City of Abbotsford Sumas Mountain Sensitive Ecosystems Inventory Mapping

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Cover Image: Endangered Oregon forestsnail surveys on Sumas Mountain (R. Durand 2007).

EXECUTIVE SUMMARY

Sumas Mountain is well known as a biological hot spot, known to be inhabited by at least 40 species-at-risk and 27 ecosystems-at-risk. The 6,600ha mountain is one of the last relatively intact forested expanses in the lower Fraser Valley. Approximately 4,570 hectares, or 70%, of Sumas Mountain is located within the boundaries of the City of Abbotsford, of which 3,900.2 hectares was mapped for this project. Sensitive Ecosystems Inventory mapping and Wildlife Habitat Suitability Rating of Sumas Mountain within the City of Abbotsford was completed for land use planning and management purposes.

This report describes the results from Bioterrain Mapping, Terrestrial Ecosystem Mapping (TEM) and Sensitive Ecosystems Inventory Mapping (SEI) completed on Sumas Mountain within the City of Abbotsford from 2009 to 2010. It provides detailed descriptions of Sensitive Ecosystems (SE), Other Important Ecosystems (OIE), and Not Sensitive (NS) along with a variety of maps showing their locations and relative abundance. Additionally, habitats for targeted species-at-risk were rated as high, moderate, low or nil in accordance with the BC Resources Inventory Committee *Wildlife Habitat Rating Standards* (1999) to produce a series of habitat suitability maps.

The SEI mapping indicates that 31.1% of Sumas Mountain should be considered SE, 35.6% is OIE, and 33.3% is NS. Sumas Mountain habitats within the City of Abbotsford sustain high, moderate, low and nil rated habitats for each of the targeted species-at-risk.

This report and associated mapping products are resources for local planning and contribute to the foundation of a future conservation plan for Sumas Mountain.

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ACKNOWLEDGEMENTS

Many people and organizations have been involved in this project. Kathleen Wilkinson compiled species-at-risk lists, assisted with the development of Sensitive Ecosystem descriptions, and provided comments and data throughout the project. Daniel McAllister (D.A. McAllister Associates) completed terrain mapping and was involved with all field work. Steve Gillanders (Touchstone Environmental) completed air photo digitizing and assisted with map production. Lisa Fox, Steve Clegg and Natashia Cox of the Fraser Valley Conservancy were involved throughout the project. Staff from the City of Abbotsford (Rod Shead and Tanya Bettles) provided base data and reviewed various components of the project. Metro Vancouver Parks (Wendy DaDalt, Bonnie Blue, Josephine Clark and Janice Jarvis) provided samples of their adjacent ecosystem mapping, and sensitive ecosystem class classifications. Simone Runyan (Kestrel Ecological Consulting) assisted with the development of sensitive ecosystem classes.

GLOSSARY AND ABBREVIATIONS

Terminology used throughout this report is defined when first used. The following list of terms and abbreviations may assist readers.

Blue-listed	Species that is considered to be of special concern and sensitive to human activities or natural events (CDC 2010).
Biogeoclimatic Zone and Subzone	Provincial ecological land classification system that identifies geographical areas (zones) in which a broadly homogenous macroclimate results in similar patterns of energy flow, vegetation, and soils. Subzones are derived from each zone based on precipitation, temperature, or relative continentality.
CDC	Conservation Data Centre
COA	City of Abbotsford
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CVN	Central Valley Naturalists
CWH	Coastal Western Hemlock Biogeoclimatic Zone
Endangered	A wildlife species facing imminent extirpation or extinction (COSEWIC 2010).
Extinct	A wildlife species that no longer exists (COSEWIC 2010).
Extirpated	A wildlife species that no longer exists in the wild in Canada, but exists elsewhere (COSEWIC 2010).
FVC	Fraser Valley Conservancy
FVRD	Fraser Valley Regional District
GIF	Ground Inspection Form
GIS	Geographical Information System
HS	Habitat Suitability
HSR	Habitat Suitability Rating: final rating assigned to an ecosystem unit with all assumptions and adjustments taken into account.

Life Requisite	Specific activities of an animal that are critical for sustaining and perpetuating the species and that depend on particular habitat attributes or conditions. Life requisites include feeding, cover, breeding, migration, hibernation, etc.
Model	A graphical representation of a species' habitat use over a defined landscape.
NS	Not Sensitive
OIE	Other Important Ecosystems
Rating	A relative estimate or evaluation. A value assigned to a map unit to express the suitability of that unit to support a wildlife species for a particular life requisite and season.
Rating (e.g., high, low)	Ratings are compared to provincial benchmarks of capable habitat for that species to fulfill a particular life requisite in a particular season.
Red-listed	Species that is considered to be endangered or threatened of extinction or extirpation (CDC 2010).
RISC	Resource Inventory Standards Committee
SAR	Species at Risk
SE	Sensitive Ecosystem
SEI	Sensitive Ecosystems Inventory
SHIM	Sensitive Habitat Inventory Mapping
Site Series	All sites within a Biogeoclimatic subzone that are capable of producing the same mature or climax vegetation unit. Site series are identified using a combination of vegetation, soils, and site conditions (aspect, slope, elevation, etc.).
Special Concern	A wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats (COSEWIC 2010).
Suitability	Ability of the habitat in its current condition to provide life requisites of an animal.
Threatened	A wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction (COSEWIC 2010).

TEM	Terrestrial Ecosystem Mapping
TRIM	Terrain Resource Inventory Mapping
VRI	Vegetation Resource Inventory
WHA	Wildlife Habitat Rating: preliminary rating assigned to an ecosystem unit in the field.

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1.0 INTRODUCTION

1.1 LANDSCAPE CONTEXT

Sumas Mountain is located in the Fraser Valley of BC (Figure 1). It is bordered to the west and south by rural and urban development, to the north by the Fraser River, and to the east by the Sumas River. The western portion, mainly privately owned, is administered by the City of Abbotsford while the eastern portion lies within Electoral Area "G" of the Fraser Valley Regional District (FVRD) and consists primarily of Crown land, including Sumas Mountain Regional Park (Figure 2).

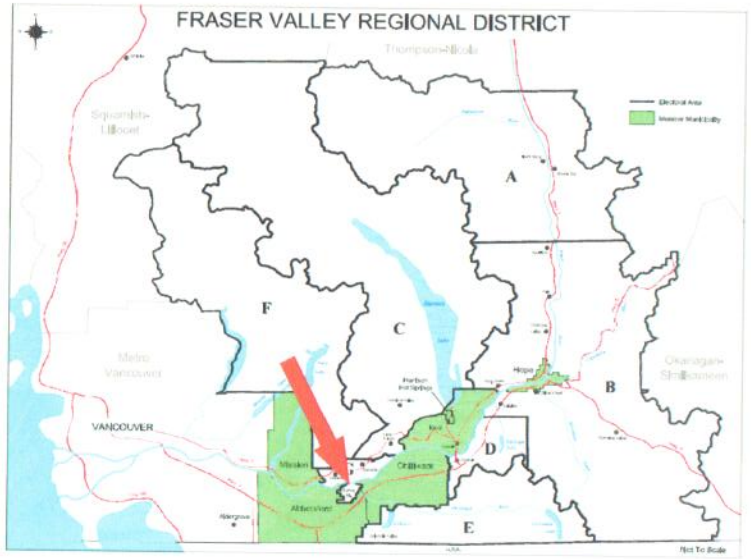


Figure 1. Study Area Location (Adapted from FVRD – 2009).

Sumas Mountain is a relatively unique feature located in the lower Fraser Valley just upstream of the freshwater/saltwater interface of the Fraser River and the Pacific Ocean. It is unusual in its geologic formation and ecology, as well as its location. Rising several hundred metres from a valley bottom that is otherwise flat and just above sea level, the 6,600 hectare mountain is a dominant feature in the local landscape. The mountain is one of the few relatively intact forested areas in the lower Fraser Valley; a

landscape otherwise characterized by extensive farmland and a rapidly urbanizing land base. Approximately 4570 hectares, or 70%, of Sumas Mountain is located within the boundaries of the City of Abbotsford.

The study area is located in one of the wettest areas of BC, with the City of Abbotsford recording over 1,500mm of rain per year, mainly during the October to March period. Snow is generally uncommon and does not persist, but large infrequent storm events do occur resulting in an annual snowfall average of over 60cm. The area is strongly influenced by arctic outflows resulting in strong northeasterly winds. (Abbotsford Weather Page 2009)

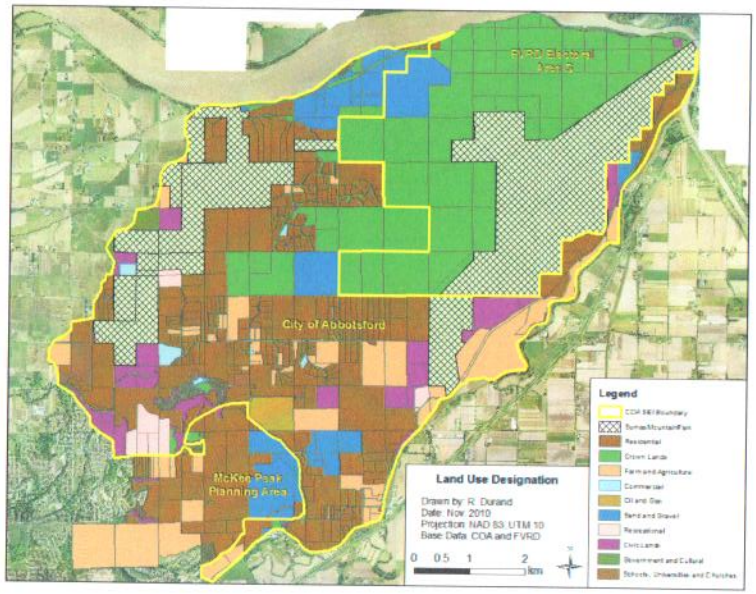


Figure 2. Land Use Designation (from COA 2005 OCP).

Due to its proximity to the Pacific Ocean (roughly 100km away), many teleconnections[1] directly affect Sumas Mountain. The region is strongly influenced by the ocean resulting in relatively warm, humid air

[1] Teleconnections refer to global connections such as major oceanic currents and global transfer of energy (heat). It is typically associated with atmospheric systems whereby changes in a given location on the planet influence climatic patterns in a different area.

moving from sea to land for most of the year and resulting in high precipitation rates and frost-free days. On a short term scale, El Nino and La Nina phases affect local precipitation levels, although much less dramatically than at lower latitudes. On a longer time scale the Pacific Decadal Oscillation produces similar climate influences with El Nino like conditions resulting in mild winters and reduced precipitation, and La Nina producing the opposite effect (Perry *et al.* 2008).

Sumas Mountain is located within the Coastal Western Hemlock (CWH) Biogeoclimatic Zone and contains three subzones; CWHdm (dry maritime), CWHxm1 (very dry maritime), and CWHvm2 (wet maritime) (Figure 3). In southwestern BC the CWH occurs from sea level to about 1,000m. The dm and xm1 subzones are characterized by relatively warm, dry summers with long growing seasons and rare water deficits. Winters are generally mild with little snowfall. The vm2 occurs at upper elevations (restricted to the peak of Sumas Mountain, outside of the City of Abbotsford boundaries) of the zone and typically has shorter summers with substantial rainfall and a longer lasting snowpack. (Ministry of Forests and Range 2009).

