were generally used in alpine areas, but these are too sweeping for conservation applications. Non-forested subalpine and parkland ecosystems were also only broadly characterized and mapped. Subalpine forests and woodlands, in contrast, have been classified in greater detail (Banner *et al.* 1993, Trowbridge and Banner 2004).

In the Babine River watershed, there are a number of alpine and subalpine ecosystems that may be listed in the future, or that are regionally significant (J. Pojar and S. Haeussler *personal communication* 2012).

1)
indswept, but cool aspect slopes with very high lichen cover. There may be some of this ecosystem at the height of land to the south of study area (north-facing)(J. Pojar 2012, *personal communication*). Lichen cover is much higher (90-100% lichens) on these sites than in lichen fellfields. These ecosystems may be sites for arctic-alpine outliers.
2) Windswept ridges, with very low to no winter snow cover. The alpine grass, *Kobresia myosuroides,* is an indicator of this ecosystem. Most of the mountain ranges have very deep snow packs. Windswept ridges with low snow cover are probably rare in the Babine River watershed.
3) Recently de-glaciated bedrock areas may also be sites for arctic-alpine outliers. Glacier retreat may leave scoured bedrock and other interesting habitats for colonization, particularly if there is calcareous bedrock.
4) Glacier-caused cold air ponding in north-facing, deep gulches. Similar to Glacier Gulch, these humid, cold-air drainage site may support unique ecosystems.
5) Alluvial ferricrete ecosystems and *Anthelia*-dominated bryophyte communities (*sensu* Haeussler 2004, 2006). These alpine ecosystems are associated with white-precipitate mineral springs and streams, and unusual iron-rich, red-stained and highly cemented soils, respectively. Both ecosystems are found on mineralized and very acidic rock, which are often at risk from mineral exploration.
6) Subalpine and alpine streams above 1200 m. The endangered aquatic lichen, *Peltigera gowardii*, is found growing in spring-fed streams in open subalpine and sometimes alpine

meadows in our region. This lichen is currently being assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The streams are usually one metre or less across with flowing, cool, silt free water. *Peltigera gowardii* has been found on Hudson Bay Mountain, John Brown Creek and in Terrace (J. Pojar 2012, *personal communication*.). There may be suitable habitat in the Babine River watershed. There are only five known occurrences in Canada for this lichen.

7) White bark pine trees are ranked "endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and blue-listed in BC because of a number of interwoven threats – bark beetle, fire suppression, climate change and white pine blister rust. The closest localities are McKendrick Pass and Mount Sidney Williams. South-facing, convex rapidly draining sites are most likely to harbour this species, but they can occur on talus or glacio-fluvial habitats (S. Haeussler 2012, *personal communication*).

SHRUB DOMINATED COMMUNITIES

Shrub dominated ecosystems are a significant component of the Babine River watershed. There were several shrub sites detected in previous Babine River watershed vegetation studies but very little ecological information was provided. Mapping by Madrone (1994), Mahon *et al.* (2004), and Lea and Kowall (1992) distinguished among shrub-dominated sites; however, without an established classification framework it is difficult to adequately assess shrub ecosystems. Wetland and floodplain shrub ecosystems have been recently studied by MacKenzie and Moran (2004), however not a lot of work has been done on upland shrub-dominated sites. In spatial coverage, edaphic shrub communities are often rare on the landscape and specific assemblages may be very rare.

AVALANCHE TRACKS

Avalanche tracks are well known for providing important food for grizzly bears; however, they are also generally higher in plant species diversity than adjacent undisturbed forests. Avalanche tracks with frequent disturbance events and over anomalous geology (e.g. base-rich soils) may harbour un-described rare plant communities, or provide key habitat for rare species (Bartemucci 2006*).* Avalanche tracks also provide appropriate habitats for alpine plant species at low elevations, thereby causing a mixing of alpine and low-elevation species, often resulting in high species diversity. Tall shrub communities, though poorer in species than open herb-dominated zones of avalanche tracks, can have small areas of herb meadows interspersed.

While there has been preliminary work done to classify avalanche zones in BC (e.g. Schaerer 1973, Park and Petrovcic 2002, Himmer *et al.* 2008) further classification is needed in order to assess the diversity, distribution, prevalence and conservation value of avalanche tracks.

