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Sensitive Ecosystems of the Atlin-Taku Planning Area

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Executive Summary

The Integrated Land Management Bureau (ILMB) of the British Columbia Ministry of Agriculture and Lands, and the Taku River Tlingit First Nation (TRTFN) are embarking on a joint land use planning initiative in the Atlin-Taku region of northwest British Columbia. This sensitive ecosystem inventory was undertaken to provide information on sensitive ecosystems for the planning process. The inventory followed the Standard for Mapping Ecosystems at Risk in British Columbia (RISC 2006), at a reconnaissance level (1:250,000 scale). The Atlin-Taku planning area covers more than 3 million hectares, and includes portions of the Atlin, Gladys, Tagish, Taku and Whiting watersheds within northwest British Columbia.

The objectives of this report are to:

1) Conduct a reconnaissance level inventory of terrestrial sensitive ecosystems in the Atlin-Taku planning area.

2) Provide an overview of the threats to these sensitive ecosystems.

3) Map the location of the inventoried sensitive ecosystems.

A biophysical approach was used for this project, as this method identifies locations with atypical environmental characteristics. These atypical sites will be enduring on the landscape and will continue to harbour regionally unusual biota and processes regardless of climate or environmental change. Water features were not the focus of the report, though some that were identified by contacted individuals are listed in the report.

Sensitive ecosystems covered 66,700 ha or 2.2% of the Atlin-Taku study area. Sensitive ecosystem types were very diverse, ranging from those depending on hydrological processes such as flooding, those depending on geological processes such as landslides, to those depending on bedrock geology such as limestone canyons, calcareous wetlands, ultramafic bedrock influenced plant communities, and hydromagnesite and tufa deposits.

At 31,000 ha, sensitive riparian ecosystems covered the largest area of the sensitive ecosystem classes. Floodplains comprised most of the sensitive riparian area. Most of the sensitive floodplain was located along the lower Taku River, with significant amounts on the Inklin and Sheslay rivers.

The Grasslands–Shrub/Steppe ecosystem was the second most abundant sensitive ecosystem, covering 10,700 ha. The majority of this was in the Fourth of July Creek–Coronation Creek area on extensive glaciofluvial deposits. Other areas of Grassland–Shrub/Steppe were located along the Sheslay and Nahlin rivers on steep south-facing slopes.

Canyons in limestone bedrock along the Nakina River and Houdini Creek covered 8,600 ha. These areas are important for their diversity of plant communities, unusual plant communities, limestone features and unusual hydrological processes.

The Lichen Landscape in White Pass covered 6,100 ha. This area is unique because the complex microtopography, consisting of glacially scoured bedrock, glaciofluvial deposits, ponds, lakes and wetlands, has extraordinarily high lichen diversity.

Sensitive wetlands occupied 4,300 ha, with a large wetland complex on the Heart Range making up the majority of this. Six calcareous wetlands form the remainder of the sensitive wetland area.

Pine-Lichen woodlands covered 4,000 ha, mostly near Steamboat Mountain and Indian Lake; additional ecosystems of this type are likely to occur in the study area.

Ecosystems on ultramafic bedrock covered 1,400 ha, and included a pine-lichen woodland and steep terrain where a landslide has occurred. Herbaceous meadow occupied 350 ha, including the spray zone around Bishop Falls. Tufa covered 54 ha at the Atlin Warm Springs, though additional deposits are known but were not located. Hydromagnesite deposits covered 29 ha near the town of Atlin.

Threats to sensitive ecosystems include climate change, electricity generation projects, forest harvesting, invasive species, mineral exploration and mine development, recreational use, road construction and utility corridor construction. Overall, the greatest threat to sensitive ecosystems is from mineral exploration and mine development activity, because of low levels of development for other activities and the high degree of mineralization in the area. Development on the floodplain and wetlands beside Tulsequah River and Shazah Creek is on-going.

The sensitive ecosystems under greatest threat are the hydromagnesite deposit at Atlin and the tufa deposit at the Atlin Warm Springs. The hydromagnesite deposit is covered by a mineral claim targeting the deposit, and the tufa deposit has a long history of use and disturbance.

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1.0 Introduction

The Integrated Land Management Bureau (ILMB) of the British Columbia Ministry of Agriculture and Lands, and the Taku River Tlingit First Nation (TRTFN) are embarking on a joint land use planning initiative in the Atlin-Taku region. Planning projects require background information to inform the planning process. Knowledge of sensitive ecosystems in the Atlin-Taku area is minimal due to the scarcity of relevant inventory work in the area. It is important, therefore, to compile existing information on sensitive ecosystems and to ensure that gaps in this information be filled. It is also important to understand threats to the integrity of these ecosystems. Combined information on presence of the ecosystems and threats will allow these sites to be better protected through the planning process.

Existing reports or databases covering the Atlin-Taku region did not explicitly address sensitive ecosystems, though numerous reports contain pieces of relevant information. Fuller (2002) and Klohn Crippen Berger Ltd. (2006) conducted Terrestrial Ecosystem Mapping (TEM) for mining projects in the region, but either did not address sensitive ecosystems or did not record any. Earlier mining projects in the region did not require vegetation mapping (Norecol Environmental Consultants 1987). Heinemeyer *et al.* (2003) produced a Conservation Area Design (CAD) for the Atlin-Taku area for the Taku River Tlingit First Nation. The CAD used a predictive model using Biogeoclimatic Ecosystem Classification (BEC) subzones, vegetation cover, forest age class and topography to define ecosystems in the Atlin-Taku area. This model predicted 201 ecological communities in 10 broad forest groupings. These communities covered areas ranging from 6 ha to over 541,000 ha.

Some of the information contained in this report has come from publications that describe vegetation either explicitly, such as theses (Anderson 1970, Buttrick 1977, Buttrick 1978), or incidentally, such as geological reports (Kerr 1948). The BEC database contains data from 394 plots in the study area. Individuals contacted provided much information gained from personal knowledge of the area.

The objectives of this report are to:

1) Conduct a reconnaissance level inventory of terrestrial sensitive ecosystems in the Atlin-Taku planning area.

2) Provide an overview of the threats to these sensitive ecosystems.

3) Map the location of the inventoried sensitive ecosystems.

2.0 Study Area Description

The Atlin-Taku planning area covers over 3 million hectares and includes portions of the Atlin, Gladys, Tagish and Taku watersheds within northwest British Columbia (Figure 1). Included in this area are Atlin, Gladys, Nakina, Sloko, Surprise, Tagish, Tatsamenie and Tutshi lakes and Dudidontu, Upper Gladys, Hackett, Inklin, Nahlin, Nakina, Nakonake, O'Donnell, Samotua, Sloko, Sutlahine, Sheslay, Swanson, Taku, Tulsequah and Whiting rivers. Some of these rivers have large floodplains that are important for biodiversity on the landscape.

The western side of the study area is occupied by the Boundary Ranges of the Coast Mountains and contains extensive icefields and steep gradient rivers with wide braided floodplains. The eastern portion of the study area includes the Tagish Highland and Teslin Plateau of the Yukon Plateau and the Tahltan Highland, Taku Plateau, Nahlin Plateau, and Kawdy Plateau of the Stikine Plateau. The Tagish and Tahltan Highlands are transition areas between mountains to the west and plateaus to the east. The plateaus generally have low relief and rolling topography (Holland 1976). Both the highlands and plateaus contain many large linear lakes and few major rivers. Demarchi (1995) grouped these physiographic units into four Ecosections: Boundary Ranges, Stikine Plateau, Tahltan Highlands and Teslin Plateau. Recent evidence indicates that some of the region may have escaped Wisconsinan glaciation and served as a glacial refugium for plant and animal species during the Pleistocene (Marr *et al.* 2008).

The geology of the study area is the most diverse in the province, containing rocks of very different origin spanning 500 million years (Horn and Tamblyn 2002). Bedrock in the study area that is of specific interest to this report includes limestone, basalt and ultramafics such as serpentinite and peridotite (Aitken 1959, Mulligan 1963, Souther *et al*. 1969, Souther 1969, Souther 1971, Levson 1992).

Vegetation reflects the coastal–boreal transition across the study area. Lowland coastal areas are dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*), with cottonwood (*Populus balsamifera* ssp. *trichocarpa*) abundant on floodplains and sub-alpine fir (*Abies lasiocarpa*) occurring fairly commonly. Mountain slopes in coastal areas have mountain hemlock (*Tsuga mertensiana*) as the dominant tree species, but there are extensive non-forested areas containing shrubby vegetation on avalanche tracks and other areas. Alpine areas have a combination of herbaceous meadows and heathlands.

Low elevation inland areas are dominated by white spruce (*Picea glauca*) and sub-alpine fir. Lodgepole pine (*Pinus contorta*) and trembling aspen (*Populus tremuloides*) occur regularly and dominate in some areas. Spruce-fir forests also dominate middle and upper slopes. Extensive areas of willow - scrub birch shrubland occur in many subalpine areas. Alpine areas are drier and contain more grass and less heather than those in coastal areas.

Road access in the study area is limited, with access from the Alaska Highway south to the town of Atlin, the nearby Surprise Lake-Ruby Creek area, and O'Donnell River; along Highway 2 from Carcross to Skagway on the northwestern edge of the study area; and from Telegraph Creek Road northwest to Golden Bear Mine area near Samotua River, though this road is now impassable in places. Historic mining and exploration activities have created seldom used secondary roads in various stages of disrepair along side drainages branching from the roads mentioned above.

2.1 Biogeoclimatic Classification in the Study Area

The Atlin-Taku planning area spans a transition between coastal and interior boreal environments. This is reflected in the Biogeoclimatic Ecosystem Classification (BEC) of the area, which includes coastal, transitional, and interior boreal biogeoclimatic zones, subzones and variants (Table 1) (Banner *et al.* 1993). The study area is dominated by boreal biogeoclimatic units (BWBS, SWB and BAFA), which cover 71% of the study area; coastal biogeoclimatic units (CWH, MH and CMA) cover 16% of the study area; and transitional biogeoclimatic units (ESSF and SBS) cover 13% of the study area. Alpine ecosystems are prominent on the landscape, with the interior BAFA zone and the coastal CMA zone together covering 35% of the study area.

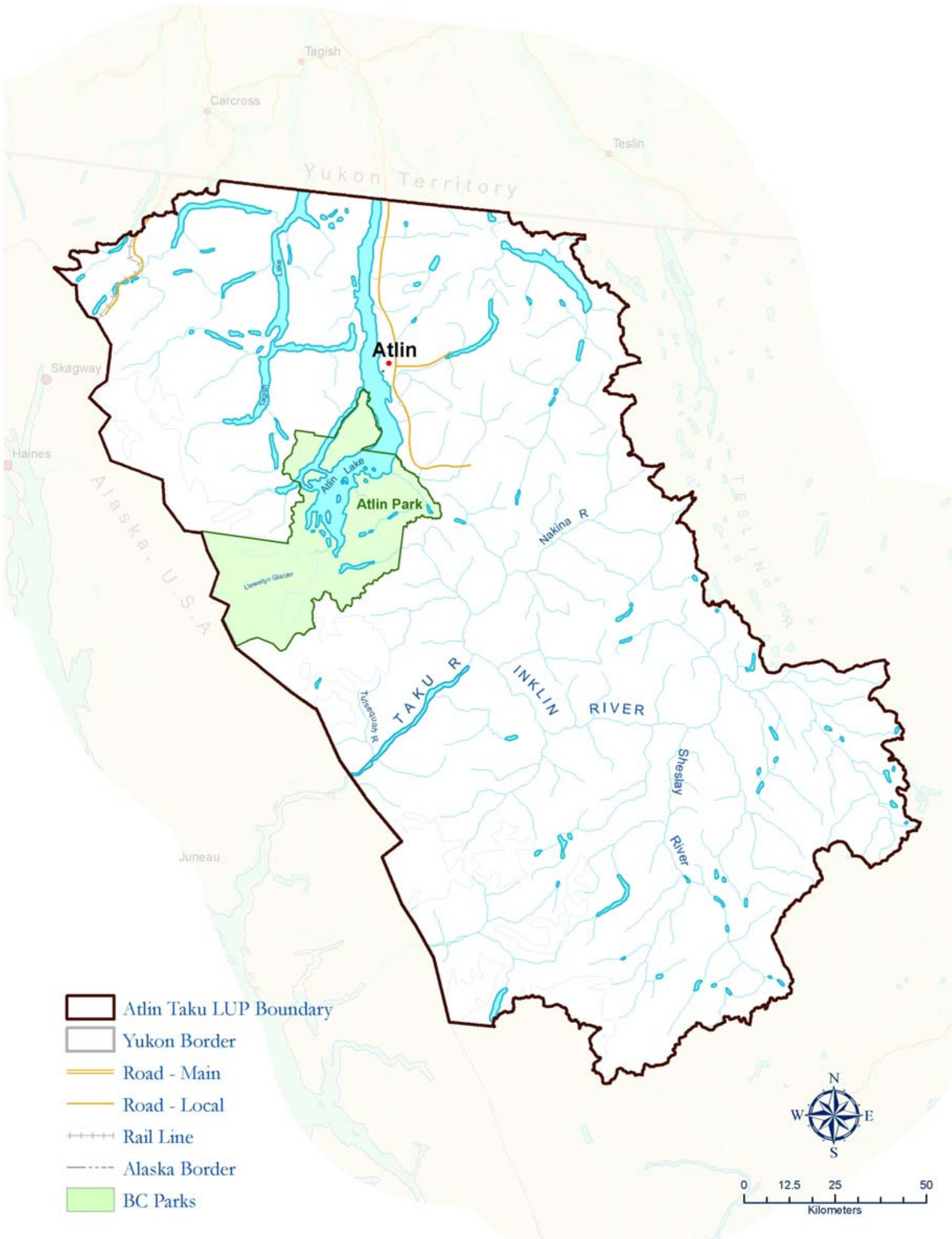

Figure 1. Location of study area

Table 1. Biogeoclimatic zones, subzones and variants in the Atlin-Taku Area

Biogeoclimatic zone	**Biogeoclimatic subzone / variant**	**Hectares**	**% of the study area**
Boreal Altai Fescue Alpine (BAFA)	BAFAunp	741,085	24.4
Boreal White and Black Spruce (BWBS)	BWBSdk1	679,981	22.4
Coastal Mountain-heather Alpine (CMA)	CMAunp	322,346	10.6
Coastal Western Hemlock (CWH)	CWHwm	61,989	2.0
Engelmann Spruce – Subalpine Fir (ESSF)	ESSFwv	210,994	6.9
Mountain Hemlock (MH)	MHund	123,217	4.0
Spruce-Willow-Birch (SWB)	SWBmk	252,119	8.3
	SWBun	467,739	15.4
Sub-Boreal Spruce (SBS)	SBSund	181,423	6.0
	TOTAL	3,040,893	

Due to inadequate sampling, some of the BEC subzones remain undescribed. Further, the classification of some of the other subzones requires additional sampling to become more robust (A. Banner *pers. comm*.).[1]

[1] The BWBSdk1 in the study area may be revised to the BWBSdk3 in the next version of BEC for this area.

3.0 Methods

The Standard for Mapping Ecosystems at Risk in British Columbia: An Approach to Mapping Ecosystems at Risk and Other Sensitive Ecosystems (RISC 2006) was followed for this project. The reconnaissance survey level intensity was used. The Ecosystems at Risk standard includes two groups of ecosystems: 1) Sensitive Ecosystems, which are at-risk or ecologically fragile in the provincial landscape including those listed as Special Concern, Threatened, or Endangered by the BC Conservation Data Centre (CDC), and 2) Other Important Ecosystems, which are not designated at-risk ecologically or ecologically sensitive but have significant values that can be identified and mapped. Here, only sensitive ecosystems were identified, due to the reconnaissance level of the project. A biophysical approach was used, which identifies areas with atypical environmental characteristics in the study area (RISC 2006). The biophysical method was used for identifying sensitive ecosystems because unusual physical sites are expected to be enduring on the landscape, and will continue to harbour regionally unusual biota and processes regardless of climate change and other agents of global environmental change.