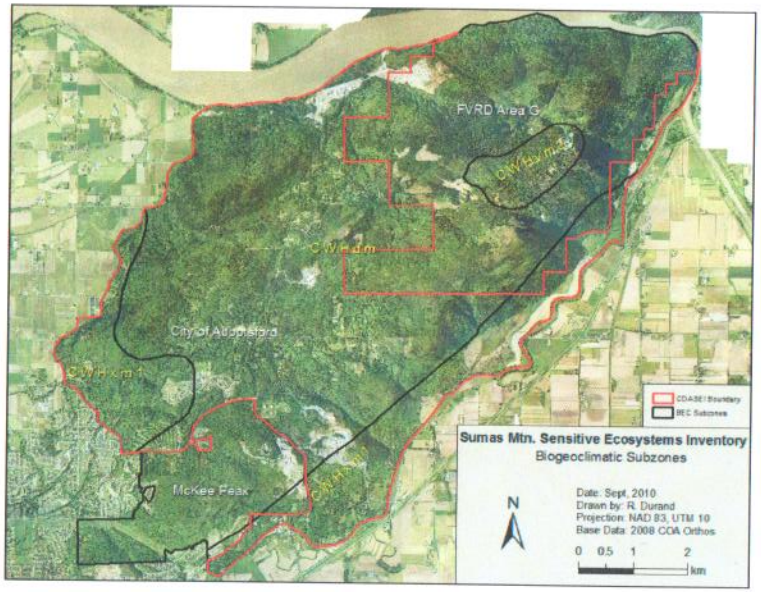


Figure 3. Biogeoclimatic Map (TRIM base data – date unknown).

Sumas Mountain has a complex geological history. It is underlain by the Coast Range Batholith which is expressed in bedrock outcrops of granodiorite, quartz diorite, and hornblende. Sedimentary rocks of the Harrison Lake Formation overlay the batholithic rock and occur underneath Eocene shale, sandstone, conglomerates and clays. Glacial and glacialfluvial deposits are common throughout the mountain (Payne 1989).

Surficial material is equally complex. Lower and mid slopes are generally composed of glacial till and glacial fluvial terraces, often overlain by a veneer of aeolian silt. Steep lower and mid slopes, and most upper slopes are comprised of colluvial veneers over bedrock. Bedrock outcrops and extensive cliff bands cliffs are common. Small fluvial deposits along the larger creeks are common, but never extensive. Section 4.1 contains more detailed information from the Sumas Mountain terrain mapping.

The study area consists of numerous types of land cover and land use. It contains coniferous, deciduous and mixed forests of various ages and structural stages; as well as shrub-dominated early successional areas, cliffs, wetlands, lakes and complex riparian systems. With the exception of several small pockets of older growth forest, the east side of the mountain is dominated by 2nd growth stands, while the western side supports a variety of land uses including small farms, rural residences, dense subdivisions, active aggregate quarries and woodlots, a cement plant, crude oil pipelines and an associated tank farm, and various types of civic land. There is an associated infrastructure of roads, railways, power transmission lines, and gas pipelines.

Typical of most low elevation mountains in the Fraser Valley, Sumas Mountain was extensively logged and mined starting in the late 1800s. Primeval forests were cleared and likely burned, and clay and aggregates were extensively mined. A general lack of old stumps with spring board notches, and an abundance of more recent, cleanly cut stumps indicate that much of the mountain was logged twice. Logging is ongoing on the mountain and aggregate extraction is increasing. Although the population of the mountain is relatively small at the moment, it is likely that pressure for residential development will increase substantially in the western portion of the area in the near future as the local and regional population grows.

The popular Centennial Trail traverses the mountain and numerous unofficial hiking and mountain biking trails have been established. Recreational use by hikers, cyclists and nature enthusiasts is also expected to grow in the future as the population of the Lower Mainland expands.

The mountain lies within the traditional territory of the Stó:lo Nation, especially the Sumas First Nation. It is associated with much of their oral tradition and has great cultural significance to the people. Some archaeological sites have been documented, particularly along the Sumas and Fraser Rivers, and more are considered possible (D.Schaepe, Stó:lo Archaeologist, pers.comm, June 6, 2003 as quoted in the Fraser Valley Regional District Electoral Area "H" OCP (2003).

1.2 Terrestrial Ecosystem Mapping and Sensitive Ecosystems Inventory

Terrestrial Ecosystem Mapping (TEM) uses air photo interpretation of ecosystem attributes and field surveys to classify a landscape into map units according to a combination of ecological features, such as climate, physiography, surficial material, bedrock geology, soil, and vegetation. In this project Sensitive Ecosystem–themed TEM mapping was done at a scale of 1:20,000 using standardized provincial methodology and the resulting polygons analyzed to identify sensitive and other important ecosystems based on rarity in the province and locally, sensitivity to and level of disturbance, and habitat value.

TEM and SEI mapping can be used by local municipalities, regional governments and non-governmental organizations (NGOs) for conservation planning purposes. This document provides an overview of Sumas Mountain ecosystems within the City of Abbotsford along with a detailed description of TEM/SEI methodology and the results of the associated mapping and field investigations.

The TEM and SEI has resulted in the delineation of several sensitive ecosystems and for each sensitive ecosystem a general description, including characteristic vegetation and wildlife is provided. Other Important Ecosystems and valued environmental features are also discussed in less detail.

2.0 ECOSYSTEMS OF CONCERN

The conservation importance of Sumas Mountain and the biodiversity, ecosystem and cultural services that could be preserved through a conservation strategy and associated actions are described in the Sumas Mountain Conservation Strategy (Wilkinson & Durand 2010). A critical first step in protecting these values is identification of environmentally significant areas, including ***Sensitive Ecosystems*** and ***Other Important Ecosystems,*** concepts developed in previous Sensitive Ecosystem Inventories carried out in BC[2].

These have been modified here to reflect the conditions of the Sumas Mountain study area as revealed through TEM/SEI conducted as part of the Fraser Valley Conservancy's Sumas Mountain Conservation Project; detailed base data (mainly species at risk occurrences and Sensitive Habitat Inventory Mapping (SHIM) made available by the City of Abbotsford, Fraser Valley Conservancy, Central Valley Naturalists, the BC Conservation Data Centre); and other sources such as personal observations, discussions with knowledgeable individuals and environmental assessments of specific land parcels.

[2] (McPhee, M., P. Ward, J. Kirkby, L. Wolfe, N. Page, K. Dunster, N.K. Dawe and I. Nykwist. 2000. Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands, 1993-1997. Volume 2: Conservation Manual. Technical Report Series No. 345, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia; Iverson, K. and C. Cadrin. 2003. Sensitive Ecosystems Inventory:Central Okanagan, 2000 – 2001. Volume 1: Methodology, Ecological Descriptions,Results and Conservation Tools. Technical Report Series No. 399,Canadian Wildlife Service, Pacific and Yukon Region, British Columbia).

Sensitive Ecosystem (SE) classes represent generalized groupings of ecosystems that share many characteristics, particularly ecological sensitivities, ecological processes, rarity and wildlife habitat values (Iverson and Cadrin 2003). Ecosystems are classed as sensitive in this report if they have one or more of the following attributes:

- are rare or of restricted distribution
- have high biodiversity
- have high values as habitat, especially for known or potentially occurring species at risk
- are sensitive to disturbance and human impacts

Several Sensitive Ecosystem classes for Sumas Mountain were adopted from previous SEI projects on Vancouver Island (McPhee et al. 2000) and the Central Okanagan (Iverson and Cadrin 2003). Section 5.4 provides detailed descriptions of the SE classes developed for this project. The purpose of the Sumas Mountain SEI is to provide baseline information that can be used in land use planning and decision making. Technical terminology has been kept to a minimum to make the report user-friendly for all anticipated users, including the general public, landholders, government, industry, developers, consultants and environmental non-governmental organizations.

Other Important Ecosystems (OIE) provide values such as habitat, wildlife corridors and ecosystem services but in most cases have been modified by human use and are not usually considered as environmentally significant or sensitive as designated SEs. Section 5 provides detailed descriptions of the OIE classes developed for this project.

3.0 MAPPING AND INVENTORY METHODOLOGY

SEI mapping was created in 1993 by the Canadian Wildlife Service and the BC Conservation Data Centre. It was created in *'response to a need for inventory of at-risk and ecologically fragile ecosystems, and critical wildlife habitat areas on the east side of Vancouver Island.'* Since then, numerous projects have been completed on the Sunshine Coast, Bowen Island, and throughout the Okanagan, from Osoyoos to Vernon (SEI Website date unknown). In 2006 a *Standard for Mapping Ecosystems At Risk in British Columbia* was created by the Resource Inventory Standards Committee to promote a standardized process province wide. (RISC 2006)

The main purpose of SEI mapping is to describe the ecological diversity of a given area, and determine the type and extent of vulnerable and rare elements (RISC 2006). The SEI standard (2006) describes an overview of the assessment process as follows:

> 'The SEI classification uses two primary groupings of ecosystems: ***Sensitive Ecosystems*** and ***Other Important Ecosystems***. Within each of these groups a series of classes and subclasses is defined that provides a general level of ecosystem description that is appropriate for public education and local planning exercises. Sensitive Ecosystem classes are generalised groupings of ecosystems that share many characteristics, particularly ecological sensitivities, ecosystem processes, at-risk status, and wildlife habitat values. Criteria for ecological sensitivity include: ***environmental specificity***, susceptibility to hydrological changes, soil erosion, especially on shallow soils, spread of invasive alien plants, and sensitivity to human disturbance. Other Important Ecosystems have significant ecological and biological values associated with them that can be identified and mapped, although they are not defined as Sensitive Ecosystems because they have been substantially altered by human use. Identification of Other Important Ecosystems is critical to capturing key elements of biodiversity of some project areas; they sometimes provide recruitment sites for ecosystems at-risk or important wildlife habitat requiring recovery or restoration.'

SEI mapping can be a standalone product, or, as was done for this study, it can be modeled from Terrestrial Ecosystem Mapping (TEM) or other mapping products. The resultant product is a set of maps that can be used as a flagging tool to a variety of users to assist with land use planning and management.

3.1 Study Limitations

This study has the following limitations:

1. Many polygons were not ground-truthed due to the project budget, difficult or unsafe access (steep slopes, cliffs, distance from roads, etc.), and private property access. Visual checks were performed on steep slopes from lowland areas with the use of binoculars where possible.

2. Many small ecosystem types (primarily small wetlands and fluvial ecosystems) are not included in the final mapping product due to a maximum of three ecosystem types per polygon and minimum polygons sizes.

3. Image quality in several areas resulted in poor terrain and ecosystem boundaries and interpretation.

While the resultant mapping and descriptions should be considered an accurate representation of Sumas Mountain, site specific assessments should be conducted on any areas considered for

development. Map and line work is considered accurate to 1:15 000; maps produced at larger scales may not provide an accurate representation of the classification.

3.2 Mapping Procedures

Bioterrain mapping was performed on stereo pairs of 1:15 000 colour 2006 air photos as per the *Standard for Terrain Mapping in British Columbia* (RIC 1996). Bioterrain polygons (which delineate surficial material, surficial expression and drainage) were then divided as necessary to delineate smaller ecosystem polygons. Bioterrain polygons were digitized as shapefiles in ArcMap 9.3 using a system whereby the typed images are scanned and then ortho-rectified in ENVI 4.5 (image processing software) using a Digital Elevation Model (DEM) and ground control points referenced from an existing orthophoto mosaic (2008 Abbotsford.ecw). Line work was then digitized from the ortho-rectified images using ArcMap 9.3 to create ecosystem polygons.

Ecosystem mapping was performed in accordance with the protocol for *Terrestrial Ecosystem Mapping* (RISC 1998). Ecosystem mapping was completed using a softcopy digitizing system (PurVIEW, Samsung 3D LCD and Nvidia 3D wireless stereovision system).