RARE VARIATIONS OF COMMON FORESTED SITE SERIES

Haeussler (1998) reported a number of rare representations of common site series (or site phases) including birch-dominated stands and deciduous stands with frequent fire history. These ecosystems are difficult to detect using PEM or TEM methods. The BC CDC does not recognize or target endangered site phases. These ecosystems, like non-forested ecosystems, are not being tracked.

Old-growth forests are another example of rare variations of common forest ecosystems. Very productive old-growth forests are not specifically designated as being at risk in BC for SBSmc2 and ICHmc subzones, though they are becoming progressively rare and are increasingly threatened due to forest harvesting. For example, ancient western red cedar stands, also called 'antique forests', can develop on a variety of site series in the ICHmc. Typically these forests, which grow on the toe slope position, support very large trees, up to 2 m dbh or greater. Antique forests represent prolonged continuity and stand ages may be much older than the oldest trees. Similarly, large productive and possibly antique spruce forests can develop in the SBSmc2. Such forests are recognized as being critical habitat for a large number of old-growth dependent lichen species (Goward and Pojar 1998), some of which are listed by COSEWIC. It is difficult to identify antique forests from TEM and PEM projects because there is no structural stage or age class for forests that may be many hundreds of years older than age class 9 (>251 years), nor a specific site series designation that would identify these forests with PEM models.

RECOMMENDATIONS

If an accurate assessment of rare ecosystems is a priority of the Babine River Watershed Monitoring Trust, then we recommend further inventory. Several vegetation mapping projects have been completed for the area; however, projects done with appropriate survey intensity comprise a small proportion of the watershed (approximately 7445 ha, or 2%). The field verification study of the Kispiox PHM, the MOF BEC plot data and Haeussler's rare ecosystems study represent additional widely distributed coverage of unknown area. Of these studies, only Haeussler's project was specifically directed toward identifying rare ecosystems.

There are many problems with data obtained from TEM projects in the Babine River watershed. Composite polygons, mapping at small-scales, and a lack of classification of many non-forested ecosystems limit the application of existing TEM data for rare ecosystem assessment. Furthermore, none of these projects assessed the quality of the ecosystem, its threats to persistence nor any other factor that may be used to assess conservation status.

While predictive ecosystem mapping covers the entire Babine River watershed, we have serious concerns about using the two current models to detect rare ecosystems without subsequent field verification. Even so, these models were not developed with the objective of detecting rare ecosystems and we believe that ground-truthing rare ecosystems predicted by PEM models would not result in an adequate inventory because PEM models are ineffective at differentiating most non-forested ecosystems.

With unlimited funds, a full rare ecosystem inventory (RISC 2006, de Groot and Bartemucci 2003) would be the best way to meet the objective of identifying rare ecosystems. However, field-based rare ecosystem surveys are expensive because of the time spent in the field and transportation costs, particularly if helicopter travel is required. A priority approach to field surveys could be developed to help direct plans for field surveys with a modest budget.

The priority approach would be similar to that proposed by de Groot and Bartemucci (2003), in which regions of interest within the Babine River watershed would be ranked according to 4 factors:

1) evel of previous inventory effort
2) otential for locating additional rare ecosystems
3) umber of documented rare plant communities
4) erceived threats

To date, there has been a range of inventory effort across the Babine River watershed: from areas that have not been visited by ecologists to areas that have been mapped and surveyed. Areas that have not been visited at all would be ranked highest and areas that have seen higher levels of inventory (e.g. large scale TEM map with good field verification) would be ranked low. From high to low inventory effort (or low to high priority), the TEM projects could be ranked: South Park Access (Babine River Corridor Park), Babine – Skeena River confluence, Big Slide Area, Upper Nilkitkwa River, Tommy Jack Pass, Babine River Biophysical Area.

In addition to the studies that we have summarized in this report, we have held interviews with four regional experts (Sybille Haeussler, Allen Banner, Jim Pojar and Will MacKenzie). We were able to determine areas in the Babine River watershed that have not been previously surveyed, and areas with a high potential for supporting rare ecosystems. Despite the proximity to Smithers, these ecologists have spent relatively little time in the Babine River watershed. In most cases visits were brief and detailed ecological information was taken only in a few plots.