An initial list of sensitive ecosystems was developed using CDC lists. Biophysical types and sensitive ecosystems within each biophysical type were identified using a wide variety of sources, including published and unpublished reports, environmental assessments for proposed mines, and knowledge from First Nations, residents and professionals. Air photos were obtained for these areas and potential sampling sites identified. The locations in this initial list were assessed for completeness of information currently available, relative significance of the site, and likelihood of gathering new information with a site visit. This subjective assessment and air photos were used to create up a field-sampling plan for the project. The field-sampling program was constrained by the large size of the study area, and the lack of road access. Sites within Atlin Provincial Park were given lower priority for visits as the park is only indirectly addressed by the land use planning process.

Listed plant species were considered when identifying sensitive ecosystems; however, rare species are only one component of what was considered. There are also issues concerning peripheral species and jurisdictional rarity that must be considered when using listed plant species in this type of project. Jurisdictional rarity occurs when only a small portion of a species' geographic range occurs within a political jurisdiction (Bunnell *et al*. 2004). A formal analysis of jurisdictional rarity was not undertaken, but was informally considered.

Rare ecological communities described by the CAD process (Heinemeyer *et al*. 2003) were prioritized for field checking. This was done subjectively using knowledge of ecosystems in the area and by obtaining a list of priority ecosystems for checking from the CAD authors. We visited 15 different CAD ecological communities using a combination of ground and visual plots.

Field sampling used a combination of full plot descriptions (FS882; B.C. Ministry of Environment and B.C. Ministry of Forests 1998), ground inspections, and visual checks (Ground Inspection Forms). A total of 76 plots comprised of 49 full plots, 21 ground inspections and 6 visual checks were completed. BC CDC Conservation Evaluation Forms were filled out at sites where there had been human impacts, but due to remoteness and lack of human activity in most areas, little information was available, and the forms were not always filled out. Plant voucher specimens were collected when there was uncertainty about species identity or if the species was rare or unusual. Voucher specimens were lodged with herbaria at the B.C. Ministry of Forests and Range, Smithers office; University of British Columbia and Royal British Columbia Museum.[2]

While this report is concerned mainly with terrestrial or wetland ecosystems, several water features are also listed, although aquatic ecosystems were not field sampled or mapped.

A map at a scale of 1:250,000 was produced. We drew large and generalized polygons using aerial photographs and field knowledge. Mono-restitution and the digital transfer of information

[2] Plant nomenclature follows the Illustrated Flora of British Columbia (Douglas *et al*. 1998a & b, 1999a & b, 2000, 2001a & b, 2002).

directly from air photos were not used in this reconnaissance-level survey; the polygons were at a scale that visual transfer from topographic maps and air photos was possible.

A database following Sensitive Ecosystem Inventory Standards (RISC 2006) containing polygon attributes was created. Using a biophysical approach to the project made it difficult to fit the biophysical classes into the provincial standard Ecosystem Classes. To facilitate this, some new Ecosystem Subclass codes were used after consultation with B.C. Ministry of Environment staff (Table 2) (C. Cadrin *pers. comm*., D. Filatow *pers. comm*.). In addition, as this project was done at a reconnaissance level that produced large complex polygons, detailed polygon attributes were not provided. Plot summaries are provided in Appendix B, which can be linked to polygons using the project map.

Table 2. Ecosystem classes and subclasses and codes used in project

Ecosystem Class	**Class Code**	**Ecosystem Subclass**	**Subclass Code**	**Typical Conditions**
Grassland	GR			Matrix of grasslands and shrublands usually on south-facing slopes
		Grasslands	gr	Usually on well-drained steep south-facing slopes such as eskers but may also occur on other parent materials
		Shrublands	sh	Usually on well-drained steep south-facing slopes such as eskers but may also occur on other parent materials
Herbaceous	HB	Herbaceous	hb	Herbaceous community, includes subalpine meadows and herbaceous spray zone communities near waterfalls
Riparian	RI	Floodplain complex	fp	Can contain high, middle and low benches and non-forested floodplain wetlands
		Jökulhlaups	jk	Riparian areas influenced by jökulhlaups that have special characteristics relating to this process
Wetland	WN			Wetland complex may include numerous wetland types and small lakes, may be associated with complex terrain produced by landslides
		Calcareous	ca	Calcareous wetlands are often complex, containing fen, marsh and open water.
Woodland	WD	Coniferous	co	Pine–Lichen woodlands on well drained materials such as glaciofluvial outwash plain
		Ultramafic	ul	Pine–Lichen woodlands on ultramafic peridotite bedrock
Mature forest	MF	Coniferous	co	Dry CWHwm/02 forest
Sparsely Vegetated	SV	Hydromagnesite	hm	Hydromagnesite deposits and associated alkaline areas with sparse vegetation
		Rock	ro	Lichen dominated landscape on exposed bedrock with stunted conifers, heathland and wetlands
		Tufa	tu	May not all be sparsely vegetated, could also contain shrublands, forests, wetlands and herbaceous areas
Cliff	CL	Canyon	cy	Limestone canyons with associated vegetation and karst features
		Ultramafic	ul	Steep terrain associated with landslides on ultramafic bedrock

Information on sensitive ecosystems from TEM projects is referenced in this report but the polygons are not shown on the maps associated with this project. A more detailed sensitive ecosystem assessment would be required as part of any development project.

4.0 Results

4.1 CDC List of At-Risk Ecological Communities

The CDC identifies 14 ecological communities as Red-or Blue-listed[3] in the biogeoclimatic units that occur in the study area (Table 3) (British Columbia Conservation Data Centre 2004a). Several of these communities were recorded in the study area by Fuller (2002), as noted in Table 3 and discussed in the text describing the relevant community types.

Table 3. Ecological communities listed by the Conservation Data Centre in the BEC units occurring in the study area

Scientific Name	Common Name	BC Status	BEC Unit	Comments
Alnus incana/Equisetum arvense	Mountain alder/common horsetail	Blue	BWBSdk1/Fl01; CWHwm/Fl01	Low bench floodplain
Carex lasiocarpa/Drepanocladus aduncus	Slender sedge/common hook-moss	Blue	BWBSdk1/Wf05	Peaty flats beside lakes or in basins
Carex sitchensis - Oenanthe sarmentosa	Sitka sedge - Pacific water-parsley	Blue	CWHwm/Wm50	Beside slow streams, ponds and lakeshores
Carex sitchensis/Sphagnum spp.	Sitka sedge/peat-mosses	Red	CWHwm/Wf51	Wet drainage channels, hollows, sloping peatlands
Equisetum fluviatile - Carex utriculata	Swamp horsetail - beaked sedge	Blue	BWBSdk1/Wm02	Back channel depressions, slow streams and bogs
Myrica gale/Carex sitchensis	Sweet gale/Sitka sedge	Red	CWHwm/Wf52	Early flooded areas, fluctuating water table. Recorded by Fuller (2002)
Picea sitchensis/Lysichiton americanus	Sitka spruce/skunk cabbage	Blue	CWHwm/09	Swamp forests on level receiving sites and wet depressions
Picea sitchensis/Rubus spectabilis Wet Maritime	Sitka spruce/salmonberry Wet Maritime	Blue	CWHwm/05	High bench floodplain Taku and Whiting rivers. High value bear habitat. Recorded by Fuller (2002)
Poa glauca ssp. *rupicola*	Glaucous bluegrass	Blue	BAFA SWB/00	Herbaceous vegetation on alpine saddles used by mountain goats and sheep (Pojar 1991)
Populus balsamifera (ssp. *balsamifera*, ssp. *trichocarpa*) - *Picea* spp./*Cornus stolonifera*	(Balsam poplar, black cottonwood) - spruces/red-osier dogwood	Red	BWBSdk1/12	Not in BEC guide. CDC gives middle bench floodplain site.

[3] **Red List**: List of indigenous species, subspecies, and ecological communities that are extirpated, endangered or threatened in British Columbia.
Blue List: List of indigenous species, subspecies, and ecosystems of special concern in British Columbia.

Table 3. Ecological communities listed by the Conservation Data Centre in the BEC units occurring in the study area (Continued)

Scientific Name	Common Name	BC Status	BEC Unit	Comments
Populus balsamifera ssp. *trichocarpa - Alnus rubra/Rubus spectabilis*	Black cottonwood - red alder/salmonberry	Blue	CWHwm/06	Middle bench floodplain. Recorded by Fuller (2002)
Salix lucida ssp. *lasiandra/Cornus stolonifera/Equisetum spp.*	Pacific willow/red-osier dogwood/horsetails	Red	BWBSdk1/Fl03	Low benches on large rivers
Trichophorum cespitosum/Campylium stellatum	Tufted clubrush/golden star-moss	Blue	BWBSdk1/Wf11	Base-rich fens
Tsuga heterophylla - Picea sitchensis/Hylocomium splendens	Western hemlock - Sitka spruce/step moss	Blue	CWHwm/02	Driest upper slopes and ridge crests. Common but rarely extensive. Recorded by Fuller (2002)
Tsuga heterophylla/Sphagnum girgensohnii	Western hemlock/common green peat-moss	Blue	CWHwm/08	Scrubby hemlock forests in areas with poor drainage and cold exposure

4.2 Sensitive Ecosystems grouped by Biophysical Site Type

In the following section, sensitive ecosystems are organized according to biophysical site types. Since the entire project area was not mapped, only the sensitive ecosystems were identified. Mapping was at a reconnaissance scale. Ecosystems that might be mapped in a detailed inventory at a larger scale, for example, mature forests and alpine, were not mapped here. Instead the focus was on biophysical sites that would be persistent on the landscape.

Sensitive ecosystems covered a total of 66,732 ha or 2.2% of the landbase in the Atlin-Taku study area (Table 4). Sensitive riparian ecosystems covered the greatest amount of area; approximately 1% of the study area. Floodplains comprised the largest component of sensitive riparian ecosystems. Grassland - Shrub/Steppe covered the second largest area, followed by Canyons, Lichen Landscape, Wetlands and Pine-Lichen woodlands.

Table 4. Summary of area (hectares) in sensitive ecosystem types

Ecosystem class	Ecosystem subclass	Total Area	% of Study Area
Canyons		8,641	0.2
Grasslands/Shrub Steppe	Grassland	6,577	0.2
	Shrub/Steppe	2,254	<0.1
	Grassland – Shrub/Steppe complex	1,861	<0.1
	Total	10,692	
Herbaceous meadow		349	<0.1
Hydromagnesite		29	<0.1
Lichen Landscape		6,174	0.2
Pine-Lichen woodlands		3,987	0.1
Riparian	Floodplain	22,969	0.7
	Jökulhlaups	8,050	0.2
	Riparian complex	53	<0.1
	Total	31,072	
Tufa		54	<0.1
Ultramafic Bedrock	Steep terrain	625	<0.1
	Woodland	753	<0.1
	Total	1,378	
Wetlands	Calcareous	155	<0.1
	Wetland complex	4,200	0.1
	Total	4,355	
	Total	66,732	2.2

For each site type, general information and information from other sources are presented first, followed by information collected during the fieldwork portion of this project.

4.2.1 Grasslands-Shrub / Steppe

Low elevation grasslands and shrub/steppe not dominated by Altai fescue (*Festuca altaica*) usually occur only on dry south-facing slopes when they occur in the northwest portion of the province. These dry warm non-forested habitats are rare and biologically significant parts of the largely moist cold forested landscape mosaic of the northwest part of the province because of the rarity of the habitat they provide on the landscape and their importance for wildlife (Ketcheson 1989, Williston *et al.* 2004, Haeussler 2007). In most parts of the province, grasslands have been grazed by cattle and horses, whereas in the Atlin-Taku area they are generally undisturbed by domestic livestock. In British Columbia, grasslands cover less than 1% of the landbase.

In the Stikine River area, a number of sensitive ecosystems have been identified on warm, dry, south-facing slopes, but none of these ecosystems have been formally described (de Groot and Bartemucci 2003).

Ecosystems restricted to dry south-facing slopes in the Atlin-Taku area can have either shallow rocky soils or deep melanized or chernozemic soils. The following grassland-shrub/steppe ecosystems have been preliminarily described by J. Pojar:

Sheslay River, Red Bluff area

- Trembling aspen - Kinnikinnick - Creeping juniper *(Populus tremuloides - Arctostaphylos uva-ursi - Juniperus horizontalis)*; dry SW-facing ridge; 650 m; lots of bare soil.

- Creeping juniper - Pasture sage - Purple reedgrass *(Juniperus horizontalis - Artemisia frigida - Calamagrostis purpurascens)*; very dry boreal steppe on steep mid-slope; 720 m; erodible, weakly calcareous soil.

Fourth of July Creek

- Altai fescue - Rocky Mountain fescue - Sage *(Festuca altaica - Festuca saximontana - Artemisia)* subalpine grassland.

- Sage - Glaucous bluegrass - Spreading Arctic sedge *(Artemisia (borealis, frigida) - Poa glauca - Carex supina spaniocarpa* (very dry boreal steppe on convex south faces of eskers and kames).

- Kinnikinnick - Common juniper *(Arctostaphylos uva-ursi - Juniperus communis)* (dry dwarf scrub).

- Trembling aspen - Prickly rose - Soopolallie - Fireweed *(Populus tremuloides - Rosa acicularis - Shepherdia canadensis - Epilobium angustifolium)* (dry aspen forest).

Juniper grasslands in general

- Creeping juniper - Pasture sage - Purple reedgrass *(Juniperus horizontalis - Artemisia frigida - Calamagrostis purpurascens)* (and related boreal steppe communities) occurs on suitable dry, relatively warm sites along the Sheslay, Nahlin, and Nakina rivers; also scattered on glaciofluvial landforms and rocky ridges at moderate elevations on the Teslin Plateau and around Atlin and Teslin lakes. Rocky Mountain juniper x Creeping juniper (*Juniperus scopulorum* x *horizontalis)* savanna hasn't been reported from the study area, but should be looked for along the lower Nahlin and in the Nakina canyonlands.

Grasslands and shrub/steppe were sampled in several locations, including Sheslay River, Fourth of July Creek/Consolation Creek area and Tatsatua Creek. Grasslands in the Fourth of July Creek area were the most well-developed ones seen in the study area. The area also contains a variety of shrub/steppe and dry forest communities. Grasslands are best developed on well-drained south-facing slopes of glaciofluvial deposits, but also occasionally occur on other rapidly drained landforms and slope positions. These grasslands are important for regional biodiversity, as they support a large number of plant species not found in other plant communities in the study area. In neighbouring regions there are a variety of animal species that specifically depend on grassland habitats, such as garter snakes, cicadas and other invertebrates (Haeussler 2007).

The most sensitive grassland community type occurs on the crest of south-facing slopes and is dominated by slender wheatgrass (*Elymus trachycaulus*), Rocky Mountain fescue, purple reedgrass and pasture sage with varying amounts of stunted aspen, common or horizontal juniper and dogbane (*Apocynum androsaemifolium*). This grassland type may be relict from a warmer climatic period when it was more extensive across the region. It is now confined to the warmest portion of the landscape. On slightly moister south-facing slopes the grassland community is increasingly dominated by timber oatgrass (*Danthonia intermedia*) and Altai fescue. A conspicuous feature of these grasslands which does not occur in more southerly grasslands of northwest B.C., such as those of the Stikine and the Bulkley Valley, is the prairie crocus (*Anemone patens*).

Figure 2. Grasslands on south-facing glaciofluvial terrain near Fish Lake.

Above the Sheslay and Nahlin rivers, dry juniper-dominated steppes of the type described above occur in several locations on steep south-facing slopes with a soil pH of 7.5 (Figure 3). They are likely more common than mapped, especially on drainages with an east-west orientation, such as the upper Sheslay River upstream of Hackett Creek, Lower Nahlin River, and lower Samotua Creek. This shrub/steppe community is analogous to the Creeping juniper - Pasture sage - Purple reedgrass community identified along the Stikine River canyon.