Both terrain and ecosystem mapping followed conventional methods for assigning classification codes to mapped polygons. To the greatest extent possible compound ecosystem typing was avoided. Ecosystem polygons were then overlain on 2009 digital orthomosaic photos and adjusted as necessary to reflect recent disturbances and land use changes. The resultant TEMapping was then converted to SEI attributes as per section 4.4.

Base data were primarily provided by the City of Abbotsford, Fraser Valley Regional District, Fraser Valley Conservancy, and via publically available downloads from the provincial government. Base data included:

- High resolution colour orthomosaic photos from 2004 to 2009 (COA and FVRD)
- Cadastral maps (COA and FVRD)
- Multiple hydrology layers (TRIM, COA, FVRD, COA SHIM)
- Species and ecosystems at risk occurrences (COA, FVC, CDC, CVN, personal accounts)
- Contours and DEM (TRIM and COA)
- VRI and forest cover mapping (GeoBC)

3.3 Ground-truthing and Data Collection

Ground truthing and data collection were performed over 20 days in October 2009, May to July, 2010 (Figure 4). Table 1 provides a summary of the type and number of sample plots established and the BEC subzones that were sampled. Figure 4 and Table 1 include sample plots from outside of the COA study area (sampled for the FVC SEI project for all of Sumas Mountain) as they were used in the development of SE classes and subclasses, as well as confirming polygon boundaries and accuracy. Within the COA, the TEM mapping was completed to survey intensity three as per RISC methodology (RISC 1998).

Sampling was completed with a combination of standard Full, Ground Inspection Forms (GIF) and visual plots. SEI conservation evaluation forms were completed for all Full and GIF plots, with the exception of the preliminary plots completed in October, 2009. Soil pits were dug for all GIF plots, but detailed soils information was not recorded as it was outside the scope of the project. A modified process was used for the GIF plots which included the completion of WHA forms for target SAR, resulting in data collection similar to standard full plots.

Digital photographs were taken of most plots, and unknown vascular plant specimens were collected when necessary. All plots and polygon boundary ground-truthing were completed with aid of a Trimble Nomad datalogger with a Pathfinder Pro XR receiver capable of submetre accuracy. ESRI's ArcPad and Trimble's TerraSync Pro were utilized to provide mobile GIS in the field.

Table 1. Summary of Sample Plots.

Description	Number of Plots (COA)			Number of Plots (FVC)			Total
BEC Subzone	*Full*	*GIF*	*Visual*	*Full*	*GIF*	*Visual*	
CWHdm	2	26	183	2	17	73	303
CWHvm2					8	6	14
CWHxm1	3	11	95	1	1	5	114
Total	**5**	**37**	**278**	**3**	**26**	**84**	**431**

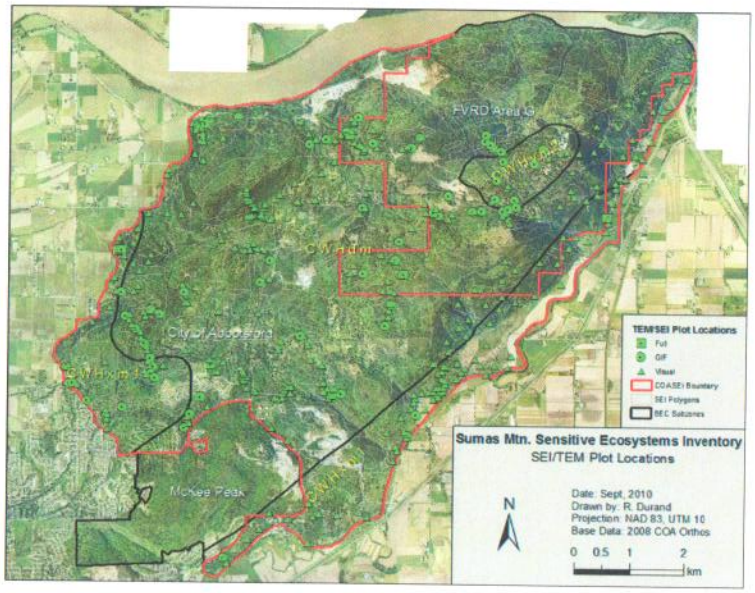


Figure 4. TEM/SEI Plot Locations.

3.4 Determination of Sensitive Ecosystems

SEI classes for Sumas Mountain were primarily adapted from a SEI project currently under development by Metro Vancouver Parks (2010) in order to make the Sumas Mountain SEI consistent with other regional and provincial projects. Minimal modifications to the Metro Van Parks classes and subclasses were made for the Sumas Mountain SEI project. The Metro Vancouver Parks SE descriptions were discussed with and reviewed by provincial Ministry of Environment staff (Carmen Cadrin and Jo-Anne Stacey) and Canadian Wildlife Service (Jan Kirkby).

3.4.1 *Sensitive Ecosystem Classes*

The following SEI classes and subclasses have been used to describe sensitive ecosystems on Sumas Mountain (Table 2).

Table 2. Sensitive Ecosystem Classes

SEI Class	SEI Subclass	Brief Description
OF: Old Forest		Forests > 250 yrs
OF	co: coniferous	Conifer > 75% of stand
OF	mx: mixed	Stand composition > 25% conifer and > 25% broadleaf
MF: Mature Forest		Forests > 80 yrs, < 250 yrs, > 5 ha
MF	co: coniferous	Conifer-dominated (> 75% of stand composition)
MF	mx: mixed	Stand composition > 25% conifer and > 25% broadleaf
WD: Woodland		Dry site, open stands with between 10 and 25% tree cover
WD	co: coniferous	Conifer > 75% of stand
WD	mx: mixed	Conifer > 25% and broadleaf > 25% of composition
RI: Riparian		Ecosystems associated with and influenced by freshwater
RI	fh: high bench	High bench floodplain terraces
RI	fm: medium bench	Medium bench floodplain terraces
RI	fl: low bench	Low bench floodplain terraces
WN: Wetland		Terrestrial – freshwater transitional areas.
WN	ms: marsh	Graminoid or forb-dominated nutrient-rich wetlands
WN	sp: swamp	Shrub or tree-dominated wetlands
WN	sw: shallow water	Permanently flooded, water less than 2m deep at mid-summer.
SV: Sparsely Vegetated		Areas with 5 – 10% vascular vegetation.
SV	cl: cliff	Steep slopes, often with exposed bedrock.
SV	ro: rock outcrop	Rock outcrops – areas of bedrock exposure.
SV	ta: talus	Dominated by rubbly blocks of rock.
FW: Lakes and Ponds (Freshwater)		
FW	pd: pond	Open water > 2 m deep and generally < 50 ha.

3.4.2 *Other Important Ecosystems*

Other Important Ecosystems (OIE) are mapped to identify important elements of biodiversity or recruitment sites for ecosystems at-risk or important wildlife habitat requiring recovery or restoration (Table 3).

Table 3. Other Important Ecosystems

Other important Ecosystem Class	OEI Subclass	Brief Description
MF: Mature Forest		Small patches of forest – stands > 80 yrs, < 250 yrs
MF	bd: broadleaf	Broad-leaf dominated (> 75% of stand composition), any size
YF: Young Forest		Large patches of forest – stands > 30 yrs, < 80 yrs
YF	co: coniferous	Conifer-dominated (> 75% of stand composition)
YF	mx: mixed	Stand composition > 25% conifer and > 25% broadleaf
YF	bd: broadleaf	Broad-leaf dominated (> 75% of stand composition)

3.4.3 *Not Sensitive Ecosystems*

Mapped areas that do not fall in the SE and OIE classes (primarily those with recent or permanent disturbances) are classified as Not Sensitive Ecosystems (NS).

3.6 Wildlife Habitat Rating

Wildlife Habitat Assessments (WHA) were performed for 12 species at risk (Table 4) known to occur on Sumas Mountain. Life pre-requisites for all target species were assessed using a standardized scale of 1 to 6 with 1 equivalent to the best habitat in the province, and 6 indicating no habitat values (Min. of Env. & Min. of For. 1998). WHA data was collected from all TEM full and GIF plots, and the majority of visual plots (Figure 4). The above species were selected as many are relatively common in the study area and a significant amount of occurrence data already exists. For all species, field surveys were concentrated in areas where limited data exists. When possible, existing RISC protocols were utilized. Incidental surveys were also conducted in all TEM plots and in general when accessing plot locations.

Utilizing plot data and literature reviews, Habitat Suitability (HS) mapping was completed for the study area. A four-class suitability[3] scheme was chosen for all species due to limited knowledge on several of the species life pre-requisites. As per the *British Columbia Wildlife Habitat Rating Standards* (RISC 1999) the four-class rating scheme uses High (H), Moderate (M), Low (L) and Nil (N) ratings for defined seasons and habitat uses. It is appropriate for larger map scales for species where there is not a detailed knowledge level of species' habitat requirements. For the purposes of this study, specific seasons for species use was not assessed, rather an overall rating was given for each species for each SEI sub-class and/or SHIM attribute. The rating included breeding and growing requirements for amphibians that utilize specific habitat during different seasons.

Table 4. Target Species at Risk.

[3] Suitability is defined as the ability of the habitat in its current condition to provide the life requisites of a species (RISC 1999).

Species	Provincial Status	COSEWIC
Amphibians		
Coastal Giant Salamander	Red	T (2000)
Coastal Tailed Frog	Blue	SC (2000)
Red-legged Frog	Blue	SC (2004)
Western Toad	Yellow	SC (2002)
Birds		
Great Blue Heron	Blue	SC (2008)
Western Screech Owl	Blue	SC (2002)
Invertebrates		
Oregon Forestsnail	Red	E (2002)
Pacific Sideband	Blue	-
Mammals		
Mountain Beaver	Red	SC (1999)
Pacific Water Shrew	Red	E (2006)
Snowshoe Hare	Red	-
Townsends Big-eared Bat	Blue	-

The following section provides a summary of the 12 target species and the assessment methods chosen to develop the HS mapping.

3.6.1 AMPHIBIANS

Amphibians were assessed for both breeding and rearing requirements using a combination of SHIM data and TEM/SEI mapping. As SHIM data does not cover the entire study area, several gaps in the analysis remain unknown.

Coastal Giant Salamander (Dicamptodon tenebrosus)

The Coastal Giant Salamander is a large member if the *Dicamptodontidae* family, reaching an adult length of 30 centimeters. It can be both aquatic and terrestrial; those that do not leave the aquatic environment tend to be smaller in size, reaching only 9 to 17 centimeters in length. Larvae at hatching reach an average length of 5 centimeters and turn terrestrial at 9 to 16 centimeters (Johnston 2004). Terrestrial adults are dark skinned with a light underbelly and marbled gold or tan markings along the back. The head is large with a blunt snout and short legs. Aquatic adults are grey or dark brown and do not exhibit marbling (Pacific Giant Salamander Recovery Team 2010). The species is relatively long lived with an average life expectancy of 25 years. Breeding occurs only once every two years with females laying up to 200 eggs in water filled chambers under rocks, logs or other covered objects in stream. Survivorship of young into adults is only 1 to 4% based on predation and desiccation (Johnston 2004).

Terrestrial adults require forested riparian habitats with abundant shelter. The species is known to prefer moist forests dominated by Douglas fir, western hemlock and western red cedar and also

associated with Devil's club and salmonberry. Aquatic (neotenic) adults require permanent, relatively deep pools of water with some habitat complexity, such as angular rocks and sand. Critical habitat includes headwater streams and adjacent moist forest, narrow, shaded mid-gradient streams with coarse rocky substrates and abundant pocket pools for mating and reproduction (Pacific Giant Salamander Recovery Team 2010).