The following general areas have been visited, though not thoroughly surveyed, by regional ecologists. Some of the visits were BEC data collection and some were flights over these areas.

Tommy Jack Pass, upper Shedin Creek
Gunanoot Lake
Rainbow Alley wetlands and floodplains (by canoe)
Natlan Peak – French Peak area
Kotsine Pass
Mount Horetzky forested ecosystems
Babine River and Hanawald Creek confluence
Upper Nilkitkwa River

The following is a list of priority areas for future surveys. These areas have been recommended by regional ecologists as being places with a high potential for supporting rare ecosystems, and many of them have not been surveyed or have seen low inventory effort.

Onerka Lake wetlands
Atna pass

Bait Range and other mountains (e.g. Mt Horetzky) that may have white bark pine. White bark pine sites have not been surveyed in the area.
Shedin River drainage
Shelagyote River drainage
Tommy Jack Pass wetlands
Upper Shelagyote
Gail Creek Canyon
Damsumlo wetlands
Rainbow Alley
Nichyeskwa area
Near Hanawald Creek and Babine River confluence
Gunanoot wetlands
South slopes of Mt Horetzky
Shelagyote and Babine River confluence
Sicintine Range
Upper Nilkitkwa River

There is relatively little known about the vegetation in many of these areas and prioritizing within this list is difficult. Bedrock geology maps and careful image analysis may help rank this long list of areas in terms of probability of finding new rare ecosystems. For example, areas with special geology (e.g. limestone bedrock) or landscape features (e.g. floodplains) would have highest potential for supporting rare ecosystems.

Identifying how many rare ecosystems have been already found in an area of the watershed is included in this ranking method because this type of "hot spot analysis" (e.g. Scudder 2003, Roemer *et al.* 1994) was considered one way to prioritize rare ecosystem management. Areas that support a diversity or abundance of rare ecosystems should have higher priority for baseline surveying and for monitoring. We could use the results of the exceptions mapping and the results from the two PEM models to locate areas of high diversity of rare ecosystems. Furthermore, areas that support endemic or globally significant ecosystems would have highest priority for more detailed surveys. Examples of these types of ecosystems would be white bark pine forests, ancient cedar forests that support COSEWIC lichens, subalpine streams that support a rare aquatic lichen, and hybridization of coastal and interior species. There have been observations of unique coastal-interior hybridizations occurring in the area surrounding the Babine River watershed. Examples such as Hybrid Sitka spruce (Roche spruce), potential *Alnus rubra* x *tenuifolia* hybrids, and *Prunus emarginata* hybrids were reported by Haeussler (1998).

The number and type of identified threats in a given area are important criteria for prioritizing rare ecosystem surveys. Threats include mineral exploration and extraction, logging, and recreation development. Areas with serious threats to rare ecosystem persistence would rank highest. One simplified approach would be to recommend rare plant surveys whenever there were plans to develop an area. The weakness of this reactive (rather than proactive) approach in that rare ecosystems may be lost if development plans are not known with enough advanced notice for surveys to take place. Other threats to rare ecosystem persistence in the Babine River watershed could be climate change and climate change-mediated effects such as increased bark beetle infestations and altered fire return intervals. Whitebark pine and dry pine-lichen forest types, and potentially scrub steppe meadows (S. Haeussler 2012, *personal communication*) are threatened by bark beetles. Subalpine and alpine communities are more directly threatened by warmer temperatures and changes in snowfall patterns.

Areas that scored high in the four criteria (previous inventory effort, potential for new records of rare elements, number of documented rare occurrences and threats) would be considered to have highest priority for inventory or mapping efforts. For example, highest priority should be given to areas that have a high potential for supporting globally rare elements and are incurring serious threats.

In the end, deciding how to prioritize rare ecosystem surveys will probably be a function of recognizing access and budget constraints—several of these areas are only accessible by helicopter. A prudent approach would be to access as many of the sites as possible by roads, and to gain access to inaccessible areas by coordinating a small number of helicopter trips with the transfer of guests and supplies to fishing lodges. There may also be an opportunity to combine rare ecosystem with rare plant surveys, as is often done.