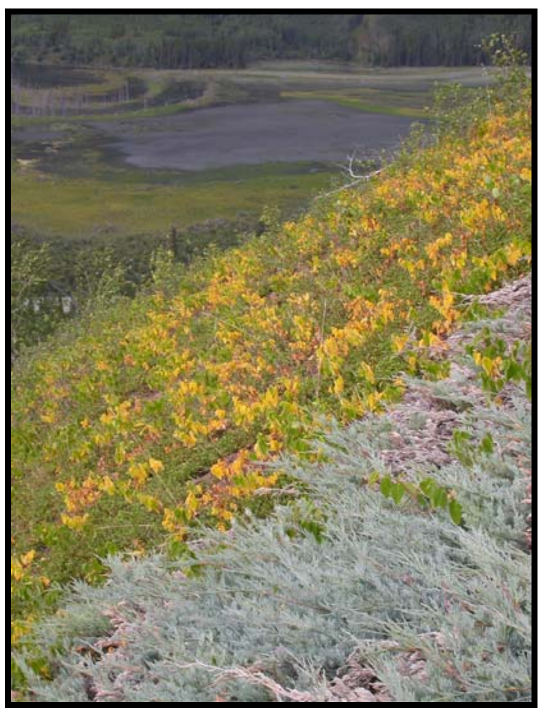

Figure 3. Juniper shrub/steppe above Sheslay River

On the Upper Sheslay River, a Nuttall's alkaligrass - Foxtail barley (*Puccinellia nuttalliana - Hordeum jubatum*) saline wet meadow (Gs02) has been sampled by the BEC program on a morainal deposit. This grassland type is found mostly in the Chilcotin area of B.C., and is Red-listed. It is normally found on saline meadows on the seasonally-flooded perimeter of small lakes and potholes where evaporation accumulates salts. This wet meadow type is considered transitional to wetlands and is usually found between wetland and upland vegetation types (MacKenzie and Moran 2004). There may be more occurrences of this community type in the Sheslay area (W. MacKenzie *pers. comm*.), and its plant species composition is similar to the saline hydromagnesite plant communities at Atlin (see Section 4.2.6).

Near Tatsatua Creek in the ESSFwv a grassland/meadow was seen that appeared similar to the mesic Aster – Meadow Rue – Peavine – Fireweed (*Aster* sp. – *Thalictrum occidentale* – *Lathyrus* sp. – *Epilobium angustifolium*) herbaceous meadows found in the Bulkley Valley (Haeussler and Hetherington 2000). The site was at 1100m elevation and had a south aspect, ~50% slope with a Soil Moisture Regime of 3-5, and a Soil Nutrient Regime of D. A visual plot was completed in this area so detailed plant data are not available.

One plant species with a range extension, thread-leaved sandwort (*Arenaria capillaris*), was collected in grasslands.

4.2.2 Dry Forests/Pine-Lichen Flats

In the CWHwm, the ecological community associated with the driest site series—02—is Blue-listed, and has been recorded in the study area by Fuller (2002), with 568 ha mapped (map code HM). Other occurrences of the CWHwm/02 site series are likely to exist in the planning area outside of the area mapped by Fuller (2002).

Pine lichen flats are important in the boreal landscape because of their value as caribou winter range, as caribou feed on the terrestrial lichens. Anderson (1970) notes "Pure old growth lodgepole pine forests are rare." He means a "lodgepole pine woodland, characterized by widely spaced, mature pine trees and a dense reindeer lichen ground cover …". Such forests provide key winter habitat for woodland caribou. On the assumption that the plant community was widespread and unexceptional, we didn't purposely seek out Pine–Lichen flats for sampling, but some were noted beside Steamboat Mountain (Figure 4), along Fourth of July Creek, near Indian Lake and near Fish Lake. Additional occurrences are likely to exist in the study area. Other Pine–Lichen communities were visited on peridotite bedrock near Yeth Creek, and upstream of Tatsamenie Lake, but these are not likely to be caribou winter range.

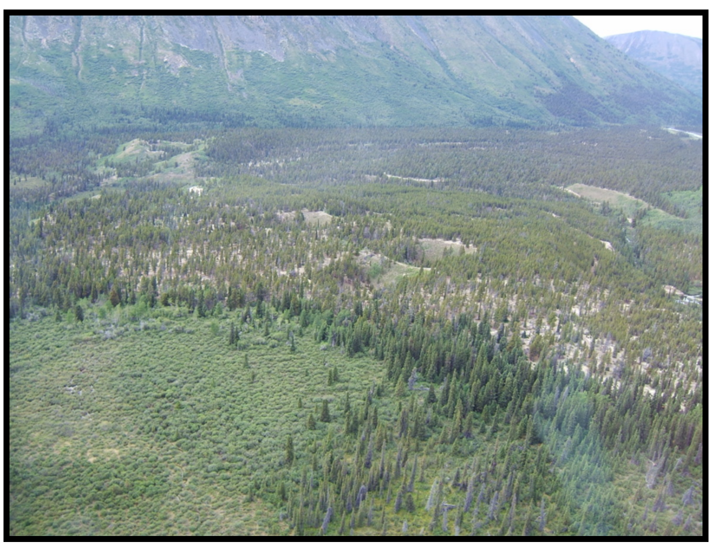

Figure 4. Pine–Lichen forest and pitted outwash plain beside Steamboat Mountain

4.2.3 Floodplains

Floodplain ecosystems are often sensitive due to their limited extent on the landbase. They provide some of the most important wildlife habitat on the landscape. Floodplains are often heavily impacted by development due to their flat linear nature, which makes them attractive for agriculture, residential developments, transportation corridors, utility developments and airstrips. Additionally, floodplains often contain highly productive forests targeted for harvesting. These land use pressures make floodplains among the most endangered ecosystems on earth (Tockner and Stanford 2002, Tockner *et al*. 2008). Additionally, floodplain ecosystems are sensitive to changes in hydrology. Key processes along a river that maintain productivity and biodiversity include erosion and deposition, movement of river water and nutrients above and below ground, channel movement, and large wood dynamics (Stanford *et al.* 2005). In addition to their many unusually productive or dynamic microhabitats, floodplains also serve as dispersal corridors for plant and animal life. Thus, while they frequently contain unusual and peripheral species not found elsewhere in the landscape, they are also highly susceptible to invasion by aggressive alien species.

Rivers with significant floodplains in the study area include the Taku, Sheslay, Inklin, Sutlahine, Whiting, Tulsequah and King Salmon rivers (Ketcheson 1989). The floodplain of the Whiting River (not visited during our fieldwork) is gravel-dominated with little forest development due to the dynamic nature of the river (B. Fuhr *pers. comm*.).

4.2.3.1 Lower Taku River and Tulsequah River

The floodplains of the Taku and Tulsequah rivers are braided and wide (Figure 5 and Figure 6). Flannigan Slough is an exceptionally large wetland complex located at the confluence of the Tulsequah and Taku rivers (Figure 7). This area contains a number of Red- and Blue-listed ecological communities, including high and middle bench floodplain communities, and several listed wetland types (Marcoux 1997, Fuller 2002, Coosemans *et al.* 2007a & b, Provincial BEC database). They are:

- Black cottonwood – Red alder/Salmonberry (CWHwm/06), a Blue-listed middle bench community, which is dominant on the floodplain and covers approximately 3,000 ha. Shrub, pole sapling and young forest structural stages have been recorded. Sites supporting this ecosystem are impacted by the Tulsequah Chief Mine development.

- Sitka spruce/Salmonberry (CWHwm/05), a Blue-listed high bench community, which covers approximately 150 ha. Shrub, pole sapling, young forest, mature forest and old forest structural stages have been recorded. Sites supporting this community are impacted by the Tulsequah Chief Mine development.

- Sitka sedge/Sphagnum spp. (CWHwm/Wf51), a Red-listed marsh community, which occurs in Flannigan Slough.

- Sweet gale/Sitka sedge (CWHwm/Wf52), a Red-listed fen wetland, occurring in Flannigan Slough.

- Mountain alder/Common horsetail (CWHwm/Fl01), a Blue-listed low bench floodplain community, which occurs in Flannigan Slough.

- Sitka sedge – Pacific water-parsley (CWHwm/Wm50), a Blue-listed marsh community, occurring in Flannigan Slough.

Figure 5. Floodplain along the lower Taku River

Figure 6. Floodplain at the confluence of Big Salmon Creek and Taku River

Figure 7. Overview of Flannigan Slough wetlands

While some of the sensitive ecosystems in the list above were recorded through TEM mapping, others have been identified only as plots during ecological classification sampling. Several wetland types were grouped under the Sedge Fen type by Fuller (2002), including Wm50 and Wf51. The Sitka spruce – Skunk Cabbage ecological community (CWHwm/09 site series, a wetland swamp) is also Blue-listed and may have limited occurrences in the lower Taku River area. Skunk cabbage (*Lysichiton americanum*) does occur, but more often in sedge/alder wetlands rather than in Sitka spruce-dominated swamp forests. Skunk cabbage is a high value spring grizzly bear food plant, and communities containing skunk cabbage are generally sensitive to changes in hydrology, water quality and other disturbances. There is also a lush, grass-forb, valley-bottom meadow along the Taku River that is presently partly occupied by an airstrip. We are not sure of its origin or if it is natural. The meadow occurs on a privately owned parcel on the south side of the river upstream of Kwashona Creek.

The Tulsequah-lower Taku floodplain is unusual because of the influence of jökulhlaups (glacial outburst floods), which occur on the Tulsequah River each year and deposit large amounts of sediments on the floodplain. These floodplain sites have few herbs and shrubs because most species cannot withstand the frequent sediment deposition; tree species are subalpine fir and cottonwood (P. Williston and L. Turney, *pers. comm*.).

Flannigan Slough and the other sloughs and backchannels in the area, such as Shazah Slough, also have high wildlife values, and are important areas for trumpeter swan nesting, moose and other wildlife. Coastal moose confine their activities to low elevation alluvial habitats along major rivers (Rescan Environmental Services Ltd. 1997). The concentration of sensitive ecosystems and high wildlife and fish values make Flannigan Slough and surroundings a very ecologically important area.

Along the Taku and lower Nakina rivers there is much groundwater discharge along the toe slopes of the mountains bordering the rivers. This discharge has produced a number of wetlands on the edges of the floodplain; all of these wetlands are very productive and important fish habitat, and are also important for mammals such as moose. Flannigan Slough, at the junction of the Taku and Tulsequah rivers, is the largest of these wetlands. Other important wetlands in this valley bottom stretch are at Shazah Creek for swan nesting, eagle nesting, and grizzly, moose and salmon use; Yellow Bluff for salmon spawning and wintering, and swan nesting; and Tuskwa Slough for salmon spawning.

The Taku River watershed has a high level of mineralization, and has seen historical and contemporary mining exploration and development. Much of the area is currently under mineral claims. Infrastructure development related to mineral exploration and mine development is the greatest threat to sensitive ecosystems in the area. The Tulsequah Chief Mine is being partially constructed on the floodplain and associated wetlands of Tulsequah River and Shazah Creek.

4.2.3.2 Sheslay and Inklin Rivers

Between Hackett Creek and Tatsatua Creek the Sheslay River has a relatively narrow and confined floodplain with many wetlands (Figure 8); the floodplain is wider where tributaries join the Sheslay River. Downstream of Tatsatua Creek, the river becomes even more confined and the floodplain is very narrow, until a mid-section of the Inklin River, where the floodplain widens again.

Figure 8. Floodplain of Sheslay River downstream of Hackett Creek

The Sheslay floodplain is dominated by Swamp horsetail - beaked sedge marshes (BWBSdk1/Wm02 – Blue-listed) and Alder – Willow/Horsetail low bench thickets (BWBSdk1/Fl01 – Blue-listed) that may be developing into black cottonwood stands. High bench white spruce stands have developed in some locations, especially where tributaries join the Sheslay River.

On the Inklin River, large fires that crossed the landscape have repeatedly burned much of the floodplain. Burned floodplains are generally rare, having a lower fire frequency than the surrounding upland landscape (Applied Ecosystem Management 1998). Snags and coarse woody debris from fire are evident on the floodplain. Unlike the Sheslay River upstream and the Taku River downstream, the Inklin River Valley has few wetlands; the floodplain here is drier and gravelly, dominated by cottonwood with willows, white spruce, lodgepole pine and paper birch (*Betula papyrifera*).

4.2.3.3 O'Donnell River

The O'Donnell River floodplain is the only significant cottonwood floodplain in the Atlin Lake area, though it too is relatively small. In a landscape that is dominated by large lakes, such as the northern portion of the Atlin-Taku study area, active floodplains are rare due to the influence of lakes on fluvial dynamics. Where O'Donnell River drains into Atlin Lake a large delta has developed. This delta is much larger than similar deltas on other rivers in the region, and is very heavily used by wildlife including moose, waterfowl and beaver. This area provides regionally important wildlife habitat. The boundary of Atlin Provincial Park follows the southwest bank of O'Donnell River from Atlin Lake upstream to Wilson Creek, thus protecting the majority of the floodplain.

Figure 9. Lower O'Donnell River floodplain near Atlin Lake

4.2.4 Limestone Bedrock Influenced Communities

Extensive areas of limestone exist in the Atlin-Taku planning area. In British Columbia, limestone terrain often supports sensitive ecosystems and plant species, along with unusual fauna due to the calcium-rich conditions and typically sharp drainage, and because the province in general is dominated by base-poor types of bedrock. Limestone bedrock can also have unusual physical formations, such as caves, sinkholes, and other karst formations. Karst formations will not be treated in detail as a separate karst report is in preparation (P. Griffiths *in prep*.). We sampled several community-types dominated or influenced by limestone, including calcareous wetlands, tufa deposits, canyons and alpine tundra.

In the greater northwest region, limestone features have been found in SE Alaska (McClellan *et al*. 2003), near Todagin Mountain (Bartemucci 2004), near Mess Lake in Mount Edziza Park (Cichowski and de Groot 2000) and in Charlie Cole Creek Ecological Reserve (de Groot and Bartemucci 2003). All of the calcareous fens in SE Alaska were located below limestone or marble ridges, or talus slopes. The vegetation of these fens was quite different from that of other palustrine wetlands in the area (McClellan *et al*. 2003). The calcareous wetlands on Todagin Mountain had upwelling water with a high pH of 7.8 and numerous calciphile indicator species (Bartemucci 2004). The extensive calcite formations at Mess Lake contain sensitive ecosystems (Cichowski and de Groot 2000, de Groot and Bartemucci 2003). The calc-tufa mineral spring deposits in Charlie Cole Creek Ecological Reserve have several rare plant species (de Groot and Bartemucci 2003).

4.2.4.1 Calcareous wetlands

Calcareous wetlands are relatively rare worldwide because of the rarity of calcium-rich bedrock in combination with hydrological conditions conducive to wetland formation. Calcareous wetlands can be important because the calcium-rich environment tends to harbour a high diversity of flora and fauna, have a diverse physiognomy, and species that are specialized in these environmental conditions. In many parts of North America calcareous wetlands have been given special conservation consideration (Johnson and Steingraeber 2003).

There are few invertebrate data available for northern British Columbia, but calcareous wetlands in the Atlin area have been shown to support the muskeg emerald dragonfly (*Somatochlora septentrionalis).* Collected from calcareous peatlands near Atlin, it is rare in, or absent from, most other northern B.C. peatlands (R. and S. Cannings *pers. comm*.). These peatlands are located near Kennedy Creek, Shaker Lake, Pike River mouth, Como Lake and Tutshi Lake (Figure 10).

Figure 10. Marl deposit in calcareous wetland near Shaker Lake

Other calcareous wetlands were reported by Anderson (1970), who sampled the plant cover and palynology of six wetlands as part of his study of regional vegetation and Holocene geobotanical history of the Atlin region. Four of the wetlands are in the study area: Mile 47 Bog at Telegraph Creek, Mile 52 Bog north of Fourth of July Creek, Jasper Creek Bog 26 kilometres south of Atlin and Wilson Creek Bog 10 km east of Jasper Creek Bog. Anderson (1970) reports that these wetlands were calcareous with marly sediments making up a significant portion of the core. He also notes that limestone outcrops are extensive on the mountainsides nearby (e.g., Sentinel Mountain), and "this is probably the source area of much of the calcareous glacial material deposited farther north in the Atlin Valley as well as of marl in Wilson Creek Bog."