The species is red-listed (considered to be endangered or threatened of extinction or extirpation) in British Columbia and considered threatened nationally. Only one percent of the species range is within Canada, and in British Columbia it is restricted to the Chilliwack River Valley and nearby watersheds; with no known occurrences known north of the Fraser River. It has been found in up to 75 streams and tributaries in the lower Fraser Valley. The salamander is considered vulnerable due to its limited dispersal ability in both aquatic and terrestrial adults, a complex life history, and low reproductive potential. Due to its need for all preferred habitat types to be met in a restricted dispersal range throughout its lifecycle, the species is sensitive to urban and rural development, timber harvesting, predation from fish stocked water bodies, micro-hydro projects, and potential habitat contaminants (Johnston 2004).

HS mapping (Figure 38) was completed using the following criteria (based on Johnson 2004 and Ovaska et. al. 2004):

- **High:** all watercourses with permanent flow, <5m width, intermediate gradients, and steep-pool or riffle-pool morphology are considered to be high potential habitat. A 60m buffer on these stream segments (where SHIM data were available) was created to define high breeding habitat suitability.

- **Moderate:** all SEI polygons adjacent to high breeding habitat that contain mature and old forests were considered to contain good growing terrestrial habitat potential.

- **Low:** SEI polygons with younger vegetation classes were ranked as low suitability.

Coastal Tailed Frog *(Ascaphus truei)*

The Coastal Tailed Frog (*Ascaphus truei*) is one of only two species of frog found in British Columbia belonging to the *Ascaphidae* family, and the only known frog species to breed in fast flowing mountain streams. The frog is characterized by a large head with vertical pupils, flattened outer toes, and a lack of ear membranes (tympana). Adults have grainy skin ranging from tan, brown or olive green. The skin may also be marked with speckles or a copper bar between the eyes and snout (Mallory 2004). Male frogs

have a short conical tail used for breeding. The species is long lived with an average life expectancy of 15 to 20 years. Tadpoles have a flattened body, laterally compressed tail and are black or light brownish grey with a flattened oral dish that acts as a suction to cling to rocks in swift currents. Tadpoles generally reach metamorphous at 65 millimeters in length, which can take up to four years from hatching.

Adult frogs forage primarily at night along creeks and feed on a variety of insects and invertebrates. Unlike most frog species, the Coastal Tailed Frog lacks a tongue attachment allowing it to flick its tongue to catch prey. Tadpoles feed on diatoms scraped from submerged rocks, pollen and algae (Mallory 2004). Due to its unique habitat requirements, the Coastal Tailed Frog requires streams with a step pool morphology or riffles, clear water, riparian vegetation and coarse woody debris for forage and cover.

The Coastal Tailed Frog is blue-listed (considered to be of special concern and sensitive to human activities or natural events) in British Columbia and considered to be of special concern nationally. Vulnerability is due to its specialized habitat requirements, limited dispersal capabilities, low reproductive rates and low tolerance to changes in temperature in occupied streams. Threats include logging, erosion, natural disturbances such as wind throw, snow and debris avalanches, and wildfire (Michelfder et. al. 2008).

HS mapping (Figure 39) was completed using the following criteria:

- **High:** all watercourses with permanent flow, <5m width, intermediate gradients, coarse substrates, high total cover, and steep-pool or riffle-pool morphology that flow through SEI polygons with structural stages 6 and 7 (mature and old) are considered to be high potential habitat. A 100m buffer on these stream segments (where SHIM data were available) was created to define high breeding suitability. (Johnson 2004, Ovaska et. al. 2004, pers. comm. E. Wind 2010, Horn et. al. 2009)

- **Moderate:** all watercourses with similar characteristics as the high rating that occur in younger SEI forest types. 100m buffers were also placed on these stream segments.

- **Low:** while the HS mapping identifies potential habitat, connections between suitable streams are also important. Within-basin dispersal between individual streams and stream networks is considered critical to maintaining populations. Connections can include ephemeral streams and seepages that are not normally considered good habitat. As well, forest type is an important consideration as thermal cover must be maintained. Potential important connections were

included in the low suitability rating using SEI polygons that occurred within 100m of high ranked buffers. (Horn et. al. 2009)

Red-legged Frog (Rana aurora)

The Red-legged Frog is one of six species of 'true' or ranid frogs native to western North America. It is a medium sized frog reaching a length of 7 to 10 centimeters, with brown or reddish smooth skin marked with black freckling and long slender hind legs. The face has a dark mask and lighter upper jaw stripe running to its back shoulders and a distinctive red underside to the hind legs (BC Min. of Env. 2010). Tadpoles are tan or greenish brown, with the body, tail and fins typically covered in gold colored flecking. Tadpoles are distinguished by a stubby appearance and reach metamorphous at four to five months. Breeding occurs in the early spring and females lay eggs loosely attached to the underside of aquatic vegetation. Egg clusters of 750 to 1,300 eggs are laid at a time (COSEWIC 2004).

The Northern Red-legged Frog extends from south western British Columbia to north western California, Vancouver Island, the Gulf Islands and the adjacent mainland. The species prefers moist low elevation forests and requires both aquatic breeding habitat and terrestrial foraging habitat. The frog typically breeds in ponds, ditches, springs, marshes, the margins of large lakes and other slow moving water bodies where emergent vegetation is abundant. When on land, adults tend to use areas that are well sheltered, cool and damp along the edges of riparian areas (COSEWIC 2004).

The species is blue listed in British Columbia and considered vulnerable nationally. Threats include habitat modification, the draining of wetlands, loss of riparian vegetation, pollution and predation by non-native sport fish and bull frogs. The frog is most vulnerable at the tadpole stage where predation is more common and vulnerability to pollutants and epidemic disease is more likely (COSEWIC 2004).

Red-legged frogs are abundant on Sumas Mountain, having been observed in 154 locations. They are difficult to assess in terms of potential habitat as they are known to utilize a wide variety of terrestrial habitats, wetlands, ponds and streams, and their dispersal ability between suitable habitat is unknown (Maxcy 2004).

The following methods were used to assess Red-Legged Frogs (Figure 40):

- **High:** 50m buffers around all occurrences and all watercourses, wetlands and ponds within 150m of each occurrence.

- **Moderate:** 50m buffer on all watercourses, wetlands and ponds (existing occurrences were found in a wide variety of aquatic and riparian habitat, so all watercourse are considered potential habitat for this species).

- **Low:** all SEI polygons within 100m of Red-Legged Frog buffer locations. These areas are identified as potential terrestrial growing habitat. While Red-Legged Frogs have a strong affinity to mature and old growth forests, local knowledge of the study area and the mapped occurrences indicates they are found in a wide variety of vegetation types and structural stages.

Western Toad (Bufo boreas)

The Western Toad is one of few amphibians that inhabit alpine areas. It is characterized by dry bumpy olive green, reddish brown or black skin, oval shaped poratoid glands, horizontal pupils, and a cream colored stripe. The poratoid glands and upper legs give off a mild white poison when threatened by predation. Males are generally 6 to 11 centimeters in length and females up to 12 centimeters in length. Females lay 5,000 to 16,500 eggs per breeding season, where the black tadpoles will aggregate along shorelines when hatched. The toads hibernate for 4 to 6 months each year in animal burrows or under debris where they can be in contact with moisture. Life expectancy of the Western Toad is 9 to 11 years (COSEWIC 2002).

The Western Toad ranges from the southern Yukon, throughout British Columbia, and western Alberta. The toad breeds in a variety of natural and artificial aquatic habitats with or without tree or vegetative cover, coarse woody debris or emergent vegetation. Males return to breeding sites annually and females once every two to three years. Terrestrial habitat includes wet shrub-land, forest, avalanche chutes, and sub-alpine meadows. Adults eat a variety of invertebrates and tadpoles feed on algae and organic detritus (COSEWIC 2002).

Western Toads are considered secure in Canada, but are considered rare, threatened or uncommon within its range in the United States. It is the only IUCN red listed amphibian in Canada because of population declines over 50% in the past ten years. It is vulnerable to mass reproductive failure in areas of isolated populations, non-native fish stocking, disease and stochastic events (COSEWIC 2002).

The only known occurrences of Western Toad in the vicinity of the study area are from McKee Peak (Knopp 2008). As it was not feasible to assess all potential breeding sites due to private property access and survey timing, night searches along many of the roads on Sumas Mountain were completed. Over 20 hours of searches occurred during nights with suitable weather and during known migration times. This technique has proven successful in other areas of the Fraser Valley. No Western Toads were located during the night surveys, or day time assessments. It is also worth while noting that the COA SHIM project mapped several hundred kilometers of watercourses and hundreds of wetlands within the study area over a three year period. While 154 occurrences of Red-Legged Frog, as well as other amphibians such as Green Frogs, Tree Frogs, American Bullfrog, along with a variety of salamanders, were recorded, no confirmed or potential Western Toads were observed. For these reasons, no HS mapping was created

for this species and the potential for it to occur within the study area in general is considered to be low. As well, if the species does occur, its habitat would be expected to largely overlap that of the other amphibians described in this report.

3.6.2 Birds

Great Blue Heron (Ardea herodias)

The Great Blue Heron is the largest wading bird in North America, measuring approximately 60 centimeters in height and between 97 to 137 centimeters in length. It is characterized by a long slender neck, blue grey plumage with a white crown, and a distinctively slow, deep wing movement in flight (Vennesland 2004). Life expectancy of herons is generally 17 years. Herons nest in colonies, where both males and females share responsibility for incubating eggs and feeding young. Colonies are usually located close to foraging habitat and in areas inaccessible to humans and predators. Breeding takes place in April, with three to five eggs being laid for an incubation period of 28 days. Young are grey in color with brown flecking (Can. Wildlife Service & Can. Wildlife Fed. 2003).

Great Blue Herons breed from southern Canada south to Central America and the Galapagos and winter along the Pacific coast as far south as South America. In British Columbia they are found in the southern interior and throughout the Strait of Georgia. Breeding occurs in late winter or early spring between February and April with a typical clutch size of three to five young. Pairs may breed more than once if the first attempt fails. Colonies are typically used for many years, but may relocate if disturbed. Colonies occur in areas of contiguous forest, fragmented forest and individual trees. Herons stalk prey by standing in shallow water, preying on amphibians, reptiles, invertebrates and less commonly, birds. In winter they may forage for rodents in upland areas or fields (Vennesland 2004).

The Great Blue Heron is blue listed in British Columbia with populations observed to be stable to declining and suitable habitat declining. Foraging habitat, such as shallow water bodies and inland fields are considered to be more important than nesting habitat. Bald eagle predation and human disturbance in considered to lower reproductive productivity, while other threats include food supply limitations, contamination and inclement weather (Vennesland 2004).

Great Blue Herons are relatively common on the low elevations of the study area, mainly along the Sumas Canal and the Fraser River. They are one of the easier species to determine potential habitat due to their affinity to riparian areas and old fields. For the purposes of this study, the habitat assessments focused on medium and high bench floodplain forests and a variety of wetlands types (Figure 41). No rookeries are known or suspected to occur in the study area.

Western Screech Owl (Otus kennicottii)

The Western Screech Owl is a small grey and brown owl with streaked plumage and distinctive ear tufts. The length of adults varies between 19 to 25 centimeters, with an average weight of 120 to 305 grams. Females tend to be larger than males. It is non-migratory and nests in the natural cavities of trees, generally in holes made by woodpeckers or in nest boxes. Owls breed at one year of age, laying three to four eggs in late March to May. Owlets hatch by late summer (COSEWIC 2002).