Maintaining rare ecosystems

In the Babine Watershed Monitoring Framework, the two objectives pertaining to rare ecosystems are to:

- -maintain structural and functional integrity of red and blue-listed plant communities, with no reduction in functional area; and
- -retain representative examples of rare and endangered plant communities within Core Ecosystems.

With the information summarized in this report from all available sources, there are insufficient data to determine whether the objectives are being met. As stated earlier, there are many gaps in our knowledge of what is rare, particularly for non-forested ecosystems. However, if we assume that the two lists of rare ecosystems (BC CDC listed and regionally rare) that we have compiled are complete, what can we contribute to assessing these land management objectives?

In 2002, an analysis was undertaken to assess whether predicted rare ecosystems in the Bulkley TSA occurred in Core Ecosystems (including Special Management Zones, and protected areas)(Section 2.7, State of the Forest Report (2004)), using an earlier version of the Bulkley PEM model (Ministry of Forests 2002). The list of rare plant communities analyzed included red and blue-listed plant communities (BC CDC 1998) and those recommended for listing by Haeussler (1998) for a total of 32 current or potential rare ecosystems. They used PEM predictions to conclude that 14 rare ecosystems are poorly represented in Core Ecosystems (SMZs and protected areas).

In the 2002 study, PEM was only able to predict locations for 21 out of 32 rare ecosystems, and there were some errors and duplications. For example, the results stated that the PEM model predicted the occurrence of Douglas fir – feather moss (SBSdk/04) forests, but Douglas fir does not occur in the Bulkey TSA (Haeussler 1998). We are uncertain how the PEM 2002 model could distinguish between different meadow communities (cow parsnip meadows, bracken fern – cow parsnip –riceroot, and mesic, montane meadows) or how it picked out timber oat-grass dry grassland from common heath grasslands. There were also duplicates of identical ecosystems (e.g. two SBSdk/08 ecosystems).

In summary, the 2002 Bulkley TSA PEM was inadequate for identifying rare ecosystems and results from the analysis were insufficiently reliable for making management decisions. The 2002 PEM model had very low accuracy and was later completely rebuilt (Timberline 2010).

With the knowledge that we have gathered in 2012, we can see how many predicted and known occurrences of rare ecosystems are within core ecosystems, special management zones and protected areas in the Bulkley portion of the Babine River watershed (Map 20). When we include only confirmed occurrences (vs. predicted or interpreted occurrences using PEM and small-scale TEM), there are 22 listed or regionally rare ecosystems in the Bulkley TSA portion of the watershed. Six of these occurrences occur in areas of conservation, representing 27% of the known occurrences. In terms of predicted occurrences, many occurrences of regionally rare ecosystems were found in areas of conservation, mostly in the upper Nilkitkwa River and upper Boucher Creek drainages (Map 20).

Whether the structural and functional integrity of rare ecosystems is being maintained in the Kispiox Forest District portion of the Babine River watershed is very difficult to assess with PEM and the additional existing sources of information. There are 24 known occurrences of rare ecosystems in the Kispiox portion of the watershed, and they occupy small, discrete areas.

The Babine River watershed occurs at an ecological transition where the coastal and interior flora and fauna merge, and the watershed supports a diversity of landscape features. There is much uncertainty in our understanding of how many rare ecosystems occur in the Babine River watershed, and whether they are in danger of extirpation. It is, however, very likely that additional rare ecosystems will be found with further investigation.

DEFINITIONS

These definitions originate from the BC CDC glossary website: (http://www.env.gov.bc.ca/atrisk/glossary.html) and from the BC Forest Service (http://www.for.gov.bc.ca/hre/becweb/system/index.html).

Biogeoclimatic Ecosystem Classification System (BEC) – is a multi-scaled, ecosystem-based classification system that groups ecologically similar site based on climate, soils and vegetation. It is used as a framework for resource management and scientific research.

Blue Listed Plant Community - an ecological community of special concern (formerly vulnerable) in British Columbia.