Anderson (1970) called these wetlands 'bogs' but by contemporary definitions they are more accurately called fens, marshes and swamps (MacKenzie and Moran 2004). The dominant vegetation of these wetlands can be characterized as a Scrub birch - Water sedge - Common hook-moss (*Betula glandulosa - Carex aquatilis - Drepanocladus aduncus)* community type, which is frequent and widespread in northern B.C.-southern Yukon, but each wetland contains a mosaic of wetland types. For example, the Telegraph Creek wetland contains a soft-stemmed bulrush (*Schoenoplectus tabernaemontani)* marsh; bulrush marshes are uncommon in the region.

We visited seven of the nine wetlands noted above; they have a variety of hydrological regimes and consequently vegetation types, and commonly contain several discrete wetland types, making them very biologically diverse. For example, a single wetland may have open water at the centre with a marsh fringe that changes to a fen on the perimeter. The common feature of the wetlands was a high pH (or evidence of calcium influence through effervescence with HCl). Some wetlands had deep deposits of marl that had precipitated from the calcium-rich waters, while others had calcium-rich encrustations on the base of the vegetation but no marl (Figure 11). The Red-listed plant species Siberian primrose (*Primula nutans*) and the Blue-listed dwarf clubrush (*Trichophorum pumilum*) were found in some of the calcareous wetlands sampled. Other calciphytic plant species commonly found include: Seaside arrow-grass (*Triglochin maritima*), Marsh arrow-grass (*Triglochin palustris*), sage willow (*Salix candida*), tufted clubrush (*Trichophorum caespitosum*), star moss (Campylium stellatum) and sausage moss (*Scorpidium* spp.).

Figure 11. Calcareous wetland near Como Lake

It will be important to maintain the hydrological integrity of calcareous wetlands if management activities occur nearby, especially in the recharge zones. Additional calcareous wetlands likely occur in the study area, but will require field visits to reliably identify. During flights south of Atlin, some wetlands and lakes with white edges or bottoms were seen, indicating the possibility of calcium inputs. On the ground, the presence of calcium can be seen by whitish encrustations or marl deposits on the base of plants.

4.2.4.2 Tufa

Tufa is a calcium carbonate deposit precipitated from calcium-enriched seepage or spring waters in limestone bedrock areas. Tufa deposits have high value for the active geological processes that are occurring on them, the unusual formations that occur on them such as pool-step terraces and the unique assemblage of plant species associated with them. As they are small, tufa deposits may be overlooked and their distribution on the landscape is not well documented. If additional tufa deposits are located they should be documented.

A tufa deposit south of Atlin at the Atlin Warm Springs was surveyed. Other tufa deposits in the region were not visited. For example, Kerr (1948, p. 42) reported calcareous tufa "On the southwest side of King Salmon Valley, at the base of the mountain west of King Salmon Mountain, there are thick and extensive beds of calcareous tufa. They have been formed by a large number of springs, and extend for some distance along the mountainside. Moss grows upon the tufa and is encrusted by it."; however, the exact location of this deposit is not known. Tufa has also been reported in the Samotua River drainage southwest of Moosehorn Lake formed by the discharging calcium-rich waters on a talus slope (Gray and Walton 1983). Other tufa deposits likely occur in the region, and have been seen during other field projects in the area, but their location has not been recorded (R. Trowbridge *pers. comm*.).

Several warm water springs produce the water that forms the tufa deposit at the Atlin Warm Springs. A variety of formations and plant communities are associated with the springs and the resulting landform. This includes a fan-like deposit, pool and step formations and wetlands. The vegetation is varied and includes: Sparsely vegetated areas, forest in drier areas, a sedge fen, and herbaceous vegetation on pool-step formations (Figure 12).

Figure 12. Sparsely vegetated area at tufa deposit at Atlin Warm Springs

The plant communities on the Atlin Warm Springs tufa deposit are unusual and have some rare and interesting plant species. This includes two Blue-listed plants species, low sandwort (*Arenaria longipedunculata)* and marsh felwort *(Lomatogonium rotatum);* one native plant species that is a range extension, jointed rush (*Juncus articulatus*); and one exotic species that is a range extension, yellow waterlily (*Nymphaea mexicana*). Other plant species of interest include Greenland primrose (*Primula egaliksensis),* leafy aster (*Aster foliaceus*) and common watercress *(Rorippa nasturtium-aquaticum*). The tufa also contains Chara, which is a green algae thought to be the closest non-vascular relative of green land plants.

Atlin Warm Springs Creek, which flows through the tufa deposit, also contains lake chub and toads. The lake chub are distinct physiologically in that they are less able to tolerate cold water than other lake chub that have been tested from Liard Hotsprings and Green Lake. This likely results from the near uniform water temperature in Atlin Warm Springs year round (Dr. Eric Taylor, UBC, *pers. comm*.). These differences warrant protection of the lake chub and their habitat (McPhail 2007). Overall, the physical tufa formation, plant species, plant communities and fish species make this area unique in the study area and provincially important.

The Atlin Warm Springs and much of the tufa deposit are privately owned, and have a number of buildings such as residences, outbuildings and greenhouses. A significant portion of the area has been disturbed by a wide variety of uses such as gardening, bathing pool construction, road construction, drainage, water diversion and logging. This resulted in parts of the pool-step formation drying out, and exotic plant species invasion. Current residents indicated that they might use the water from the warm springs, which already warms greenhouses, for a microhydro installation for the residence. These disturbances place this ecosystem under a high level of threat.

4.2.4.3 Canyons

The Houdini Creek Canyon is a mostly dry limestone canyon between Victoria Lake and Yeth Creek, ending in a limestone amphitheatre. The dry canyon is a relict of drainage patterns that are no longer operating. Nearby Victoria Lake presently drains northeast and then south to hook up with the Nahlin River, but at some past time it appears that the drainage was west to Yeth Creek, which perhaps carved the canyon of Houdini Creek. There is water in the upper part of the canyon but this water drains subterraneously. There is one area where water accumulates in the spring and slowly drains through the summer, and small areas where water may flow at certain times of the year. The canyon walls have numerous cave entrances and other limestone features. The canyon also contains sinkholes (Figure 13). Noteworthy ferns on limestone here are mountain bladder fern (*Cystopteris montana),* green spleenwort (*Asplenium viride*), slender rock-brake (*Cryptogramma stelleri*) and Rocky Mountain woodsia (*Woodsia scopulina*).

Figure 13. Houdini Creek Canyon

The wetland in the amphitheatre at the mouth of Houdini Canyon—where the disappearing creek reappears—has common regional vegetation, but features an unusual karst process known as a polje**,** which floods rapidly and drains slowly after a rainstorm (Figure 14). Similar poljes occur in the Nahanni karstlands. Above Victoria Lake there are limestone mountains with caves. There are karst features in this area such as sinkholes, which are reported to contain bones of animals that have fallen into them. These features could be important for paleoecological research.

Figure 14. Limestone amphitheatre at junction of Houdini and Yeth creeks

The distinctive physiography for the region has produced a unique pattern of vegetation and plant diversity. This diversity is operating on multiple scales. The physiography and drainage patterns are unique at a landscape scale, and plant communities are unique at a stand scale.

Canyons along the Nakina River and some of its tributaries are incised into limestone bedrock and have abundant karst terrain, including caves, disappearing creeks, hoodoos and waterfalls. The dramatic gorge that forms the Nakina River Canyon is a significant physical feature on the landscape, an Area of Interest/Official Study Area in the Protected Areas Strategy Report (RPAT

1996) (Figure 15). This area was identified as containing sensitive ecosystems based on the sampling done on Houdini Creek Canyon.

Figure 15. Nakina River Canyon

4.2.4.4 Alpine

Alpine tundra was not targeted during the 2008 field survey because it is widespread (35% of the planning area) and is generally not at risk in the study area, though in other parts of the province alpine is mapped as sensitive. This was not done here because of the large amount of alpine in the study area. Alpine in limestone bedrock areas was sampled in two locations during brief stops with karst inventory personnel. At a location east of Nakina River near Dry Lake the Blue-listed species northern Jacob's-ladder *(Polemonium boreale*) was collected at an elevation of 1498 m. The vegetation was dominated by dwarf shrubs, forbs and lichens and included avens (*Dryas* spp), Arctic lupine *(Lupinus arcticus)* and net-veined willow (*Salix reticulata*) (Figure 16). The second location was on Sinwa Mountain, which was formed by a karst-rich limestone reef – the King Salmon Thrust – which crosses the Taku River and carries on up into the King Salmon drainage. The alpine vegetation here was typical of inland alpine areas in the region generally (Figure 17).

Figure 16. Alpine vegetation on limestone near Dry Lake

Figure 17. Alpine vegetation on limestone on Sinwa Mountain

4.2.5 Ultramafic Bedrock

Ultramafic bedrock contains high concentrations of minerals, especially Magnesium (Mg) and Iron (Fe), which can influence the local flora and fauna. In the Atlin-Taku area two types of ultramafic bedrock occur - serpentinite and peridotite. Atlin Intrusion on Taku Plateau is a highly metamorphosed ultramafic body composed mainly of fractured and sheared serpentinite. Serpentinite-rich parent material gives rise to soils with high Mg:Ca ratios and high levels of basic elements, which can be toxic to plants. Also, these soils commonly have low levels of macronutrients (Balmer *et al*. 1992). Such conditions give rise to “serpentinite barrens” where vegetation is sparse, and where endemic and indicator species tolerant of these unusual soil conditions can be found, though these effects diminish with increasing latitude (Kruckeberg 1979, Fuller 2002, Lewis 2005). The unusual growing conditions can produce plants that are physiologically different and vegetation that is physiognomically different from that growing on other bedrock types (Lee 1992).

Two areas with ultramafic bedrock were sampled - an open Pine-Lichen woodland on the north shoulder of Peridotite Peak (Figure 18), and a landslide area at Yeth Creek that is partially on peridotite. Both areas were identified as sensitive ecosystems. The open Pine-Lichen woodland is unique in the study area and is heavily influenced by the bedrock type and resulting soils. The woodland is all-aged and there is no evidence of a fire history, perhaps because the trees are too widely spaced to carry a crown fire and the ground vegetation too sparse to carry a ground fire. The pine trees carry a very heavy load of horsehair (*Bryoria*) lichens (Figure 19).

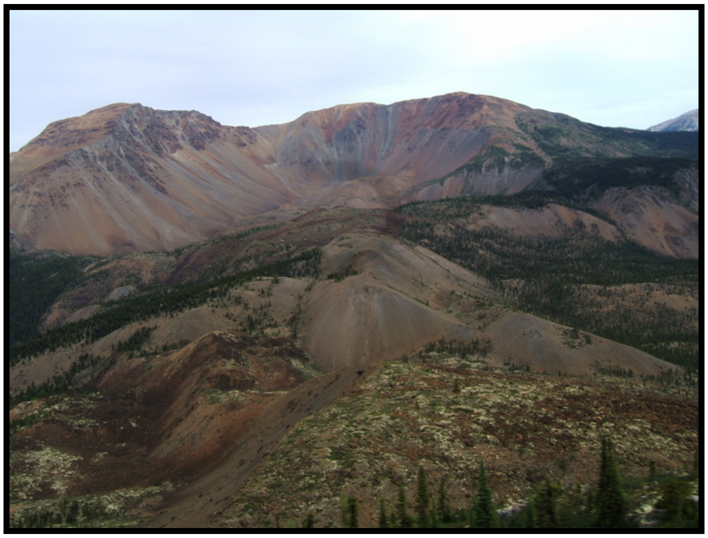

Figure 18. Overview of Pine–Lichen vegetation on peridotite bedrock

Figure 19. Open Pine–Lichen vegetation on peridotite bedrock

The peridotite landslide is an unusual landform in the study area, comprised of rocky outcrops, caverns and very large blocky rubble (Figure 20). It also contains a variety of vegetation types, including dry Pine–Lichen woodlands more commonly found on fluvial or glaciofluvial landforms. The area had an abundance of mountain goat sign (pellets and hair). Landslides have been recognized as having high value due to the site, soil and habitat diversity they provide and the corresponding increase in biological diversity that often results (Geertsema and Pojar 2007). Such diversity combined with an unusual ultramafic bedrock type confers special significance to this landslide area. The vegetation is generally typical of the region but the landform and ferns are unusual. This landslide and the Pine-Lichen woodland are in close proximity on the same peridotite occurrence encompassing areas with differing geomorphological processes – stable and unstable.

Figure 20. Overview of Yeth Creek landslide on peridotite bedrock

Kruckebergs holly-fern *(Polystichum kruckebergii*) is a Blue-listed plant species that was found at these peridotite bedrock areas, and provincially is restricted to serpentine soils (Moreau 1996, Douglas *et al*. 2000).

4.2.6 Hydromagnesite Deposits

Magnesium leached by groundwater from serpentine bodies east of Atlin has surfaced as deposits of hydromagnesite in wetlands and springs within the village. *Wenah*, the Tlingit name for the area now occupied by the village of Atlin, means “alkali”; evidently caribou used to come to the alkali flats in great numbers. Tlingit elders say “it was like their salt lick.”

There are two hydromagnesite deposits near the town of Atlin with the larger deposit covering 7.3 ha and the smaller covering 2.5 ha in three locations (Figure 21) (Young 1915, Simandl *et al.* 2001). These are the northernmost hydromagnesite deposits in British Columbia. All others are in the Chilcotin area. Hydromagnesite is hydrated magnesium carbonate generally associated with weathering of products of magnesium-rich rocks. The water in the wetland has a pH of ~8.6, alkalinity of 4727 mg/L HCO_3, Mg concentration of 780 ppm and an Mg:Ca ratio of at least 50:1 (Power *et al.* 2007). The high concentrations of calcium and magnesium make these sites hypereutrophic, with growing conditions intolerable to all but a select few plant species. Most plants live on the margins of the deposits. The main deposits are sparsely- or non-vegetated.

Figure 21. Hydromagnesite deposit at Atlin

The hydromagnesite deposits form a unique ecosystem containing at least one Red-listed plant species – Alkali plantain (*Plantago eriopoda)* – which occurs on the margin of the largest deposit. Seaside arrow-grass, Nuttall's alkaligrass and foxtail barley are the dominant plant species. The smaller deposit supports the Blue-listed marsh felwort (*Lomatogium rotatum*).

When the hydromagnesite dries out wide cracks form. These cracks are densely inhabited by wolf spiders (Lycosidae). Other wildlife that use these areas includes moose and Canada geese. Because they are within the town of Atlin, the deposits have seen much activity over the years including scientific research (Power *et al.* 2007). Disturbances have included corduroy road construction, ATV use, fence construction, gravel dumping and drainage.

Additional small alkali flats may occur south of Atlin, but these were not visited and no details were provided on their location through public input.

4.2.7 Wetlands

There are many types of wetlands in the study area associated with different types of hydrogeomorphologic processes, including fluvial, lacustrine, and palustrine systems and hotsprings. These systems may contain fens, swamps, bogs, and floodplain wetlands. Bedrock type can influence wetland water chemistry and the flora and fauna of the wetland. Calcareous wetlands are discussed under Limestone Bedrock – Calcareous Wetlands (Section 4.2.4.1), floodplain wetlands are discussed under Floodplains (Section 4.2.3) and wetlands influenced by other special bedrock types are treated under Ultramafic Bedrock (Section 4.2.5). Several listed calcareous and floodplain wetlands occur in the study area.

Some wetlands are important for waterfowl including Geese Lake (Hutsagola), a waterfowl staging area; Atlin Slough, which can have large waterfowl aggregations in spring when it has open water before Atlin Lake, and also has recreational values; and wetlands near McDonald Lake that are important for swans. These water-based features were not mapped.