The Western Screech Owl ranges from British Columbia south to Mexico. The *kennecotti* sub-species of Western Screech Owl are found along the British Columbia coast, including Vancouver Island and excluding the Queen Charlotte's. The interior sub-species are found in the southern interior concentrated in the Okanogan Valley. The species prefers low elevation mixed forests, dominated by Douglas fir, arbutus, western red cedar, grand fir and red alder. Roosting sites are often found in riparian habitat adjacent to open wetlands or fields for foraging. Prey is varied and includes small mammals, fish, birds, insects and other invertebrate (COSEWIC 2002).

The Western Screech Owl is blue listed in British Columbia and considered to be of Special Concern nationally. The Vancouver Island population appears to be stable, while elsewhere in its range it is declining. Declines in the mainland portion of its range seem to correlate with an increase in numbers of Barred Owl, a predator of the Western Screech Owl. It is also vulnerable to predation from Great Horned Owls, Spotted Owls and Raccoons. Loss of habitat and collisions with motor vehicles are also cited as potential threats (COSEWIC 2002).

Due to limited specific data to correlate its habitat preference with a species SE classification, and limited occurrence data (2 mapped locations), HS mapping could not be completed for this species.

3.6.3 *Invertebrates*

Oregon Forestsnail (Allogona townsendiana)

The Oregon Forestsnail is a member of the *Polygyride* family of land snails. Adult shells reach between 28 and 35 millimeters in diameter and are of a pale brown or straw yellow color. The apertural lip of the shell is pale and broadly expanded, lacking the parietal denticle (tooth like structure), while the rest of the shell is globular. The snail is a hermaphrodite, slow maturing, and long lived. It is most active in spring, laying multiple eggs in soft depressions within moist soil. Average life expectancy is thought to be 11 years (COSEWIC 2002).

The Oregon Forestsnail is restricted to a very small area of the southwestern British Columbia mainland and southern Vancouver Island. Within the mainland, populations are concentrated in and around the lower Fraser Valley from Langley to the Chilliwack River Valley. It appears to prefer mixed forests dominated by bigleaf maple with a dense understory of herbaceous vegetation, though it tolerates

disturbed sites. It likely requires coarse woody debris, large amounts of leaf litter and both living and decaying vegetation (COSEWIC 2002).

The Oregon Forestsnail is red listed in British Columbia and is considered endangered (considered to be facing imminent extirpation or extinction) nationally. Populations of the snail are fragmented and dispersal abilities limited due to highly modified habitats caused by rapid urban development within the species range. It is prey to a variety of mammals, birds, amphibians, reptiles, and invertebrates. It is also vulnerable to competition and predation by non-native snails (COSEWIC 2002).

A significant amount of data occurs on the distribution of Oregon Forestsnail on Sumas Mountain. In fact, there are likely more known occurrences (624 locations) of this species in the study area than anywhere else in its known BC range. It is strongly associated with young to mature Big-leaf maple / stinging nettle communities at low elevations. Due to its ability to persist in small, remnant patches of forest and disturbed area, the HS mapping likely under-estimates the full potential habitat of this species. As the HS mapping of the Oregon Forestsnail and the Pacific Sideband indicated a preference for very similar habitat, they are depicted together on a single Mollusc HS map (Figure 42).

Pacific Sideband (Monadenia fidelis)

The Pacific Sideband is a member of the *Bradybaeridae* family and is characterized by a large depressed umbilicus which makes it unique in Canada. The shell is generally 22 to 36 millimeters in diameter and moderately thick and opaque. The shell is chestnut brown or yellow with a narrow pale yellow band just below the periphery of the shell and a wider dark brown band above and at the base. The apertural lip of the shell is pale brown or purplish brown. Straw yellow shells with pale banding also occur. The body of the snail is rosy brown with a bold rust colored band and a pale grey sole. Average life expectancy is thought to be 8 years (Forsyth, 2010).

The Pacific Sideband ranges from British Columbia to northwestern California. Within British Columbia is it found from the Georgia Strait to the Broughton Archipelago and the Coastal and Cascade Mountains. The snail is found within deciduous, mixed and conifer dominated forest types, but can also be found in open areas and grassy meadows. It is assumed to feed on fungi and plants.

The species is blue listed in British Columbia, with major areas of concern being habitat loss and fragmentation from urban and agricultural development (Forsyth, 2010).

Pacific Sidebands are common on Sumas Mountain (182 occurrences) and occur in a wide variety of habitats. As with the Oregon Forestsnail, they have an affinity for moist areas with substantial leaf litter. Figure 42 presents their habitat suitability based on local knowledge of habitat requirements (Durand &

Brown 2008) and correlated to actual occurrences. Although this mapping appears to be well correlated to actual occurrences, limited habitat knowledge of this species has resulted in an unknown confidence level of the HS beyond the study area.

3.6.4 MAMMALS

Mountain Beaver (Aplodontia rufa)

The Mountain Beaver is a primitive rodent with a reddish, brown, or blackish coat and a light patch under each ear. It weighs between 18 to 32 ounces and is 30 to 50 centimeters in length. It has a distinctively short tail, slightly opposable thumbs, and an unusual projection on each molar which points toward the cheeks on the upper tooth row and toward the tongue on the lower. The cheek teeth lack the complex folds found in most other rodents. Mountain beaver are temperature sensitive and cannot thermo-regulate and have a high need for water (Griffth 2010).

Mountain Beavers range from the Cascade Range in British Columbia to as far south as eastern California. They are found in both conifer and deciduous dominated forests and in clearings at lower elevations and characterized by wet soils. They require high levels of vegetation and high humidity due to their lack of ability to thermo-regulate. Breeding occurs between January and March with an average of two to three young being born in the early spring. Mountain beavers have an average life expectancy of five to ten years. The species is an herbivore, eating below ground in elaborate burrow systems. They are primarily nocturnal, with most activity restricted to within a twenty-five meter radius of their burrows. They do not hibernate.

There are two sub-species of Mountain Beaver. '*Rufa rainieri*' found east of Hope, is blue listed within British Columbia due to a small population size. '*Rufa rufa*' is found south of the Fraser River from Hope to Aldergrove and is red listed provincially due to loss of habitat and urban development. Critical habitat includes areas associated with high rainfall and conditions that promote the development of succulent vegetation. Predators include bobcats, coyotes, cougars, golden eagles and owls. Mountain Beaver is also host to a large parasitic flea (Griffth 2010).

SHIM data and SEI mapping were used to create the below HS map for Mountain Beaver (Figure 43). The HS assessment was based on the following criteria:

- **High**: All wetlands, streams and SE polygons that contain known occurrences, or are located within 30m of a known occurrence.

- **Moderate**: SEI polygons with a swamp wetland (WN:sp) component.

- **Low:** All other SEI polygons with mapped watercourses (excluded FVRD portion of Sumas Mountain).

Due to the large SEI polygons relative to Mountain Beaver habitat, the HS mapping indicates many areas with high residential and/or agricultural development. While large portion of these areas are not suitable habitat, local experience indicates that Mountain Beaver is often found in close proximity to developed areas in remnant forested patches along streams and wetlands. The map is also skewed towards the western portion of the study area due to a greater number of mapped occurrences, and detailed SHIM mapping. Additional field surveys in the east would likely discover many new Mountain Beaver colonies.

Pacific Watershrew (Sorex bendirii)

The Pacific Watershrew is a large member of the shrew family, measuring a total length of 15 centimeters. Its coat ranges from a dark brown to black with a dark brown underside and it has prominent whiskers and short ears. It has large hind feet and short legs, with a stiff fringe of hairs up to one millimeter in length and five clawed toes. It is a semi-aquatic species and is capable of swimming and diving underwater for short lengths of time and running on top of water for short durations (Blood 1995).

The Pacific Watershrew can be found from northern California throughout western Oregon, Washington and southwestern British Columbia. In British Columbia it is restricted to the lower Fraser Valley from the Chilliwack River Valley to Harrison Lake. It is associated with stream or marsh habitat and closely associated with skunk cabbage, red alder and western red cedar. It is more abundant in older to mature forest stands with abundant coarse woody debris and leaf litter. It is insectivorous and forages on larvae, slugs, snails, mayfly, naiads and earthworms. Females produce two to three litters of five to seven young between February and August of each year. The average life expectancy of the shrew is 18 months (COSEWIC 2006).

The Pacific Watershrew is red listed in British Columbia and is considered endangered nationally. In Canada it is found at the northernmost extent of its range and may have always been an uncommon species. It is both rare and restricted to riparian and wetland habitats, which has made it vulnerable to habitat loss and modification. Habitat fragmentation has limited its dispersal abilities. Predators include owls, domestic cats, fish and Pacific Giant Salamanders (COSEWIC 2006).

Habitat modeling with SHIM data was completed by Dr. Vanessa Craig for Raincoast Applied Ecology (pers. comm. P. Lilley 2010) for most of the study area. Due to the complexity of the modeling, it was not expanded upon for the portion not completed by Dr. Craig (the former FVRD Area H). Habitat modeling was completed for the entire study area using the 2010 TEM and methodology created by Dr. Craig (2007) (Figure 44). At the time of this study, the critical Pacific Watershrew habitat had not been

provided by the provincial recovery team, however SAR buffers created by Raincoast Applied Ecology that included the critical habitat was included in the SAR occurrence buffers.

Pygmy Snowshoe Hare (Lepus americanus washingtonii)

The Pygmy Snowshoe Hare is a smaller than average sized hare with long ears and large feet. It is chestnut colored throughout the year, with black tipped ears and pale creamy white toes. It does not change color in the winter similarly to the Snowshoe Hare found elsewhere (Zevit 2010).

Very little is known about the breeding and foraging habits of Pygmy Snowshoe Hare, but it is thought to have similarities with other Snowshoe Hares in that it likely has two to four young per litter and up to four litters per year. Young are born with their eyes open and fully furred, leading to early self sufficiency. The species is mainly active at night, foraging for orchard grass, Kentucky blue grass, fescues and salmonberry. It prefers a dense understory with abundant cover for thermal regulation and security in conifer and mixed forest types.

The Pygmy Snowshoe Hare is red listed in British Columbia and is restricted to lower elevation areas throughout the Fraser Valley. Some populations may be extirpated, with the only known breeding population identified at Burnaby Lake Regional Park. Other populations may occur in areas from Burnaby to Mission and south of the Fraser River as far east as the Chilliwack River Valley. Outside of British Columbia it ranges throughout the Puget Sound lowlands and western Oregon (Zevit 2010).

Due to limited information on the habitat requirements of this species (in terms of linking it specifically to a SEI classification), and the lack of local occurrence data (one occurrence), HS mapping was not completed.

Townsend's Big-eared Bat (Corynorhinus (Plecotus) townsendii)

The Townsend's Big-eared Bat is characterized by enormous ears that measure half their body length and two fleshy protrusions on its muzzle, called paratiinal glands). The ears are used both in regulating body temperature and may assist in flight. The fur on the bat varies from pale brown to blackish grey, with the underbelly generally being paler than the rest of the body. It is a medium sized bat with an average length of 10 centimeters and wingspan of 30 centimeters (Blood 1995).

In summer, the bat forms maternal colonies ranging from several bats to several hundred bats in buildings, caves or mine sites. Only small colonies have been found in British Columbia. Mating occurs in autumn and early winter before hibernation, where the female then stores the sperm needed for fertilization until spring. This is referred to as delayed fertilization. Only one young per female is produced per year. Female bats are known to return to maternal colonies each year, while males may

roost singly or in scattered locations. Natural mortality of young is high and half of the young do not survive the first year of life. The average age of Townsend's Big-eared Bat is 16 years.