British Columbia Conservation Data Centre (BC CDC) – is the provincial agency that is responsible for listing and keeping records for rare and endangered organisms and ecological communities in British Columbia. In 1996 the BC CDC produced a preliminary list of over 200 endangered and vulnerable plant associations (McLennan 2000 Mapping the Central Coast). The most recent list includes assessment for 624 ecological communities (BC CDC 2012).

Conservation Framework - The Conservation Framework provides a set of decision support tools to enable collaboration between government and non-government resource managers and practitioners using the best available information and clearly defined criteria to: 1) prioritize species and ecosystems for conservation in British Columbia; and 2) determine the most appropriate and effective management actions. The three goals of the Conservation Framework are:

1. Contribute to global efforts for species and ecosystem conservation
2. Maintain the diversity of native species and ecosystems
3. Prevent species and ecosystems from becoming at risk

Ecological Community – is the term used by the B.C. Conservation Data Centre and the NatureServe network to indicate a conservation unit with an association of species. It incorporates natural plant communities and plant associations, and includes a wide range of known ecosystems with their site requirements such as soil moisture and nutrients, climate, physiographic features and energy cycles. The term formerly used by the BC CDC was "plant community".

Ecosystem – An ecosystem is a dynamic complex of plant, animal, and microorganism communities, climatic factors and physical geography, all influenced by natural disturbance events and interacting as a functional unit. Ecosystems span a broad range of scales.

Identified Wildlife (Identified Wildlife Management Strategy Version 2004)
Identified Wildlife are species at risk and regionally important wildlife that the Minister of Water, Land and Air Protection designates as requiring special management attention under the Forest and Range Practices legislation. Under this legislation, the definition of species at risk includes endangered, threatened or vulnerable species of vertebrates, invertebrates, plants and *plant communities*. Regionally important wildlife include species that are considered important to a region of British Columbia, rely on habitats that are not otherwise protected under FRPA, and are vulnerable to forest and range impacts

The Identified Wildlife Management Strategy (IWMS) provides direction, policy, procedures and guidelines for managing Identified Wildlife. The goals of the Identified Wildlife Management Strategy are to minimize the effects of forest and range practices on Identified Wildlife, and to maintain their critical habitats throughout their current ranges and, where appropriate, their historic ranges. In some cases, this will entail restoration of previously occupied habitats, particularly for those species most at risk.

Plant Association – a classification concept that groups similar plant communities according to the rules of vegetation classification (e.g. site series in the Biogeoclimatic Ecosystem Classification - BEC). Plant association can be a habitat for an "ecological community".

Plant Community – an assemblage of plants that inhabit a common niche, and is distinguishable as a unit (patch) of vegetation. Also called an ecological community.

Predictive Ecosystem Mapping (PEM) - is a modeled approach to ecosystem mapping, whereby existing knowledge of ecosystem attributes and relationships are used to predict ecosystem representation in the landscape.

Rare Ecosystem - an ecosystem (site series or surrogate) that makes up less than 2% of a landscape unit and is not common in adjacent landscape units (Forest Practices Code Biodiversity Guidebook 1995). The ecological communities listed as endangered, threaten or of special concern by the BC CDC.

Rare Plant – a plant species, subspecies or variant that is listed as endangered, threaten or of special concern by the BC CDC.

Red Listed Plant Community – ecological communities that are extirpated, endangered or threatened in British Columbia. There is no legislation to protect red-listed plant communities; however, they may receive some special management if designated under the Identified Wildlife Management Strategy, in the *Forest and Range Practices Act*. Only 15 plant communities in BC are formally designated under the Identified Wildlife Management Strategy, none occur in northwestern BC.

Regionally Significant Ecosystem – plant communities recognized as rare or otherwise significant by regional experts, which are not currently listed by the BC CDC.

Scale – the ratio of the distance on a map to the distance on the ground. For example for the scale 1:20,000, one centimeter is equal to 200 metres.

Sensitive Ecosystem – an ecosystem that is considered fragile to human disturbance.

Terrestrial Ecosystem Mapping (TEM) - is a methodology that requires direct air photo interpretation of ecosystem attributes by a mapper. This approach is typically used at larger scales where more detailed information is required.

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