4.2.8 Water Features

Water features are important on the landscape, but were not visited as part of the fieldwork. Most of the identified water features are related to fish values, which were beyond the scope of this project. However, individuals identified some water features as important during project research. These are presented here but are not mapped.

Underwater Dunes

Underwater dunes, created by salmon in heavily used spawning areas, are an important feature of the waterscape; they are often downstream of large lakes. Known spawning dunes are located on Tatsatua Creek (Figure 22) downstream of Tatsatua and Tatsamenie lakes. Spawning dunes have also been reported from the Nahlin, Tseta and Dudidontu rivers.

Figure 22. Chinook salmon spawning dunes on Tatsatua Creek

Rivers and Lakes

Rivers and lakes identified as having particularly high biological values include:

- Atlin River, which connects Atlin and Tagish lakes, has high aggregations of graylings and round whitefish during the summer.
- King Salmon River – the flats on the lower King Salmon River have complex hydrology and ecology, and are used by salmon for spawning.
- Indian Point – contains unusual aggregations of several thousand whitefish in a small area of shallow water throughout the summer. The area is also the site of an historic Tlingit village, and may be an important wildlife corridor. The location is not revealed due to the sensitivity of the fish at this location.
- Spawning areas – high-value spawning areas include King Salmon, Kuthai, Tatsamenie and Little Trapper lakes, and Nakina, Dudidontu, Hackett, Nahlin, Yeth, Taku, King Salmon, Tseta and Tuskwa streams.

Persistent winter-open water

In cold aquatic systems that are mostly ice-covered in winter, a key habitat occurs where groundwater discharge is of a quantity and quality to maintain open water and support aquatic species throughout the winter. Some of the big lakes have areas, usually at their outlets or inlets, with open water all winter, or early in spring. This open water provides critical overwintering habitat for water birds and serves as migratory bird stopover habitat for species such as trumpeter swans and tundra swans.

4.2.9 Warm Springs

Warm springs can be important biophysical features on the landscape, especially if the waters are calcium-rich. Atlin Warm Springs are one such example (Section 4.2.4.2). Sheslay River Warm Springs, located on the west side of Sheslay River near the confluence with Tatsatua Creek, are not known to have calcium deposits or unusual vegetation (B. Fuhr *pers. comm*.). There may be additional warm springs on Monarch Mountain and in some creek outlets along Torres Channel in Atlin Lake, but no detailed information is available.

4.2.10 Jökulhlaups/Glacial Outburst Floods

Glacial outburst floods, or jökulhlaups, occur when water stored behind, within or under glaciers is rapidly released (Neal 2007). The Tulsequah River is subject to frequent jökulhlaups originating from Tulsequah Lake and Lake No Lake. Tulsequah Lake and Lake No Lake occupy side valleys blocked by Tulsequah Glacier, which fills the main Tulsequah Valley. These lakes have a history of glacial outburst floods (see Kerr 1948 pages 16-18 for a dramatic account). Jökulhlaups from Tulsequah Lake have become smaller during the 20th century, while those from Lake No Lake have increased in size since they began about 50 years ago (Geertsema and Clague 2005, Neal 2007).

The jökulhlaup process has produced geomorphological features and associated ecosystems that are rare in British Columbia:

1) Former deltas of at least three ages are found adjacent to the current lower Lake No Lake (Figure 23). In 2001, J. Pojar and M. Geertsema sampled 15 plots at three sites with vegetation characterised as Willow - Yellow mountain-avens - Rock moss (*Salix (alaxensis, sitchensis, arctica) - Dryas drummondii – Racomitrium).* Although the pioneer vegetation developing here is fairly typical of coast-interior transition, upper montane/subalpine fluvial sites (elevation ca 650 m), such a time series of recent periglacial landform/ecosystem combinations is rare.

2) The floodplains inundated by the jökulhlaups have few herbs due to the frequent deposition of sediments. Over time, the area flooded becomes progressively smaller, allowing natural succession to occur on the built-up floodplain deposits.

3) Behind levees along the Tulsequah River there are unusual wetlands with lenses of mineral soils between the organic layers. These lenses are deposited when large jökulhlaups breach the levees and flood the wetlands.

The former deltas have been mapped as a sensitive ecosystem area, because of unique geomorphic attributes and scientific value, which would be lost if the area was highly disturbed.

Figure 23. Former deltas into Lake No Lake

4.2.11 Waterfalls

Waterfalls can produce spray zone ecosystems that are rare on the landscape due to the constantly moist growing conditions and may contain rare plant species. For example, P. Williston (*pers. comm*.) found several rare lichen and bryophytes in spray zones of waterfalls on coastal British Columbia. S. Haeussler and J. Pojar have also found several rare vascular plants in spray zone of Netalzul Waterfall, Bulkley District (Haeussler 1998). Waterfalls in the study area include Bishop, Sinwa, Sloko and Pine Creek Falls.

Bishop Falls on Kwashona Creek adjacent to the Taku River is 500 m high (Figure 24). The accessible spray zone on the east side of this waterfall was visited. The waterfall produces a sensitive spray zone herbaceous ecosystem. This ecosystem is sensitive to disruption, and was mapped.

Figure 24. Bishop Falls on Kwashona Creek

Sinwa Falls, located along the Taku River, is a resurgence, that is, it emerges from a cliff face (Figure 25), and likely drains an underground aquifer in limestone bedrock. This waterfall has a small spray zone and has low potential for rare plants since it is located where the climate is drier and lacks a bowl that would be kept moist by the waterfall spray. Nonetheless it represents a significant and sensitive ecosystem. The site is sacred to the Taku River Tlingit First Nation. Sloko Falls, located below the outlet of Sloko Lake, and Pine Creek Falls near Atlin were not visited. Sloko Falls is within Atlin Provincial Park. Pine Creek Falls is unlikely to contain sensitive ecosystems because of the lack of a spray zone.

Figure 25. Sinwa Falls resurgence along the Taku River

4.2.12 Volcanics

A variety of different volcanic features occurs in the study area. All are part of the Stikine Volcanic Belt. The most well known are the tuyas, flat-topped steep-sided mountains formed when volcanoes melted up through the Pleistocene ice sheet. These are prominent on the Kawdy Plateau. Tuyas are globally uncommon, though there are seven or more in northwestern British Columbia. Kawdy Mountain (ca 1950 m) is the highest, rising 600 m above the local plateau (Holland 1976).

Columnar basalt is formed during the cooling of thick lava flows, and is found in some lava deposits in the region, including those near Level Mountain (Figure 26). Columnar basalt may provide important nesting habitat for some bird species such as peregrine falcons and gyrfalcons, and uncommon, nutrient-demanding plant species can often be found within the crevices. While the use and species richness of the deposits in the Atlin-Taku area is not known, any occurrences of columnar basalt should be treated as sensitive. The columnar basalt in Figure 26 was not visited or mapped because of time constraints and uncertainty about its exact location.

Other volcanic features or areas include:

- Level Mountain, which is a large shield volcano about 35 km in diameter that rises to Meszah Peak (2164 m); it is part of the Nahlin Plateau (Holland 1976). The area provides important caribou habitat.

- Heart Peaks, which is a prominent and colourful volcanic feature on the Nahlin Plateau, northwest of and distinct from Level Mountain. There is a big complex landslide on the west side of this massif, slumping down to the Sheslay River.

- Ruby Creek volcanic area includes Volcanic Creek, Cracker Creek and Ruby Mountain cinder cones; Llangorse Mountain, Mount Sanford, Chikoida Mountain, Hirschfeld/Line Lake volcanic outcrops and lava flows.

The cliff-nesting raptor habitat is specific to the columnar basalt of volcanic deposits, while the caribou habitat is not specific to volcanic deposits. Caribou habitat will be described in greater detail in forthcoming wildlife habitat reports for the planning area (N. McLean *in prep*.). The only volcanic deposit surveyed was a cinder cone in Volcanic Creek. No sensitive ecosystems were found at this location.

Figure 26. Columnar basalt formation near Level Mountain

4.2.13 Landslides

Large landslides can produce uncommon topography and landforms where the slide deposits and rearranges material along and at the base of the slope. These big slides create a mosaic of habitats and form nodes of diversity (species, soils, ecosystems, successional stages) in the northern landscapes (Geertsema and Pojar 2007). There are a number of landslides in the Atlin-Taku region, including the Yeth Creek, Heart Peaks, Inklin, Sharktooth and Sloko landslides. The Yeth Creek landslide was the only landslide sampled in this project.

The Yeth Creek landslide, east of Peridotite Peak, occurs on a mixture of peridotite and granodiorite bedrock, with peridotite dominating (Section 4.2.5). The landslide features large blocky talus (up to house size) and subterranean streams. Many ponds are scattered over the surface of the slide. They have an intense blue colour and resemble marl lakes, but their water chemistry and aquatic biota could be very different. The Yeth Creek landslide was identified as a sensitive ecosystem because plant species on ultramafic bedrock may have developed unusual physiology to be able to tolerate their growing conditions, and contain rare plant species such as Kruckebergs holly fern.

The Heart Peaks landslide near the Sheslay River, where a large landslide has produced complicated topography that consists of scarps, slumps, seeps, wetlands and mounds, is another example of the complex topography produced by landslides. This area was mapped as a sensitive ecosystem because of the topographic and vegetative complexity of the site combined with the landslide process.

The Inklin landslide blocked the Inklin River in 1979, creating a temporary lake 12 km long. The water level was raised by 20 m before the blockage was breached. The flooding killed the coniferous forest along the river, which was replaced by shrubby deciduous vegetation, increasing vegetation complexity on the landscape (Geertsema 1998, Geertsema and Pojar 2007). The Sharktooth landslide, which occurred in 1980, pushed the Sheslay River across the valley bottom (Geertsema 1998, Geertsema *et al.* 2006). The exposed parent materials provided substrate for primary succession. The Sloko landslide complex on the north side of the valley below the outlet of Sloko Lake has not been investigated.

4.2.14 Glaciofluvial Landforms

Well-developed glaciofluvial landforms often form diverse ecological mosaics, with a full range of aquatic and terrestrial, and hydric to xeric communities in close juxtaposition. The Fourth of July Creek area, including nearby areas in Consolation Creek and Fish Lake, is a showcase of glaciofluvial processes and landforms containing compound eskers, kames, kettles and pitted outwash plains (Figure 27) (Tallman 1975). The area also contains the southernmost known palsa[4] bog in North America. The Fourth of July-Consolation Creek area is also part of an important winter range for woodland caribou, which are declining in the Atlin region.

Figure 27. Glaciofluvial deposits at Fourth of July Creek

Fourth of July Creek was proposed as an ecological reserve in 1977 (Ecological Reserve Proposal no. 286) and later as a candidate area under the provincial protected areas strategy of the 1990's. The vegetation of this area is discussed in the grasslands section. This area is presently being examined as part of a Terrestrial Ecosystem Mapping (TEM) project related to the Adanac Mine development. The Fourth of July Creek/Consolation Creek/Fish Lake area was mapped as a sensitive ecosystem because of the diversity of grasslands, shrublands, wetlands and dry forests on prominent and outstanding glaciofluvial deposits.

4.2.15 Permafrost Features

The southernmost known palsa bog in North America is located along Fourth of July Creek, approximately 40 km northeast of Atlin (Tallman 1975, Seppala 1980). No recent information on the state of this ecosystem was found. This area is part of a 1977 ecological reserve proposal (Ecological Reserve Proposal no. 286) and later as a candidate area under the provincial protected areas strategy of the 1990's. This area is discussed in more detail in the Grasslands and Glaciofluvial Landforms sections.

4.2.16 Coastal - Boreal Transition

The Taku River is one of the few rivers to breach the Coast Mountains. A strong climatic gradient is a feature of these transitional river valleys. This important ecological corridor connects the continental interior with the coastal maritime environment, allowing the movement of plants, animals and humans (Nowacki *et al*. 2001). Thus in the Taku River valley, very wet

[4] Palsas are peat-covered mounds with permafrost cores. They are usually ombrotrophic and much less than 100 m across and from one to several meters high. They can be treeless or have sparse stunted black spruce or tamarack.

portions of the Sub-Boreal Spruce (SBS) subzone are next to the Boreal White and Black Spruce (BWBS) subzone.

The vegetation types related to this transition have provincially unusual combinations of species, and there is a high level of plant diversity across the transition due to the sharp climatic gradient. When this transition is combined with special geographic or geologic features, such as floodplains or limestone bedrock, both of which occur in the transitional area, the plant communities become more interesting. The short time spent in the area for this project did not allow detailed inventory, but visual observations include unusually rich avalanche tracks and glaciofluvial terraces with exceptional mixed-wood forest communities dominated by large paper birch and subalpine fir. No sensitive ecosystems were mapped specifically related to the Coastal–Boreal Transition, though the floodplains of the Taku and King Salmon rivers in the transition area are mapped as sensitive.

4.2.17 Rock Glaciers

Rock glaciers are frequent in the region. If active, they can be regarded as indicators of permafrost, but permafrost is not unusual at high elevations in northern B.C. Active rock glaciers could support at least locally unusual—though sparse—vegetation. In the Central Alps, the vegetation of inactive rock glaciers "did not show any apparent difference from that in the adjacent stable areas" whereas the vegetation (mostly formed by pioneer species) of two active rock glaciers "differed sharply from both that in the nearby stable areas and that on the inactive rock glacier" (Cannone and Gerdol 2003). The rock glaciers on Atlin Mountain are highly visible from Atlin, but it is not known if they are biologically important. Rock glaciers were not visited due to the low threat risk from development they face, and were not mapped as sensitive ecosystems.

4.2.18 Alpine

Alpine tundra was not targeted during the 2008 field survey because it is extremely widespread (35% of the planning area) and is generally not at risk in the study area, though in other parts of the province, alpine is mapped as sensitive.

The glaucous bluegrass (*Poa glauca* ssp. *rupicola*) alpine ecosystem is Blue-listed by the CDC. It also occurs in the SWB subzone. This is an herbaceous community that occurs on alpine saddles used by sheep and mountain goats for feeding, resting and observing. The Glaucous bluegrass ecosystem tends to be small and localized, and is a zoo-climax caused by heavy animal usage (Pojar 1991). It has not been mapped in the study area, but is likely to occur.

Another alpine/sub-alpine ecosystem that is sensitive in the region is the Glaucous bluegrass - Spreading Arctic sedge (*Poa glauca – Carex supina*) community (Figure 28) (W. MacKenzie *pers. comm*.). It occurs on steep, dry, south-facing colluvial slopes, and may also be a zoo-climax community due to heavy sheep usage (Pojar 1991, W. MacKenzie *pers. comm.,* Houwers and Weiland 2008). This community has been mapped (map code GG) on Steamboat Mountain and Red Mountain (Houwers and Weiland 2008), and is likely to occur in other areas (W. MacKenzie *pers. comm*.). Both of the above alpine communities are largely snow-free in winter (Pojar 1991).

Figure 28. Glaucous bluegrass - Spreading Arctic sedge ecosystem

Fuller (2002) calls herbaceous meadows (map unit AM) in the alpine in the Teslin Plateau Ecosection very rare. The community type occurs on gentle slopes with deep soils, and is dominated by creeping willow (*Salix stolonifera*), partridge-foot (*Luetkea pectinata*), and Sitka burnet (*Sanguisorba canadensis*). No plot locations are given in Fuller (2002). Buttrick (1978) described the alpine vegetation of Teresa Island, in Atlin Lake and Atlin Provincial Park. He distinguished 16 community types and concluded that they were generally representative of alpine vegetation in northern B.C.-southern Yukon, at least of a continental climate with some maritime influences and on soils derived from relatively nutrient-poor bedrock. Most were similar to the community types described in Gladys Lake Ecological Reserve (within Spatsizi Park) by Pojar (1991). It is possible that Buttrick's Altai fescue – Diverse-leaved cinquefoil (*Festuca altaica – Potentilla diversifolia)* rich meadow, a moist herb-rich community type, could correspond to Fuller's AM unit.