Townsend's Big-eared Bat is broadly distributed along the west coast from British Columbia to Mexico. In British Columbia it is found from Vancouver Island, east to Cranbrook and as far north as William's Lake. It prefers areas that are relatively warm in summer and not extremely cold in winter. It is sparsely distributed across its range due to its distinctive habitat needs. Habitat includes insect rich riparian areas, wetlands, forest edges and open woodland. Maternal colonies tend to be located in areas that are rich for foraging. It is primarily a cave dweller, but may in habit buildings and large trees (Blood 1995).

The Townsend's Big-eared Bat is considered to be at risk in British Columbia due to isolated areas of suitable habitat and sensitivity to disturbance and temperature changes. Disturbance of maternal colonies can significantly lower breeding success and repeated disturbance may lead to abandonment of maternal sites. Insecticide used in forestry and agricultural practices can also negatively influence populations by destroying the food supply (Blood 1995).

Bat monitoring was completed in suitable and random locations throughout the study area. Monitoring was completed using a radar acoustic system in two locations and mobile acoustic sampling in all accessible potential habitats (occurrence of cliffs or rock outcrops and water).

HS mapping (Figure 45) was based on the following criteria:

- **High:** SEI polygons containing cliffs (SV:cl) and rock outcrops (SV:ro). Also adjacent wetlands or wet areas.
- **Moderate:** SEI polygons within 100m of areas in which bats were detected and all other SEI polygons containing cliffs.
- **Low:** forested SEI polygons adjacent to standing water and wetlands.

4.0 MAPPING AND INVENTORY RESULTS

The following sections present the results of the mapping and inventory on Sumas Mountain. Bioterrain Mapping and Terrestrial Ecosystem Mapping (both fundamental components Sensitive Ecosystem Mapping) are presented and discussed first, followed by descriptions of the SE classes and subclasses, and finally wildlife habitat suitability mapping.

4.1 BIOTERRAIN MAPPING

A total of 228 bioterrain polygons were delineated in the study area (Figure 10). Table 5 and Figure 5 break down the results of the bioterrain mapping.

Table 5. Summary of Mapped Surficial Material.

Surficial Material	Hectares	Percent
Anthropogenic	1075.0	27.6%
Bedrock	177.8	4.6%
Colluvium	352.3	9.0%
Colluvium & Anthropogenic	22.9	0.6%
Colluvium & Bedrock	138.1	3.5%
Colluvium & Till	147.9	3.8%
Fluvial	95.5	2.4%
Fluvial & Organic	21.1	0.5%
Fluvial & Till	39.5	1.0%
Organic	57.2	1.5%
Till	1358.6	34.8%
Till & Anthropogenic	35.8	0.9%
Till & Bedrock	307.5	7.9%
Till & Colluvium	54.0	1.4%
Wetland	16.9	0.4%
Total	3900.2	100.0%

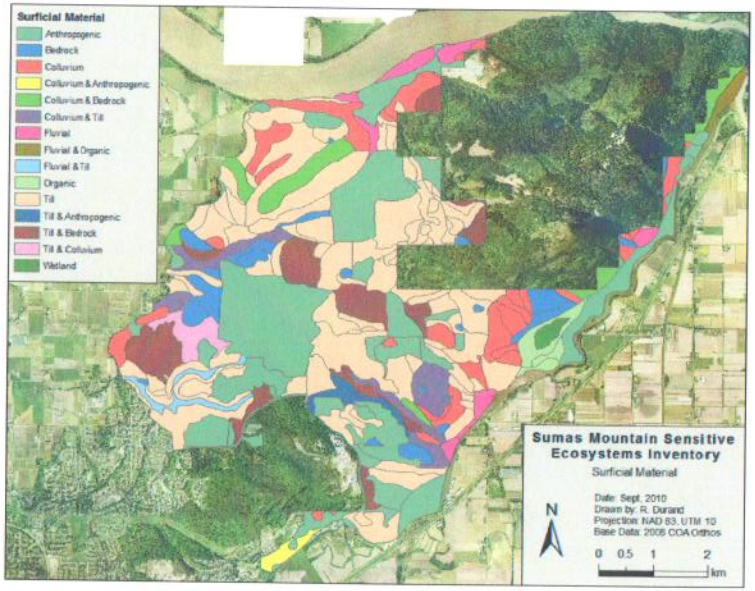


Figure 5. Bioterrain Mapping (Surficial Material).

The following description and photographs of the terrain of Sumas Mountain were provided by Daniel McAllister for this project.

The terrain of Sumas Mountain is dominated by three types: Veneers over bedrock, bedrock exposures, and morainal deposits. Almost 70% of the mapped terrain polygons contained at least 10% rock component. About 25% of these polygons contained exposed bedrock. The rest of them were comprised of thin veneers (less than 1m in depth) over bedrock. These veneers were usually thin, fine to coarse textured tills, but were also found to be made up of weathered bedrock over intact bedrock. These thin soils contribute to the rapid runoff that characterizes the hydrology of Sumas Mountain, as they have very limited ability to store water. The thin soils are found throughout Sumas Mountain, but are especially prevalent at the higher elevations. Here, the terrain is characterized by 10 to 15 cm of weakly developed soil veneer over bedrock, with exposures of bedrock being common. Bedrock exposures are also found on the lower slopes. These lower elevational exposures are often comprised of sedimentary rocks.

Figure 6. Thin soil veneers and bedrock exposures.

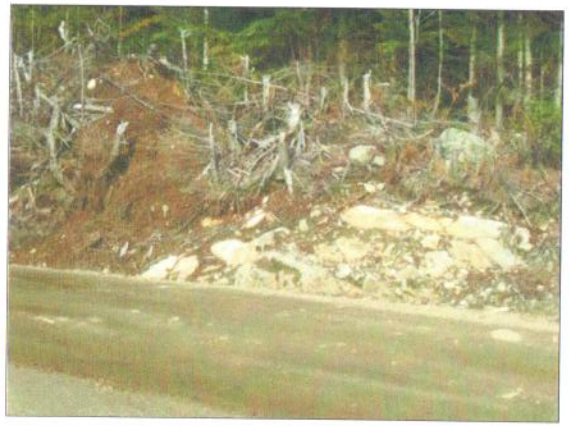


Figure 7. Thin soil veneers over bedrock.

Figure 8. Till over bedrock terrain.

Morainal deposits were found at various positions on Sumas Mountain. Generally, they were found as fine-textured blankets on the lower slopes. Often these deposits are extensively eroded, with the resulting erosional landforms dominated by gullies and, to a lesser extent, slumps and minor mass wasting events. At mid-mountain blanket and veneer deposits cover low-gradient sedimentary bedrock. Small acreage estates and hobby farms often occupy these areas. The topography is generally low relief with hills and hollows. As the topographical gradient increase at these hills, the moraine deposits become thinner, until the bedrock is exposed at the top of the small hills.

Fluvial deposits are limited to small, generally high gradient streams that are common throughout the mountain. The stream deposits usually occupy medium and low-bench positions. The deposits are the result of the erosion of the upslope moraine; as such they can be quite fine in texture. Other fluvial deposits include remnants from the Fraser River system. These can are found at the very base of the mountain at certain locations. They are dominated by silt material, and have often been converted from their natural state into agricultural production.

Colluvium is common throughout the mountain where steeps slopes have eroded. It is generally found as course-textured shattered bedrock. Occasional active failures were identified, but not commonly.

There are very limited organic deposits on Sumas Mountain. Small wetlands are common, but are almost always too small to be mapped as distinct polygons. However, these features provide important

habitat features and an effort should be made during the field mapping phase to target and classify them.

Figure 9. Low-gradient fluvial deposits up against till blankets over bedrock.

4.2 Terrestrial Ecosystem Mapping

The following section describes the results of TEM mapping on Sumas Mountain. 439 ecosystem polygons were delineated within the bioterrain polygons (Figure 15). Each polygon was classified with up to three Biogeoclimatic site series or TEM map codes. The following Tables (Figure 10) summarize the type, area, and percent of each site series or map code identified in the study area. Each site series (i.e. 01, 08, 12, etc.) corresponds to descriptions provided in the *Field Guide for Site Identification and Interpretation for the Vancouver Forest Region* (Green & Klinka 1994). The two letter map codes are standard TEM codes for natural or anthropogenic features (Table 6).

Table 6. TEM Map Codes.

Map Code	Description	Map Code	Description
ES	Exposed Soil	RN	Railway
CF	Cultivated Field (Farm)	RO	Rock Outcrop
GC	Golf Course	RW	Rural / Residential

MI	Mine	RZ	Road
OW	Shallow Open Water	TA	Talus
PD	Pond	Wm	Marsh (unclassified)
UR	Urban or Industrial	Ws	Swamp (unclassified)

The CWHdm encompasses the majority of the study area. Four site series comprise the majority of the mapped polygons in the CWHdm; 05 (27.31%), 04 (19.22%), and 07 (10.69%). Rural residential (17.48%) and mines (4.82%) accounted for the majority of the modified ecosystems (Table 7).

Table 7. CWHdm Ecosystem Distribution.

Site Series	Hectares	Percent
1	94.2	3.29%
2	37.1	1.30%
3	66.4	2.32%
4	550.6	19.22%
5	782.2	27.31%
7	306.3	10.69%
9	37.3	1.30%
12	191.9	6.70%
CF	7.9	0.28%
CL	4.5	0.16%
GC	18.4	0.64%
MI	138.2	4.82%
OW	14.5	0.51%
PD	1.3	0.05%
RN	0.7	0.02%
RO	2.7	0.09%
RW	500.6	17.48%
RZ	35.2	1.23%
UR	57.0	1.99%
Wm	13.0	0.45%
Ws53	4.5	0.16%
Total	**2,864.7**	**100.0%**

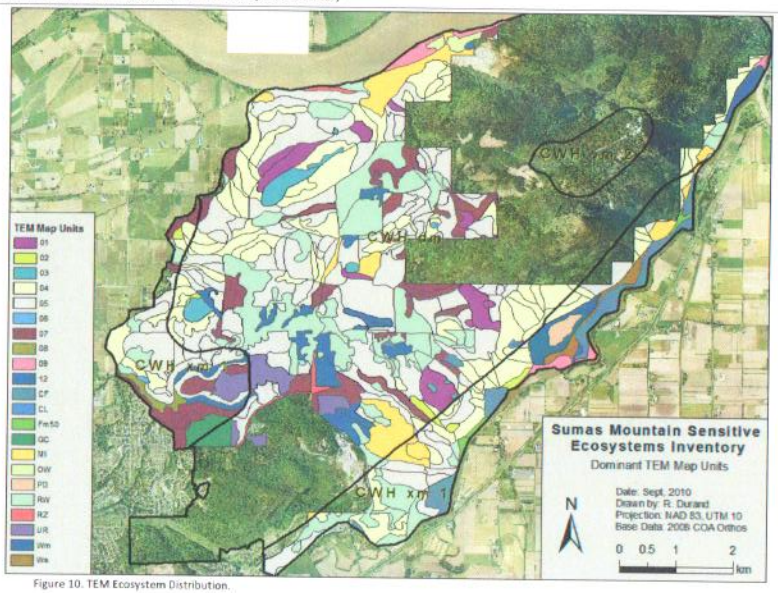


Figure 10. TEM Ecosystem Distribution.

The CWHxm1 occurs in two low elevation portions of the study area. Site series 05 (20.26%), 04 (19.73%), and 07 (9.05%) were the most common wetter ecosystems (Table 8). The CWHxm1 contained a high component of modified ecosystems, including rural residential (12.63%) and farm land (7.47%).

Table 8. CWHxm1 Ecosystem Distribution.

Site Series	Hectares	Percent
1	2.3	0.23%
2	18.5	1.79%
4	204.3	19.73%
5	209.8	20.26%
6	3.0	0.29%
7	93.7	9.05%
8	8.2	0.80%
9	12.7	1.22%
12	48.4	4.68%
CF	77.3	7.47%
CL	10.1	0.97%
Fm50	17.0	1.64%
GC	20.7	2.00%
MI	47.0	4.54%
OW	10.4	1.01%
PD	16.9	1.63%
RO	1.5	0.14%
RW	130.8	12.63%
RZ	20.0	1.93%
UR	24.7	2.39%
Wm	20.6	1.99%
Ws	37.5	3.62%
Total	**1,035.5**	100.00%

4.3 SEI Mapping

The following sections describe the results of the SEI mapping with distribution maps and representative photos, as well as detailed descriptions of each SE class and subclass. The results of the SEI mapping indicate that 31.1% of Sumas Mountain within the City of Abbotsford should be considered Sensitive Ecosystems, 35.6% is Other Important Ecosystem, and 33.3% Not Sensitive (Table 9, Figures 16 & 17, and Appendix 2).

Table 9. Sensitive Ecosystem Distribution.

SE Class: SE Subclass	CWHdm		CWHxm1		Total Hectares	Total Percent
	ha	%	ha	%		
FW:pd	1.3	0.0%	16.9	1.6%	18.3	0.5%
MF:mx	503.7	17.6%	171.6	16.6%	675.3	17.3%
MF:co	27.5	1.0%	0.0	0.0%	27.5	0.7%
OF:mx	1.2	0.0%	0.7	0.1%	1.9	0.0%
RI:fh	0.0	0.0%	7.9	0.8%	7.9	0.2%
RI:fm	37.3	1.3%	30.1	2.9%	67.4	1.7%
SV:cl	4.5	0.2%	8.4	0.8%	12.9	0.3%
SV:ro	2.7	0.1%	1.5	0.1%	4.2	0.1%
WD:mx	37.1	1.3%	18.5	1.8%	55.6	1.4%
WN:ms	13.0	0.5%	30.2	2.9%	43.1	1.1%
WN:sp	196.4	6.9%	76.4	7.4%	272.8	7.0%
WN:sw	14.5	0.5%	10.4	1.0%	24.9	0.6%
Total SE	***839.3***	**29.3%**	***372.5***	**36.0%**	**1,211.8**	31.1%
OIE (MF:bd)	291.2	10.2%	159.7	15.4%	450.9	11.6%
OIE (YF:bd)	414.5	14.5%	112.6	10.9%	527.1	13.5%
OIE (YF:co)	32.5	1.1%	2.4	0.2%	34.9	0.9%
OIE (YF:mx)	342.7	12.0%	33.6	3.2%	376.3	9.6%
Total OIE	***1,080.9***	***37.7%***	***308.3***	**29.8%**	**1,389.2**	35.6%
NS	***944.5***	***33.0%***	***354.7***	**34.3%**	**1299.2**	33.3%
Total	**2,864.7**	**100.0%**	**1,035.5**	**100.0%**	**3,900.2**	**100.0%**

Figures 11 and 12 depicts the SE, OIE and NS polygons mapped on Sumas Mountain. Figure 11 presents the SE, OIE and NS ecosystems based on the dominant ecosystem classification (i.e. ecosystem polygons may by compound ecosystems, but only the largest component is show to simplify the map). Figure 12 depicts SIE mapping with all SE classes shown. As a given polygon can have up to three ecosystem classifications, the map shows the dominant (50% or greater of the polygon) SE types with colours. The second (less than 50% of the polygon) and third classifications (less than 30% of the polygon) are depicted as hash marks for SE components only (cross hatches indicate the polygon has three SE classes represented). Appendix 2 contains a larger version of Figure 12.

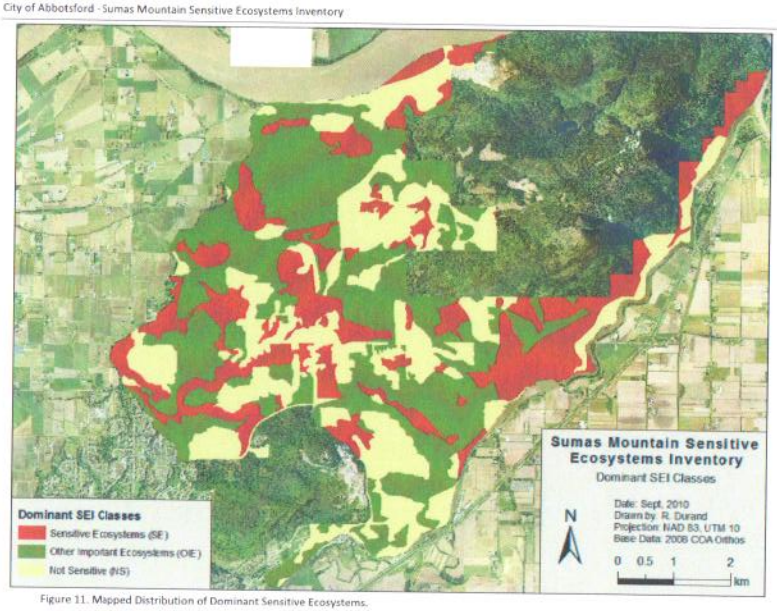


Figure 11. Mapped Distribution of Dominant Sensitive Ecosystems.

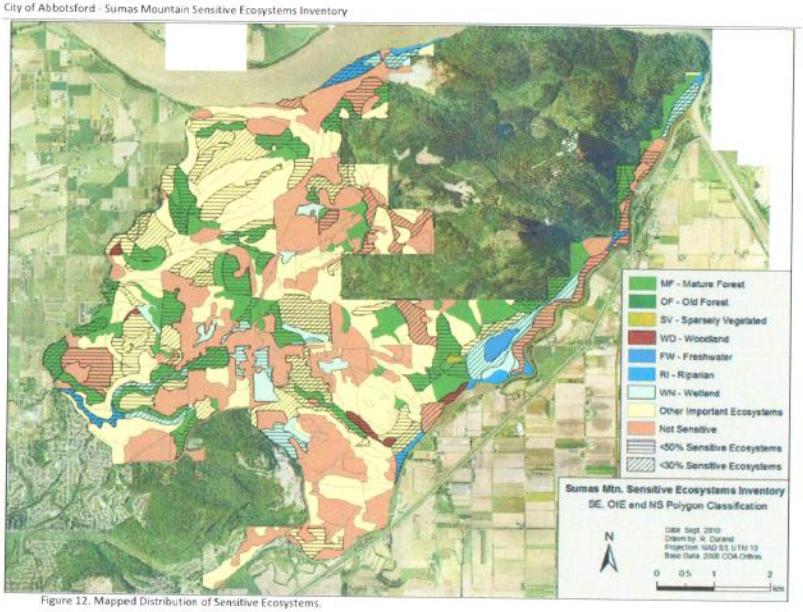


Figure 12. Mapped Distribution of Sensitive Ecosystems.

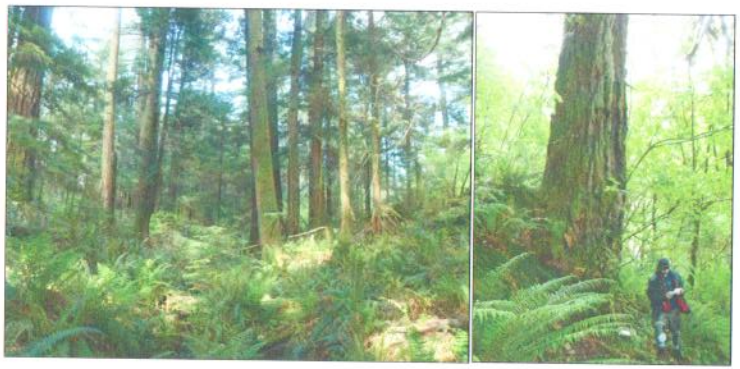
4.4 Sensitive Ecosystems

The following sections provide descriptions of the SE and OIE classes and sub-classes mapped on Sumas Mountain.

4.4.1 OLD FOREST (OF), MATURE FOREST (MF), AND WOODLAND (WD) CLASS

Forested ecosystems dominate the majority of Sumas Mountain. Due to an extensive disturbance history, forest stands are largely second growth and highly variable. Three forested types are mapped as Sensitive Ecosystems. As the three forest types contain many similar ecological values and threats, they have been combined into one section in this report. The following section describes the three types and their associated values. Section 4.4.1.1 and 4.4.1.2 contain lists of typical vegetation and wildlife found in these SE classes.

Old Forest (OF) Class. Generally conifer-dominated stands with complex vertical structure, where the canopy tree ages are mostly 250 years old or older, but may include older mixed coniferous stands (Figures 13, 14 and 15). Two subclasses are recognized; OF:co and OF:mx. OF:co are conifer-dominated forest stands (>75% conifer composition) where canopy tree ages mostly 250 – 400 years old. OF:mx are mixtures of coniferous and broadleaf trees (<75% coniferous and < 75% broadleaf composition) where canopy tree ages mostly 250 – 400 years old. Only OF:mx is known to occur in the COA portion of Sumas Mountain. (Metro Van Parks, 2010)



Figures 13 and 14. Example of Old Forest (OF:co) stands on Sumas Mountain.

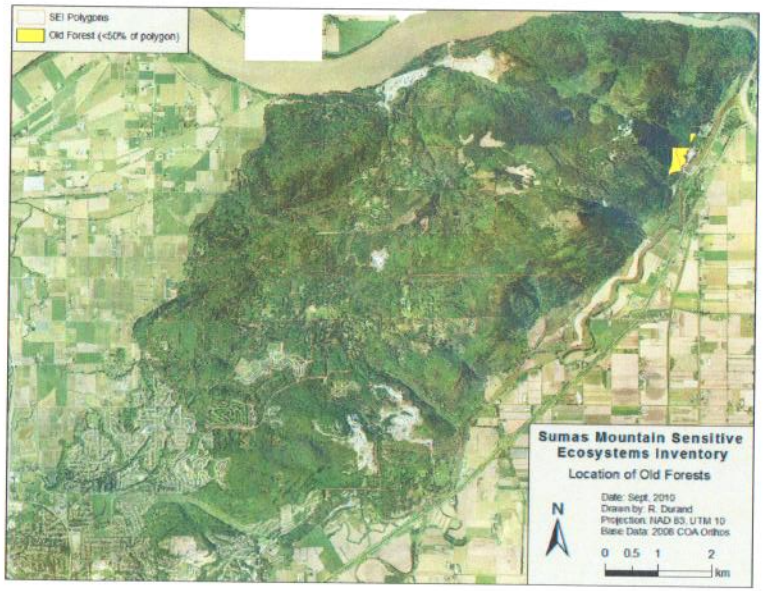


Figure 15. Distribution of Old Forests.

Mature Forest (MF) Class. Forests generally >80 yrs old and < 250 yrs old (Figures 16 and 18). Mature forests are not as structurally complex as old forests, but can function as essential habitat areas for many wildlife species and as primary connections between ecosystems in a highly fragmented landscape[4]. Two subclasses are recognized; MF:co and MF:mx. MF:co are conifer dominated (> 75% coniferous species) while MF:mx are mixed conifer and deciduous (<75% coniferous and < 75% broadleaf composition). Broadleaf dominated MF stands are considered to be Other Important Ecosystems. (Metro Van Parks, 2010)

[4] Metro Vancouver Parks proposed a minimum polygon size of 5 ha for inclusion in the MF sensitive ecosystem class. MF polygons of <5ha would be considered Other Important ecosystems. Due to the limited size of the Sumas Mountain study area, and the high number of species at risk, a minimum polygon size was not used for this classification.