Alpine areas of northwest B.C. contain a high proportion of the Red- and Blue-listed plant species found in the province; however, some of these species may be peripheral or jurisdictionally rare (Bunnell *et al*. 2004). Recent evidence indicates that parts of the study area may have escaped Wisconsinan glaciation and been a glacial refugium during the Pleistocene, and as a result may contain rare genotypes of common alpine plant species (Marr *et al.* 2008). Alpine vegetation in the region in general is not well known enough to identify all at-risk ecological communities.

4.2.19 Lichen Landscape

With a landscape reminiscent of taiga on the Canadian Shield, White Pass contains an outstanding lichen flora not found elsewhere in the study area. No other coast-interior passes in northwestern B.C. (such as Chilkoot and Chilkat) support comparable ecosystems (Figure 29). This exposed, very snowy, subalpine area has complex microtopography: Glacially scoured granitic bedrock interspersed with glaciofluvial and morainal deposits and a myriad of associated ponds, lakes and wetlands. Ground lichens, subalpine heath, and stunted wind and snow-pruned conifers rich in extraordinary lichen epiphytes dominate the plant cover. This area has a diversity of glaciofluvial landforms, including kames, eskers and moraines. The area was proposed as an ecological reserve in 1977 (White Pass Ecological Reserve Proposal no. 287), and is mapped here as a sensitive ecosystem.

Figure 29. Post-glacial landscape dominated by bedrock, lichens and stunted conifers in White Pass

4.2.20 Canyons

The largest and most spectacular canyon in the study area is the Nakina Canyon. It is a deep limestone canyon on the south flank of Sinawa Eddy Mountain. Canyons are discussed in Section 4.2.4.3. Canyons are susceptible to threats due to their suitability for hydroelectric developments.

4.2.21 Other

'The Grotto' is where Grotto Creek flows out of a limestone cliff approximately 25 km south of Atlin (Figure 30), and is a regionally significant feature. The potential for rare aquatic plant species at this site is enhanced by the constant flow of water that seldom freezes. With the exception of a number of aquatic mosses, none of which were provincially listed, only regionally common species were observed in the vicinity of The Grotto. The introduced, non-native species, common water-cress, grows in Grotto Creek approximately 20 m downstream of the spring. This species occurs only sporadically in northern B.C. and was possibly introduced by European settlers who used the plant as a culinary herb.

Figure 30. The Grotto with Grotto Creek coming out the entrance

Golden spruce are known to occur along Inklin River across from Yeth Creek (Figure 31). Golden spruce trees have a rare genetic mutation that causes their foliage to have a golden colour. Occurrences of this special form of spruce tree were not mapped but should be protected for their genetic uniqueness.

Figure 31. Golden spruce along Inklin River

Mt. Minto – Taku River Tlingit name (*K'iyan*) for this mountain means "hemlock all around the bottom". If western hemlock occurs here it would be significant, but the reference could simply be to water-hemlock (*Cicuta*). Mt. Minto is a sacred site to the Tlingit, but was not mapped.

4.3 Rare Ecosystems Identified by Conservation Area Design

Many, though not all, of the rare ecosystems identified through the CAD process were well represented on the landscape. Some of the sampled CAD polygons were sensitive ecological communities, e.g. floodplains; however, a single CAD-predicted ecological community might actually include multiple communities, some sensitive and others not, limiting the usefulness of the results (Table 5) It appears that the main limitation to the CAD process was the quality of the input data; specifically the BEC subzone lines and forest cover polygons, which lack the spatial resolution and content needed to adequately delineate sensitive ecosystems.

The BEC subzone lines in the Atlin-Taku area are not well defined due to a lack of sampling. This may lead to misclassification. For example, valley bottom areas upstream of Tatsamenie Lake are shown as Mountain Hemlock on the BEC maps and subsequently in the CAD process. However, field checking indicated that the area should be in the ESSF subzone. Thus the CAD indicated presence of a number of rare ecosystems that may not have been indicated if the BEC map was more accurate.

Forest cover data can also be inaccurate, leading to incorrect ecosystem designation in the CAD process. For example, birch was indicated on the CAD label for an area where birch was not present. Differences in tree species proportions in the forest cover label can lead to designation of ecosystem types that represent amalgamations of either successional stages or adjacent plant communities that are statistically rare but not biologically meaningful. While informative in providing an overview of the range of tree/topography combinations, this analysis has limited value in identifying sensitive ecological communities as defined by the CDC, or for the methods followed by this project (RISC 2006).

Table 5. Conservation Area Design field checking summary

CAD (BEC) subzone	Ecosystem	Polygon	Comments
Boreal Subalpine (Spruce Willow Birch)	Riparian forest and shrubland	18 and 32	These polygons were not riparian but on slopes. Mostly they are old growth fragments from last fire, containing old growth all-aged aspen forest with patches of balsam poplar and scattered conifers. Appear to be moderately common on the landscape and unthreatened.
Mountain Hemlock	Hemlock - warm	423 and 427	Did not visit these polygons but did look at their setting and location. Hemlock in the MH zone is not generally rare or under threat. Most of the MH zone in this area contains avalanche chutes or other non-forest vegetation.
Mountain Hemlock	Aspen Mixed Conifer - warm	1028	This plant community is unusual but not rare for the ESSF, the subzone this area should be mapped as, but would be rare in the MH. Interesting mix of early and late successional species on this warm disturbed south-facing slope. Tree species include aspen, subalpine fir and cottonwood.
Mountain Hemlock	Aspen Mixed Conifer - cool	1027	
Mountain Hemlock	Pure Lodgepole Pine – cool	1036	A good example of a dry Pine-Lichen ecosystem, which is generally infrequent in the ESSFmv, the subzone this area should be mapped as; much more common in northern B.C. than in the south in this subzone, but is not a rare ecosystem.
Mountain Hemlock	Pure Lodgepole Pine - warm	1038	
Mountain Hemlock	Riparian forest and shrubland	1049 and 1057	These sites were on active fans dominated by cottonwood, with some subalpine fir. Site series is undescribed/uncommon in the ESSF, the subzone this area should be mapped as, but much more common in the Boreal transition than elsewhere.
Northern Coastal Hemlock (Coastal Western Hemlock)	Pure spruce/ Spruce Spp Mixes -cool old	671, 673, 680, 682, 683, 686, 688, 689, 690	Numerous polygons in a small area beside Flannigan Slough. Confirmed to be old growth Sitka Spruce high bench floodplain - CWHwm/05 (Blue-listed). This community has been mapped in several additional locations by Terrestrial Ecosystem Mapping projects done for the mining projects in the area.
Northern Coastal Hemlock (Coastal Western Hemlock)	Pure spruce/ Spruce Spp Mixes -warm old	675, 676, 678, 684, 687, 693	
Sub-Boreal Spruce	Pure Spruce/ Spruce spp Mixes - warm old	836	The type label is correct, but this entire valley is of the same type. This polygon is on an oxbow. Very little subalpine fir on floodplain. Looks just like White spruce - Horsetail on the Sheslay River.
Sub-boreal Spruce	Spruce mixed conifer warm	571	Polygon 579 is floodplain. These adjacent polygons are very similar to the floodplain on opposite (north-facing) riverbank and a large area of burned floodplain downstream. Burnt floodplains are rare, but not in the Inklin landscape.
Sub-boreal Spruce	Spruce – Lodgepole pine /Spruce - warm	579	
Sub-boreal Spruce	Spruce - Mixed conifer - warm	293	These adjacent units are extremely common in the landscape and in the ESSF as a whole. Little or no spruce, dominated by subalpine fir and alder with a few poplars and pines; poplars are less common but frequent enough to be ecologically important.
Interior Sub-alpine Forest (Engelmann Spruce Sub-alpine Fir)	Spruce - Mixed conifer - warm	278	
Interior Subalpine Forest (Engelmann Spruce Sub-alpine Fir)	Aspen - deciduous /Birch - deciduous - warm	814 and 877	Does not contain birch and is not rare in this landscape, though quite uncommon in the ESSF as a whole. This is a burned young mixedwood forest that regenerated following wildfire. The birch may be incorrectly typed black cottonwood.

4.4 Plant Species of Interest Found During Fieldwork

During the fieldwork for this project two Red-listed and seven Blue-listed vascular plant species were collected (Table 6). Additionally, nine vascular plant species that were considered extensions to the known range of the species were collected. Final determinations of some vascular plant specimens are to be completed. Identification of non-vascular plant specimens is on-going.

Table 6. List of Plant Species of Interest Found During Fieldwork

Latin Name	Common Name	Importance	Location	UTM	Comments
Vascular Plants					
Agrostis idahoensis	Idaho bentgrass	Range extension	Houdini Creek	08 643910 6538681	Closest location in B.C. in Chilcotin. Occasionally flooded calcium-rich beaver meadow.
Arenaria capillaris	Thread-leaved sandwort	Range extension	Airplane Lake area	08 595857 6646417	Closest location in B.C. south of Kamloops, in YK without ssp, steep west-facing grassland.
Arenaria longipedunculata	Low sandwort	Blue-listed	Atlin Warm Springs	08 580675 6586306	Tufa deposit
Carex illota or C. microptera	Sheep sedge or Small-winged sedge	Range extension	Houdini Creek	08 643910 6538681	Closest location in B.C. in Findlay River or Cache Creek. Occasionally flooded calcium-rich beaver meadow. Final identification pending
Draba alpina?	Alpine draba	Blue-listed	Volcanic Creek canyon	08 589195 6625544	Final identification pending
Galium trifidum ssp. *trifidum*	Small bedstraw	Range extension	Yeth Creek	08 640920 6533789	Closest location in B.C. on Vancouver Island and near Thompson River; in YK without ssp, sedge tussock meadow.
Huperzia chinensis	Pacific fir-moss	Range extension	Kwashona Creek	08 589604 6505607	Closest location in B.C. on Lower Nass River, forest.
Juncus articulatus	Jointed rush	Range extension	Atlin Warm Springs	08 580999 6586326	Closest location in B.C. at Skeena River mouth; marl/tufa wetland.
Koenigia islandica	Iceland koenigia	Blue-listed	Volcanic Creek	08 590677 6625512	Mineral soil on margin of small pond.
Lomatogonium rotatum	Marsh felwort	Blue-listed	Atlin	08 574130 6605576	Margin of hydromagnesite across the road (north) from the helipad.
Nymphaea mexicana	Yellow waterlily	Range extension	Atlin Warm Springs	08 580533 6586108	Closest location in B.C. Victoria; Warm pond on private property by gardens.
Plantago eriopoda	Alkali plantain	Red-listed	Atlin	08 573379 6604343	Margin of hydromagnesite deposit near helipad.
Polemonium boreale	Northern Jacob's-ladder	Blue-listed	East of Nakina River near Dry Lake	08 632961 6559368	Alpine tundra, limestone bedrock; elev 1498 m.
Polystichum kruckebergii	Kruckeberg's holly fern	Blue-listed	Peridotite Mountain Yeth Creek landslide	08 639557 6535461 08 640484 6534635	Peridotite bedrock
Primula nutans	Siberian primrose	Red-listed	North of Shaker Lake	08 560872 6636003	Calcium rich fen wetland complex Wf11.
Ranunculus pensylvanica	Pennsylvania buttercup	Range extension	Taku River, Flannigan Slough	08 578915 6496017	Closest location in B.C. Skeena River near Babine River. In riparian meadow.

Table 6. List of Plant Species of Interest Found During Fieldwork (Continued)

Latin Name	**Common Name**	**Importance**	**Location**	**UTM**	**Comments**
Trichophorum pumilum	Dwarf clubrush	Blue-listed	Wilson Creek fen Telegraph Creek fen Como Lake fen Shaker Lake fen	08 590755 6582127 08 569936 6621903 08 576026 6607539 08 560872 6636003	Nutrient rich fen wetlands
Non-vascular Plants					
Nephroma occultum	Cryptic paw lichen	COSEWIC special concern	Kwashona Creek floodplain	08 589604 6505607	Floodplain in CWH BEC subzone

5.0 Threats to Sensitive Ecosystems

5.1 Methods for Ranking Threats

Identifying threats to sensitive ecosystems enables planners to address protection of the most threatened ecosystems. The Atlin-Taku planning area is relatively undeveloped, with few roads, some historical, current and planned mining development, and one community. This means that most ecosystems will be in "pristine" condition, and planning can occur in advance of development.

The CDC assesses the conservation status of ecosystems in British Columbia (British Columbia Conservation Data Centre 2004b), using the methodology given below. The following factors are used in these assessments:

- Range Extent
- Area of Occupancy
- Long-term Trend
- Short-term Trend
- Threats (Severity, Scope, and Immediacy)
- Number of Protected and Managed Occurrences
- Intrinsic Vulnerability
- Environmental Specificity
- Number of Occurrences
- Number of Occurrences with Good Viability
- Other Considerations.

For each of these factors there is a range of values that can be selected for each community. Some of the above factors can only be properly assessed when there is complete information available about the ecosystem. For this project the threats factor will be used as the main ranking factor. The following is the direction the CDC gives regarding using the threats ranking factor.

Threats (Severity, Scope, and Immediacy)

Evaluate the impact of extrinsic threats, which typically are anthropogenic but may be natural. The impact of human activity may be direct (e.g., destruction of habitat) or indirect (e.g., invasive species introduction). Effects of natural phenomena (e.g., fire, hurricane, flooding) may be especially important when the ecosystem is concentrated in one location or has few occurrences, which may be a result of human activity. *Characteristics of the ecological community that make it inherently susceptible to threats should be considered under the rank factor "Intrinsic Vulnerability"*.

Threats considerations apply to the present and the future. Effects of past threats (whether or not continuing) should be addressed instead under the short-term trend and/or long-term trend factors. Threats may be observed, inferred, or projected to occur in the near term.

Threats should be characterized in terms of:

1) Severity (how badly and irreversibly the area of occupancy of the ecological community is affected)

2) Scope (what proportion of the area of occupancy is affected)

3) Immediacy (degree of imminence, how likely the threat is and how soon is it expected).

Magnitude is sometimes used to refer to scope and severity collectively.

Consider threats collectively, and for the foreseeable threat with the greatest magnitude (severity and scope combined), rate the severity, scope, and immediacy each as High, Moderate, Low, Insignificant, or Unknown, as briefly defined below. Identify in the comment field the threat to which severity, scope, and immediacy pertains, and discuss additional threats identified, or interactions among threats, including any high-magnitude threats considered insignificant in immediacy.

1) Severity: This is in reference to the extent of 'damage' that the threat(s) will take. E.g. Clearcut harvesting of coastal forests might fall under "High" because they are long-lived forests, whereas fire maintained systems might fall under Moderate (forests) or Low (grasslands) with a shorter time to recover to original condition.

   - High: Destruction of ecological community in area affected with effects essentially irreversible or requiring long-term recovery (>100 years)

   - Moderate: Long term degradation or reduction of ecological community (50-100 years for recovery, e.g. fire maintained systems)

   - Low: Low but nontrivial degradation or reduction of ecological community, recovery expected in 10 - 50 years.

   - Insignificant: Essentially no degradation of ecological community, or ecological community able to recover quickly (within 10 years) from minor temporary loss (e.g. collecting of plant material).

2) Scope: This is in reference to the amount of area occupied by the ecological community that is affected by the threat at any given time. For example, the invasion of spotted knapweed may threaten >60% of the total grassland associations in the Central and South Okanagan, or, harvesting affects <5% of a forested association that is not normally targeted for harvesting, and may be impacted only by adjacent harvesting.

   - High: > 60 % of total area affected

   - Moderate: 20-60 % of total area affected

   - Low: 5-20% of area affected

   - Insignificant: < 5% of the area affected.

3) Immediacy: Is this happening right now or in future?

   - High: Threat is operational (now) or imminent (within a year)

   - Moderate: Threat is likely to be operational within 2-5 years

   - Low: Threat is likely to be operational within 5-20 years

   - Insignificant: Threat not likely to be operational within 20 years.

5.2 Types of Threats to Sensitive Ecosystems

Climate Change – Changing climate will affect ecosystems in many ways, altering their environmental complex and species composition. While climate change may be the greatest threat to some of the processes or ecosystems in the region, the scale of change means that little can be done to address the problem on a through a local planning project. Individual areas could be maintained in a former state by projects such as prescribed burning, which could be used to retard woody species invasion of grassland habitats.

Electricity Generation Projects – Electricity generation projects can take a number of forms from conventional hydro-electric dam projects to non-conventional projects including run-of-the-river hydro, wind power, and bioenergy from burning trees. Construction of new transmission infrastructure for electricity could spur electrical project development. This might be particularly true in the case of “run-of-river” power projects as, especially closer to the coast, the plan area has two of the main things these projects require: Plentiful water flow and suitable, steep terrain. A new market (like a mine) or way of getting power to a market (e.g., a transmission line built to facilitate industrial development, like the Highway 37 electrification proposal) is a third requirement for new electricity generation projects.

There is the threat of hydro-electric development on the Taku River, with proponents saying that dam construction on the Taku River will eventually occur (Dr. Pat McGeer, Vancouver Sun, March 24, 2008). While the impoundment may not cover the floodplain of the lower Taku River depending on where a dam was located, the altered hydrologic regime would affect this area, and would inundate other floodplain areas. Large hydro-electric projects are often located in canyons as natural constrictions are convenient locations to place dams.

Streams and rivers in mountainous areas in much of B.C. are targeted for small-scale run-of-the-river hydroelectric projects. Steep gradient waterways are suitable producing electricity. At present, the Atlin-Taku area is likely too distant from the electricity transmission grid for many small-scale hydroelectric projects to be viable; however this could change if a powerline is developed along Highway 37 or if a mine development project requires a local power source. There are presently two small-scale hydro projects in application or development the study area, on Pine Creek near Atlin and on Bryant Creek in the White Pass area. Wind power generation could potentially be investigated on the Kawdy Plateau or in White Pass.

Forest Harvesting – Forest harvesting does occur in the Atlin-Taku area, though only on a small scale. At the current harvest levels of under 3,000 m^3/year forest harvesting (Horn and Tamblyn 2002) is not a large threat to sensitive ecosystems in the study area. This situation could change if the floodplain cottonwood forests on the lower Taku River were targeted for harvesting.

Invasive Species – Invasive plant species can impact ecosystems by displacing native plants and altering the function of the ecosystem. In many cases the establishment of exotic species is facilitated by human disturbance or grazing livestock. In most of the study area, ecosystems are in pristine condition and do not support invasive species; however, even small secondary roads are sources of introduced plants, which appear to be, at present, confined to existing roadsides. Invasive plant species such as curled dock (*Rumex crispus*) and common tansy (*Tanacetum vulgare*) are known from the Atlin area.

Mineral Exploration and Mine Development – The Atlin-Taku area contains numerous mineral claims spread throughout the study area. Mineral exploration and mine development can impact sensitive ecosystems through the development of the mine footprint area, and of equal or greater impact the access corridors that provide transportation and power services to the site. Overall, development related to mineral exploration and mine development is the greatest threat to sensitive ecosystems in the study area.

Mining could also target mineral deposits that contain sensitive ecosystems. For example, hydromagnesite has the potential to be used as a natural flame retardant. The Atlin hydromagnesite deposit is among only 23 deposits in the province and is the only one not in the Chilcotin area (Cummings 1940). There is the possibility that the Atlin hydromagnesite deposits could be mined in the future, with the Atlin deposit formerly promoted as a commercial source of magnesia (Simandl *et al.* 2001).

Recreational Use – Recreational use of areas can affect sensitive ecosystems in various ways. Visitors can act as a vector spreading invasive plants into natural habitats, can alter the usage of an area by animal species, and can directly impact the ecosystems through physical disturbance.

All terrain vehicles (ATV) can access much of the terrain surrounding Atlin, but are absent from most of the rest of the study area. Remote areas of the study area have a long history of use by guide-outfitters who use horses a part of their guiding operations. Invasive plants can be spread by horses if they feed on contaminated hay before entering the guiding area. The extent of invasive plant spread in the Atlin-Taku area is not known.

Road Construction – Roads provide access to areas. This can impact ecosystems in two ways: (1) the construction corridor could directly and indirectly damage sensitive ecosystems if built through them or if they alter their hydrology, and (2) the resulting access could indirectly degrade sensitive ecosystems by facilitating access to or use of them, or by causing mortality of wildlife associated with the ecosystem. In the study area, road construction is most likely to occur in relation to mine development.

Utility Corridor Development – Floodplains are frequently used for linear developments such as roads and utility corridors. The combination of these threats makes floodplains one of the more vulnerable sensitive ecosystems in the study area. In the study area utility corridor development is most likely to be associated with mine development, though it could occur in relation to large-scale hydroelectric projects.

5.3 Ranks of Threats

Following the CDC (2004b), threats are ranked for collective severity and scope (also called magnitude), for each relevant ecosystem type. For the threat of greatest magnitude, individual ranks for severity, scope and immediacy are given (Table 7).

Table 7. Ranking of threats to sensitive ecosystems. For the greatest threat, ranks are given for each of scope, severity and immediacy. For all other threats, a rank is given for magnitude (i.e.: Scope and severity combined). Codes are described in Section 5.1.

Sensitive Ecosystem Type	Threat Type								
	Climate change	**Electricity development**	**Forest Harvesting**	**Hydrological changes**	**Invasive species**	**Mineral exploration and mine development**	**Recreational Use**	**Road construction**	**Utility Corridor Development**
Alpine	M, H, L					L			
Calcareous wetlands				M, L, L					
Canyons		H, M, I							
Coastal – Boreal transition	L, H, L								
Dry forests/Pine-Lichen	L		L				M, L, L	L	
Floodplains		M	L		L	H, L, H		M	M
Glaciofluvial						L	L	H, M, L	
Grasslands/Boreal steppe	M				M		M	L	
Hydromagnesite						H, H, L	H		
Jökulhlaups	L					M, L, L			
Landslides									
Lichen landscapes					L				H, I, I
Permafrost	H, H, L								
Rock Glaciers	H, H, L								
Tufa		H, M, M	L	M	H		H		
Ultramafic									
Volcanics							L, L, L		
Warm Springs				L			L, L, L		
Water features									
Waterfalls		M, M, I		M					
Wetlands				M, L, L		M			

L = Low; **M** = Medium; **H** = High

5.3.1 Comments on Threats to Sensitive Ecosystems

Alpine – Climate change could affect alpine areas as a warmer climate may result in plant species tracking climate and moving upslope, changing plant community composition, and could result in melting permafrost, instability of alpine soils and mass movement (Korner 2003).

Calcareous Wetlands – Calcareous wetlands are not currently threatened but their hydrology could be altered if developments such as road building occurred in their recharge area. Climate change could alter the hydrology of some wetlands, possibly causing them to get drier.

Canyons – Canyons are desirable locations for hydroelectric dams due to the natural constriction. Dams would pose a major threat to ecosystems in canyons.

Coastal – Boreal Transition – The nature of vegetation in the coastal - boreal transition will be affected by climate change. It is difficult to predict what the impacts could be but it appears that coastal environments will penetrate farther inland.

Dry Forests/Pine-Lichen Forests – Pine-Lichen forests are important caribou winter range. Climate change in the form of more frequent thaw-freeze events in winter and a denser crusty snowpack is likely the greatest threat to the functional capacity of this forest type to provide suitable habitat for caribou in winter. Winter recreational use that disturbs the caribou or facilitates predation will also have adverse effects. Other dry forest types are not likely under great threat from development but will be affected by climate change.

Floodplains – Many developmental pressures can threaten floodplains. In the Atlin-Taku planning area the greatest pressure is likely to come from mine development activities. The Tulsequah Chief Mine is being developed partly on the floodplain and associated wetlands of the Tulsequah River and Shazah Creek. Development includes road construction, airstrip construction and tailings impoundment. All are being partially built on the floodplain. Utility corridor developments are a potential threat to floodplains. Forest harvesting could occur if cottonwood becomes targeted in the area. Invasive plant species could be introduced by any development activity. Climate change could change the hydrological regime and hence floodplain dynamics.

Glaciofluvial – Glaciofluvial deposits are often targeted during road construction due to availability of suitable road building materials and the dry road-building surface compared to other types of deposit. These deposits can provide important habitat for a range of wildlife and plant species, some of them regionally uncommon, which can be impacted by road building or extraction of aggregate materials (Williston *et al.* 2004).

Grasslands/Boreal Steppe – Climate change is probably the chief threat to grasslands/Boreal steppe. These northern ecosystems will probably shrink, and are already squeezed by warmer wetter conditions and encroachment by woody plants. This boreal steppe can be regarded as a present-day analogue of the so-called Mammoth Steppe, a cold arid grassland biome that reached its peak during the last full glacial (24-18,000 years ago) and declined subsequently in the Holocene. Presently such grasslands persist on south-facing droughty slopes in the drier parts of northern B.C. and on glaciofluvial deposits generally in the north. These grassland islands represent one of the province's most threatened ecosystems. The system evolved, and today is best expressed, in dry cold conditions, whereas the climatic trends in the region appear to be toward moister warmer conditions. The grasslands of the Atlin-Taku planning area are often located on glaciofluvial deposits, so the comments for that community type apply here as well.

Hydromagnesite – The hydromagnesite deposits have mineral claims over them and have been promoted as a source of a natural fire retardant. To date no extraction has occurred that we are aware of, but if extraction occurred the entire deposit could be removed. The result would likely be irreversible alteration of the ecosystem on this site. Recreational use of the site is ongoing, with undocumented impacts. There has been historical disturbance of the hydromagnesite deposits including road building, ATV use, fence building and general use.

Jökulhlaups – The nature and size of jökulhlaups will change as the glaciers that produce them change. The threats will be to the landforms and ecosystems that have been produced by the jökulhlaups near Lake No Lake. The development of the mineral claims in the area could impact these communities.

Landslides – No threats to the landslide areas were found. As these are unstable areas, development or use is unlikely to occur on them, although the Golden Bear Mine was partly developed on an old landslide.

Lichen Landscapes – The White Pass lichen landscape occurs in a pass between inland areas and the coast. This type of corridor is commonly developed for utilities, as evidenced by the presence of a railway and highway through White Pass adjacent to this sensitive ecosystem. Additional development of this corridor is possible, but would likely follow the existing developed corridor. If development of the sensitive area did occur, invasive plant species would become established.

Permafrost – As climate change warms up the Atlin area, permafrost areas will likely be affected. As this is the southernmost palsa in B.C., it could be at the cusp of the impacts of climate change.

Rock Glaciers – As climate change warms up the Atlin area, rock glaciers will likely be affected, and could be destabilized as melting occurs.

Tufa – The tufa deposit at Atlin warm springs has numerous threats from past and current usage. Current threats include recreational and residential use, water diversion, invasive species and forest harvesting. The potential for further water diversion by the residents for microhydro development is judged to be the greatest future threat. This development could dry out parts of the pool-step formation, with major effects to the ecosystem. Where water diversion has occurred in other parts of the deposit, the result was a major change in hydrological regime and plant species, and establishment of invasive species.

Ultramafic Bedrock – The ecosystems on the peridotite ultramafic bedrock area are not currently under threat. There are no mineral claims in the area, and it is not close to any current use.

Volcanics – The potential cliff-nesting habitat on columnar basalt could be impacted by improper recreational use or by falcon poachers, but this is unlikely given its remote setting.

Warm Springs – Warm springs could be damaged by inappropriate recreational use or hydrological changes. The threats to Atlin warms springs are ranked and discussed in detail under Tufa. The level of threat to other warms springs is low, as they are not recreational features.

Waterfalls – The greatest potential threat to waterfalls is likely to be hydroelectric development, though current projects are not known to impact waterfalls.

Water Features – Water features were presented but not ranked in the report, as they are beyond the expertise of the authors.

Wetlands – The threats to floodplain wetlands are ranked and discussed in detail under Floodplains. Other types of sensitive wetlands are not currently threatened but their hydrology and species composition could be altered if developments such as road building occurred in their recharge area.

6.0 Summary

Sensitive ecosystems were identified and mapped at the reconnaissance scale in the Atlin-Taku planning area using a biophysical approach. Sensitive ecosystems were located on a wide range of physical sites, and were sensitive for a variety of reasons. Some sites have a combination of physical attributes, each of which is important, for example a landslide on ultramafic bedrock. The most extensive sensitive ecosystems were located on floodplains and limestone bedrock. Other important physical sites were grasslands/steppe, dry forests, glaciofluvial deposits, lichen landscapes, wetlands and ultramafic bedrock.

The type and level of threat differed greatly among the identified ecosystems. Overall, the greatest threat is from mineral exploration and mine development activity. This is due to the low amount of development for other purposes and the high level of mineralization in the region. However, other uses pose a real threat to specific sites and ecosystem types. For example, the tufa deposit of Atlin Warm Springs is threatened by residential, recreational and microhydro development. Climate change is also a large threat.

The ecosystems under the greatest degree of threat were the hydromagnesite deposits in the town of Atlin, and the tufa deposit at Atlin Warm Springs. The hydromagnesite deposit has seen a number of disturbances and is covered by a mineral claim. The tufa deposit at Atlin Warm Springs is partly privately owned and has a long history of use and associated disturbances, including water diversion, recreational development, residential development, forest harvesting, gardening and road construction; some of these disturbances are on-going.

Contemporary threats also confront floodplains. Because of their flat linear nature floodplains are often targeted for linear developments such as roads, utility corridors and airstrips. The Tulsequah Chief and other historical mining developments are partly situated on the floodplain and associated wetlands of Tulsequah River and Shazah Creek.

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Appendix A: Glossary

At-Risk: Area that can support ecosystems which are considered to be provincially at risk as designated by the B.C. Conservation Data Centre, and are listed as either Red (**Extirpated**, **Endangered** or **Threatened**) or Blue (**Special Concern**).

Blue List: List of indigenous species, subspecies, and ecosystems of special concern (formerly vulnerable) in British Columbia.

Ecological Community: Assemblages of species that co-occur in defined areas at certain times and that have the potential to interact with each other. This term is used by the B.C. CDC and NatureServe to include terrestrial natural plant communities and plant associations and the full range of ecosystems that occur in British Columbia. These may represent ecosystems as small as a vernal pool, or as large as an entire river basin, an Ecoregion or a Biogeoclimatic Zone. The term also accommodates the addition of marine and aquatic ecosystems.

Ecological Integrity: The quality of a natural, unmanaged or managed ecosystem in which the natural ecological processes are sustained, with genetic, species, and ecosystem diversity assured for the future.

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

Endangered: Facing imminent extirpation or extinction.

Extirpated: Taxa that no longer exist in the wild in British Columbia, but do occur elsewhere. Ecological communities that no longer exist in British Columbia, but do occur elsewhere.

Landscape Context: Landscape context is the abiotic and biotic features of the geographic area adjacent to and surrounding the area of interest. Landscape patterns (patchiness and fragmentation) and connectivity are attributes used to describe the extent and character of the surrounding landscape (NatureServe 2002).

Marl: A soft, unconsolidated earthy deposit consisting of calcium carbonate or magnesium carbonate, or both, and often shells, usually mixed with varying amounts of clay or other impurities.

Red List: List of indigenous species, subspecies, and ecological communities that are extirpated, endangered or threatened in British Columbia.

Sensitive Ecosystem: A Sensitive Ecosystem is one that is at-risk or ecologically fragile in the provincial landscape.

Special Concern: A species, subspecies, or ecological community that is particularly sensitive to human activities or natural events.

Threatened: Likely to become endangered if limiting factors are not reversed.

Viability: The ability of an ecological community or species occurrence to perpetuate itself into the foreseeable future. Viability values are: 4 (Excellent), 3 (Good), 2 (Fair) or 1 (Poor). For ecological communities see also **Ecological Integrity**.

Appendix B: Summary of Ecosystems Visited and Plot Data

Type	Plot Number	BEC Subzone	Site Series	Location	UTM Easting Northing	SMR	SNR	Elevation	Sensitive	Comments
Calcareous wetland	AT001	BWBSdk1	Wm06 Wf01	Telegraph Creek	08 569942 6621902	7-8	E-F	715	Yes	Central area soft-stemmed bulrush marsh, pH ~8.0
Calcareous Wetland	AT002	BWBSdk1	32	Como Lake	08 575032 6607548	8	E	774	Yes	Marl-like surface muck above fibrous peat, pH 8.5
Calcareous Wetland	AT003	BWBSdk1	Wf01 32	4th of July Wetland	08 572668 6614521	7	(D)E	718	No	Slight effervescence with HCl, pH 8.0
Hydromagnesite	AT004	BWBSdk1	00	Atlin helipad	08 573587 6604693	6	F	695	Yes	Alkaline flats
Hydromagnesite	AT004b	BWBSdk1	81	Atlin helipad	08 573587 6604700	2	C	695	Yes	Alkaline grassland on small mound
Hydromagnesite	AT005	BWBSdk1	00	Atlin town	08 574138 6605411			695	Yes	Alkaline flats
Tufa	AT006	BWBSdk1	00	Atlin warm springs	08 580868 6585920	6	D	700	Yes	Herbaceous meadow community
Tufa	AT007	BWBSdk1	00	Atlin warm springs	08 580986 6585947	2	B	700	Yes	Dry Spruce-Shrubby cinquefoil—Death camas community on tufa flats
Limestone Canyon	AT008	SWBun	00	Houdini Creek	08 643910 6538681	5	D	1000	Yes	Occasionally flooded herbaceous meadow
Limestone Canyon	AT009	SWBun	00	Houdini Creek	08 643317 6539009	5	E	991	Yes	Seasonally flooded depression in box canyon
Limestone Canyon	AT010	SWBun	00	Houdini Creek	08 642685 6539357	4	E	959	Yes	Herbaceous fern/herb community in canyon
Limestone Canyon	AT011	SWBun	00	Houdini Creek	08 642186 6539465	2	D	949	Yes	South-facing talus slope
Wetland	AT012	BWBSdk1	Wm01	Yeth Creek at Houdini Creek	08 641982 6539298	5	D	1000	Yes	Occasionally flooded marsh
Shrubland	AT013	BWBSdk1	00	Yeth Creek at Houdini Creek	08 641909 6539305	5	D	998	Yes	Willow-Horsetail-Cow Parsnip shrub carr
Floodplain	AT014	BWBSdk1	08	Yeth Creek at Houdini Creek	08 641892 6539282	4	E	996	Yes	Old growth Spruce – Horsetail floodplain
Grassland	AT015	BWBSdk1	81	West of Fish Lake	08 600191 6645871	1	D	985	Yes	Dry Slender wheatgrass-Pasture sage grassland on south-facing glaciofluvial terrace
Forest	AT016	BWBSdk1	01	North side Indian Creek,	08 641893 6539133	4	C	869	No	Old growth Trembling aspen-Rose forest
Forest	AT017	BWBSdk1	01	West of Fish Lake	08 600619 6645741	4	C	952	No	Mixed forest on zonal site
Tufa	AT018	BWBSdk1	00	Atlin warm springs	08 580883 6586148	3 (7-8)	E	668	Yes	Herbaceous pool-step community on tufa
Tufa	AT019	BWBSdk1	00	Atlin warm springs	08 581018 6586160	2-6	E	682	Yes	Spruce-Shrubby cinquefoil-Avens primary succession site on tufa

Type	Plot Number	BEC Subzone	Site Series	Location	UTM Easting Northing	SMR	SNR	Elevation	Sensitive	Comments
Tufa	AT020	BWBSdk1	32	Atlin warm springs	08 580999 6586326	8	E	676	Yes	Herbaceous nutrient-rich marsh on marl-like sediments
Calcareous Wetland	AT021	BWBSdk1	32	Kennedy Creek	08 581569 6582812	8	E	713	Yes	Thick marl, nutrient rich fen, lots of peat islands
Wetland	AT022	BWBSdk1	09	Kennedy Creek	08 581561 6582989	7	C	717	No	Old growth Spruce-Labrador tea-Horsetail stand on organic soils
Floodplain	AT023	SBSun	00	Taku River King Salmon River junction	08 599942 6519221	6	E	64	Yes	Cottonwood-Dogwood-Horsetail middle bench floodplain
Floodplain	AT024	SBSun	00	Taku River King Salmon River junction	08 600095 651121	4-5	D	44	Yes	Cottonwood-Sub-alpine fir-thimbleberry middle bench floodplain
Floodplain	AT025	CWHwm	05	Flannigan Slough	08 578816 6495804	5	D	7	Yes	Sitka spruce-Salmonberry high bench floodplain
Wetland	AT026	CWHwm	32	Flannigan Slough	08 578915 6496017	7-8	E	9	Yes	Willow-Rush-Sedge-Water lily backchannel marsh
Forest	AT027	CWHwm	04	Flannigan Slough	08 578656 6495886	5	D(E)	20	No	Sitka spruce-Devil's club-Oak fern forest on toe slope
Floodplain	AT028	BWBSdk1	08	O'Donnell River	08 580374 6582093	5	E	679	Yes	All age Cottonwood-Spruce-Highbush cranberry-Horsetail forest on active floodplain
Floodplain	AT029	BWBSdk1	08	O'Donnell River	08 579862 6582578	5	C	679	Yes	Spruce-Horsetail high bench floodplain on old backchannel
Grassland	AT030	BWBSdk1	81	Sheslay River near Hackett Creek	09 335343 6464821			754	Yes	Juniper shrubland on steep south-west facing slope
Dry forest	AT031	BWBSdk1	00	Sheslay River	08 668152 6481672	0	B	645	No	Steep cottonwood site with cliffs
Peridotite	AT032	SWBun	00	Peridotite Mountain	08 639637 6535298			1023	Yes	Open Pine-Lichen woodland on peridotite bedrock
Grassland	AT033	SWBun	00	4th of July Creek	08 588677 6634067	1	D	1067	Yes	Festuca-Pasture sage grassland on steep south-facing esker slope
Dry forest	AT034	SWBun	00	4th of July Creek	08 588629 6634223	2	C	1063	Yes	Pygmy Trembling aspen-Kinnikinnick woodland on esker
Shrubland	AT035	SWBun	00	4th of July Creek	08 588572 6634055	4-7	B-C	1044	Yes	Willow-Scrub birch-Carex complex on esker
Dry forest	AT036	SWBun	02	4th of July Creek	08 589895 6632238	1	B	1038	Yes	Dry Pine-Altai fescue-Lichen forest on outwash gravels
Forest	AT037	SWBun	00	4th of July Creek	08 586241 6629748	3	B	1050	No	Pine-Scrub birch-Crowberry stand on north-facing glaciofluvial slope
Forest	AT038	ESSFwv	03?	Tatsamenie Lake	08 648300 6464011	3	C	833	No	Aspen-Mixed conifer forest on active colluvium

Type	Plot Number	BEC Subzone	Site Series	Location	UTM Easting Northing	SMR	SNR	Elevation	Sensitive	Comments
Floodplain	AT039	SBSun	00	Kowatua Creek	08 645435 6487697	5	D	709	Yes	Spruce-Horsetail on oxbow
Limestone alpine	AT040	BAFAun	00	Sinwa Mountain	08 595712 6526640	0-2		1436	No	Herbaceous alpine meadow
Dry forest	AT041	ESSFwv	02	Tatsamenie Lake	08 646001 6462820	2	B	900	No	Dry Pine-Lichen forest on rock outcrop
Forest	AT042	ESSFwv	05/01	Tatsamenie Lake	08 647263 6462692	3-5	D	900	No	Balsam poplar-Subalpine fir forest on fluvial site
Forest	AT043	ESSFwv	05/01	Tatsatua Creek	08 655133 6491501	(4)5	D	975	No	Young mixedwood forest following fire.
Grassland/ Forest	AT044	ESSFwv	82/01	Tatsatua Creek	08 650559 6485489	3-5	D	1100	No	Balsam poplar forest and herbaceous meadow
Floodplain	AT045	SBSun	00	Inklin River	08 631706 6513148	4-5	C-D	250	No	Balsam poplar-Spruce-Pine forest on floodplain and colluvium
Forest	AT046	ESSFwv	05/01/04	Focus Mountain	08 655911 6033165	5	B-C	880	No	Sub-alpine fir-Pine-Alder forest
Grassland	AT101	SWBun	00	Yeth Creek	08 640484 6534635	1	A	1204	Yes	Open grassland at top of landslide cliff face
Dry forest	AT102	SWBun (ESSFwv)	00 (02)	Yeth Creek	08 640484 6534635	1	D	1032	Yes	Open Pine-Juniper-Fescue-Cladina forest on mafic colluvium
Dry forest	AT103	BWBSdk1 (ESSFwv(mk?)	02	Yeth Creek	08 641236 6534195	1	A	873	Yes	Open Pine-Juniper-Fescue forest on granodiorite bench beside landslide
Wetland	AT104	BWBSdk1	Wm01?	Yeth Creek	08 640920 6533789	5	D	733	Yes	Sedge tussock floodplain meadow
Floodplain	AT105	BWBSdk1	08	Yeth Creek	08 640878 6533690			723	Yes	Spruce-Horsetail floodplain
Wetland	AT106	BWBSdk1	Wf11	North of Shaker Lake	08 560872 6636003	8	F	703	Blue	Thick marl in one area. Lots of ungulate usage, perhaps mineral lick.
Grassland	AT107	BWBSdk1	81	West of Airplane Lake	08 595628 6646007	3	C	922	Yes	Timber oatgrass-Altai fescue grassland on glaciofluvial deposit
Grassland	AT108	BWBSdk1	81	West of Airplane Lake	08 595857 6646417	2	D	938	Yes	Dry Slender wheatgrass-Pasture sage grassland on south-facing glaciofluvial slope
Forest	AT109	BWBSdk1	03	West of Airplane Lake	08 596049 6646393	3	C	912	No	Mesic Pine-Willow-Scrub birch stand on north-facing glaciofluvial slope
Wetland	AT110	BWBSdk1	00	Airplane Lake	08 596627 6646730	7	B	926	No	Many bands of vegetation from open water to sphagnum
Limestone spring	AT111	BWBSdk1	n/a	The Grotto	08 582041 6583584	n/a	n/a	739	No	Exit of stream from cave entrance
Tufa	AT112	BWBSdk1	Mixed	Atlin warm springs	08 580674 6586303	mixed	rich	683	Yes	Complex of herbaceous, shrubby and forest vegetation on tufa. Some pool-step formation.
Wetland	AT113	BWBSdk1	Wf01	Jasper Creek	08 582496 6582416	8	C	747	No	Very wet sedge fen beside small lake
Calcareous Wetland	AT114	BWBSdk1	Wf11	Wilson Creek	08 590755 6582127	8	F	925	Blue	Lots of effervescence with HCl

Type	Plot Number	BEC Subzone	Site Series	Location	UTM Easting Northing	SMR	SNR	Elevation	Sensitive	Comments
Floodplain	AT115	SBSun	00	Taku River near King Salmon River	08 595963 6519001	6	D	50	Yes	Herbaceous floodplain wetland near backchannel and fan
Floodplain	AT116	SBSun	Fm02	Taku River near Sustahine Creek	08 595981 6508916	5	D	60	Yes	Cottonwood-Spruce-Dogwood middle bench floodplain
Fan	AT117	SBSun	00	Taku River near Sustahine Creek	08 595716 6518942	5	E	67	No	Cottonwood-Spruce-Devil's club forest on fan
Floodplain	AT118	CWHwm	05	Taku River at Kwashona Creek	08 589604 6505607	6	D	46	Yes	Cottonwood-Spruce-Devil's club middle bench floodplain in transition to high bench
Alpine	AT119	BAFAun	00	South end of Laurie Range	08 593599 6581337	3	C	1232	No	South-facing alpine grassland
Floodplain	AT120	BWBSdk1	Fm01	Sheslay River near Hackett Creek	09 333415 6468491	5	C	539	Yes	Cottonwood-Alder-Horsetail middle bench floodplain
Wetland	AT121	BWBSdk1	Wm02	Sheslay River near Hackett Creek	09 333448 6468519	7	D	539	Blue	Carex-Horsetail-Drepanocladus floodplain wetland
Floodplain	AT122	BWBSdk1	Fl01	Sheslay River near Hackett Creek	09 333501 6468560	6	D	540	Blue	Willow-Alder-Horsetail low bench floodplain
Floodplain	AT123	BWBSdk1	08	Sheslay River at Samotua River	08 673179 6477893	5	D	546	Yes	Mature Spruce-Alder-Horsetail high bench floodplain
Floodplain	AT124	BWBSdk1	Fm02	Sheslay River at Samotua River	08 673098 6478040	5	C	537	Yes	Cottonwood-Spruce middle bench floodplain
Peridotite	AT125	SWBun	00	Peridotite Mountain	08 639557 6535461	4	F	1067	Yes	Open Pine-Lichen woodland on peridotite bedrock
Lichen landscape	AT126	SBSun	00	White Pass	08 498977 6620298	2	A	851	Yes	Lichen-dominated community on granitic bedrock
Wetland	AT127	SBSun	00	White Pass	08 498924 6620391	7	B	840	No	Small gently sloping fen beside pond
Wetland	AT128	BWBSdk1	00	Near Tutshi Lake	08 517907 6647135	7	C	717	No	Occasionally flooded sedge wetland beside small lake

Appendix C: At-Risk Ecosystems from the BEC Database

Type	Plot Number	BEC Subzone	Site Series	Location	UTM Easting Northing	SMR	SNR	Elevation	List	Source
Dry forest	964040	CWHwm	02	Tulsequah River	8 576478 6517919	n/a	B	105	Blue	TEM-Tulsequah Chief
Floodplain	964026	CWHwm	05	Taku River at Tulsequah River	8 581463 6614619	4	C	55	Blue	TEM-Tulsequah Chief
Floodplain	9628503	BWBSdk1	Fl01	Sheslay River	9 334648 6463811	5	D	545	Blue	TAKU - BEC
Floodplain	961403	CWHwm	Fl01	Flannigan Slough	8 579432 6495857	6	D	100	Blue	TAKU - BEC
Floodplain	964033	CWHwm	Fm50	Tulsequah River	8 579760 6507435	5	D	20	Blue	TEM-Tulsequah Chief
Floodplain	964027	CWHwm	Fm50	Taku River at Tulsequah River	8 583785 6499259	5	D	10	Blue	TEM-Tulsequah Chief
Floodplain	964031	CWHwm	Fm50	Taku River	8 587591 6505778	5	D	10	Blue	TEM-Tulsequah Chief
Floodplain	9628568	CWHwm	Fm50	Taku River at Bishop Falls	8 588391 6506724	5	D	20	Blue	TAKU - BEC
Floodplain	9628569	CWHwm	Fm50	Taku River at Yellow Bluff	8 591246 6508647	5	D	20	Blue	TAKU - BEC
Floodplain	9628598	CWHwm	Fm50	Taku River at Bishop Falls	8 589119 6506617	5	D	n/a	Blue	TAKU - BEC
Floodplain	9628558	CWHwm	Fm50	Taku River at Zohini Creek	8 594147 6511161	5	D	n/a	Blue	TAKU - BEC
Grassland	9628535	BWBSdk1	Gs02	Sheslay River	9 334709 6464118	5	D	555	Red	TAKU - BEC
Wetland	9628594	CWHwm	Wf51	Flannigan Slough	8 580420 6498879	8	n/a	60	Red	TAKU - BEC
Wetland	961402	CWHwm	Wf52	Flannigan Slough	8 579432 6495857	8	n/a	100	Red	TAKU - BEC
Wetland	9628592	CWHwm	Wf52	Flannigan Slough	8 580420 6498879	7	C	60	Red	TAKU - BEC
Wetland	9628593	CWHwm	Wm50	Flannigan Slough	8 580420 6498879	8	D	60	Blue	TAKU - BEC