Figure 16. Example of a Mature Forest (MF:mx) stand on Sumas Mountain.

Figure 17. Example of a Woodland Forest (WD:mx) stand on Sumas Mountain.

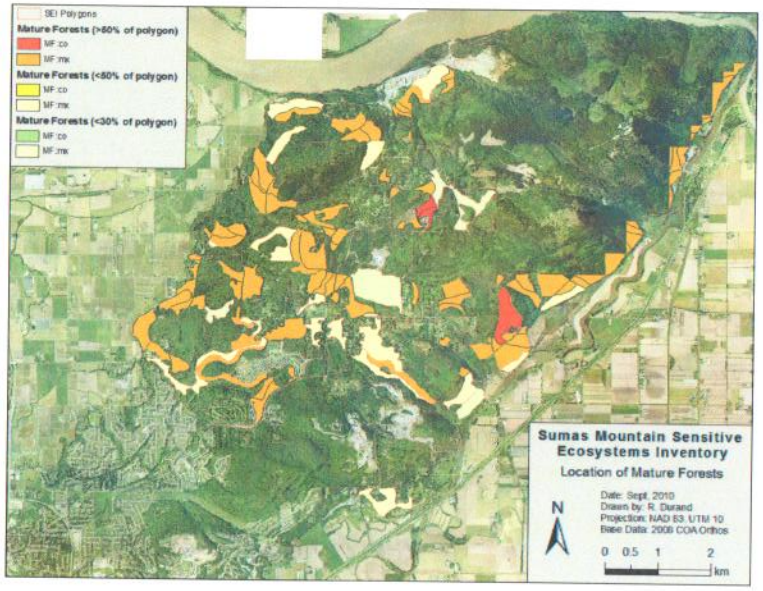


Figure 18. Distribution of Mature Forests.

Woodland (WD) Class. Woodlands are open forests, generally between 10 and 30% tree cover, as a result of site conditions, i.e., they are ecological woodlands (Figures 17 and 19). They are found on dry sites, mostly on south facing slopes of rocky knolls and bedrock-dominated areas. The stands can be conifer dominated or mixed conifer and arbutus (or deciduous hardwoods, e.g., Garry oak) stands and because of the open canopy, will often include non-forested openings, generally on shallow soils and bedrock outcroppings. Two subclasses are recognized; WD:co and WD:mx. WD:co are conifer dominated ecological woodlands (greater than 75% coniferous composition) and are not found in the COA portion of Sumas Mountain. WD:mx are mixed conifer and broadleaf ecological woodlands (minimum of 25% composition of each group comprises the total tree cover). (Metro Van Parks, 2010)

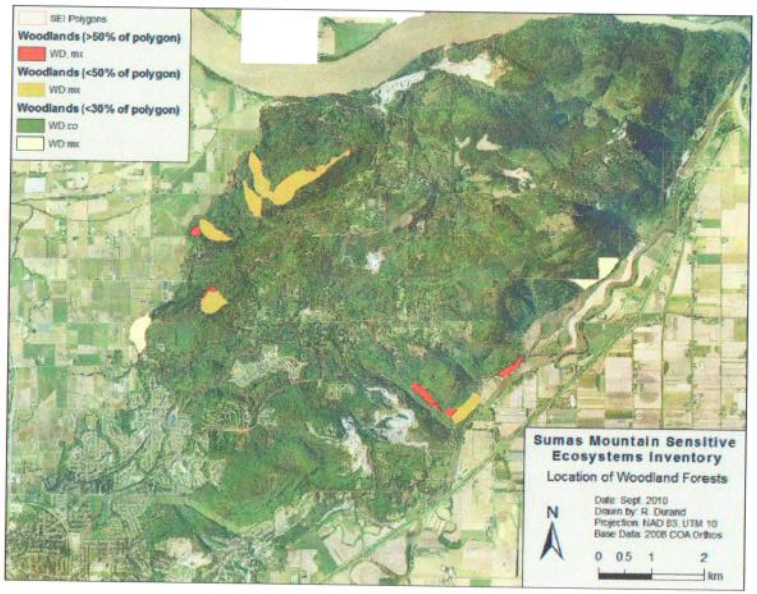


Figure 19. Distribution of Woodland Ecosystems.

4.4.1.1 Characteristic OF, MF and WD Vegetation

Table 10. Characteristic Vegetation of Forest and Woodland Sensitive Ecosystem Subclasses in the Study Area

PLANT SPECIES BY LAYER	CONIFEROUS FOREST	DECIDUOUS WOODLAND	MIXED FOREST
Trees			
Douglas-Fir	X		X
Western red-Cedar	X		X
Western hemlock	X		X
Big-Leaf maple		X	X
Paper birch		X	X
Red alder		X	X
Shrubs			
Dull Oregon-grape	X		

Salmonberry		X	X
Red huckleberry		X	X
Oceanspray		X	
Snowberry	X	X	X
Indian-plum		X	X
Thimbleberry	X	X	X
Herbs			
Vanilla-leaf	X	X	X
Sword fern	X	X	X
Fringecup	X	X	X
Foamflower	X	X	X

4.4.1.2 Characteristic OF, MF and WD Wildlife

The following wildlife species are typically found in forested ecosystems on Sumas Mountain:

Invertebrates

Robust Lancetooth, Banana Slug, Northern Bluet, Western Forktail, Anise Swallowtail, Western Tiger Swallowtail, Painted Lady, Green Comma (D. Knopp, pers. Comm. 2010)

Amphibians

Rough-skinned Newt, Long-toed Salamander, Pacific Treefrog

Reptiles

Northwestern Garter Snake, Common Garter Snake

Birds

Bald Eagle, Cooper's Hawk, Red-tailed Hawk, Ruffed Grouse, Great Horned Owl, Barred Owl, Northern Saw-whet Owl, Red-breasted Sapsucker, Hairy Woodpecker, Pileated Woodpecker, Northern Flicker, Pacific Slope Flycatcher, Steller's Jay, Winter Wren, Kinglets, Varied Thrush, Yellow Warbler, Pine Siskin

Mammals

Opossum, Common Shrew, Hoary Bat, Little Brown Bat, Deer Mouse, Porcupine, Northern Flying Squirrel, Douglas' Squirrel, Coyote, Cougar, Bobcat, Striped Skunk, Raccoon, Black Bear, Black-tailed Deer

4.4.2 *Riparian (RI) and Freshwater (FW)*

Riparian Ecosystems are associated with and influenced by freshwater, generally along rivers, streams, and creeks, but for SEI, also includes fringes around lakes (Figure 22). Ecosystems are influenced by factors such as erosion, sedimentation, flooding and/or subterranean irrigation due to proximity to the water body. Three subclasses are recognized on Sumas Mountain: RI:fm, RI:fh, and RI:fl. RI:fm are medium bench floodplains that flooded every 1-6 years for short periods (10-25 days). They contain deciduous or mixed forest dominated by species tolerant of flooding and periodic sedimentation (Figure 20). RI:fh are high bench floodplains that are periodically and briefly inundated by high waters, but contain lengthy subsurface flow in the rooting zone (Figure 21). RI:fl (which are not found in the COA portion of Sumas Mountain) are low bench floodplains that are flooded at least every other year for moderate periods of growing season. They contain plant species adapted to extended flooding and abrasion, low or tall shrubs most common. Section 4.4.2.1 and 4.4.2.2 contain lists of common vegetation and wildlife species found in these SE classes. (Metro Van Parks, 2010)

Fluvial fringes are commonly included in SEI projects; however do to the abundance of small creeks and streams in the study area it was not feasible to map these smaller riparian areas. Fluvial fringes are, for the most part, adequately captured in wetter TEM site series.

Riparian ecosystems form a transition zone between aquatic and terrestrial ecosystems and encompass areas (often linear) along creeks, streams , rivers and lakes that have more soil moisture, and therefore often have noticeably different vegetation, than the adjacent upland (Table 15). They are subject to fluctuating water tables and flooding and the soils are usually nutrient-rich. Riparian ecosystems are also generally more humid and have greater air circulation than surrounding areas, resulting in a slightly different microclimate.

In the study area, riparian ecosystems include both fluvial fringes associated with larger creeks, but lacking a floodplain; and floodplains with low, medium and high benches associated with the Fraser and canals in the Sumas Prairie. These floodplains have been significantly altered by construction and maintenance of dikes for flood protection and the railroad along the Fraser River.

Riparian areas adjacent to ponds, lakes and other wetlands were generally too narrow to be mapped and/or transitions between these wetland types and terrestrial upland vegetation were usually abrupt and lacking a distinctive riparian element. Therefore these areas are discussed in the Wetland section.

Freshwater ecosystems include bodies of water such as lakes and ponds that usually lack floating vegetation. One subclass is recognized on Sumas Mountain FF:pd. FF:pd are naturally occurring, small bodies of open water, greater than 2 m deep and generally less than 50 ha, with little to no floating vegetation. (Metro Van Parks, 2010)

Figure 20. Example of a Medium Bench Floodplain (RI:fm) on Clayburn Creek.

Figure 21. Example of a High Bench Floodplain (RI:fh) along Sumas Lake Canal.

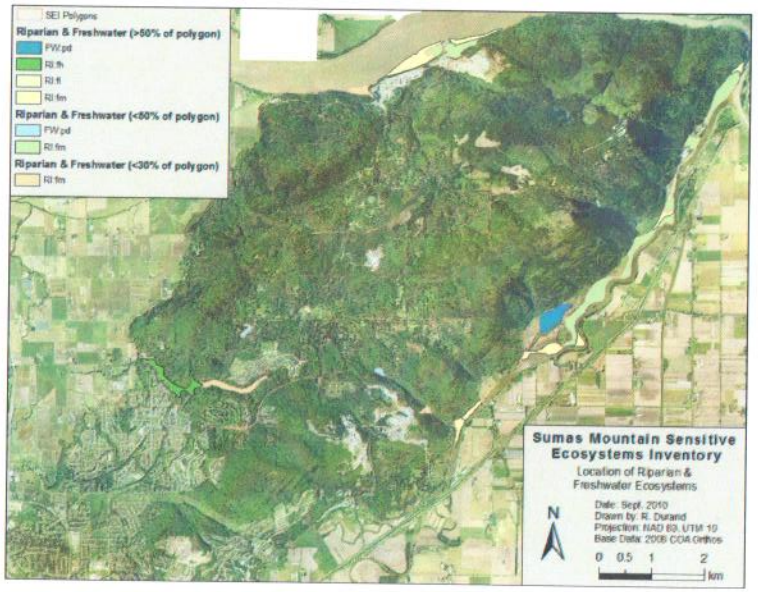


Figure 22. Distribution of Riparian and Freshwater Ecosystems.

4.4.2.1 Characteristic RI and FW Vegetation

Table 11. Characteristic Riparian and Freshwater Ecosystems.

PLANT SPECIES BY LAYER	LOW BENCH	MID BENCH	HIGH BENCH
Trees			
Black Cottonwood	x	x	x
Red Alder	x	x	x
Big-leaf Maple		x	x
Western Hemlock			x
Western Redcedar			x
Shrubs			
Willows	x	x	x
Salmonberry		x	x
Devil's-club			x

PLANT SPECIES BY LAYER	LOW BENCH	MID BENCH	HIGH BENCH
Thimbleberry			x
Red-osier Dogwood	x	x	x
Red Elderberry		x	x
Currants		x	x
Black Twinberry			x
Herbs			
Sedges	x	x	
Lady Fern			x
Swordfern			x
False Lily-of-the-valley		x	x
Horsetails	x	x	
Foamflowers			x

4.4.2.2 Characteristic RI and FW Wildlife

The following wildlife species are typically found in riparian ecosystems on Sumas Mountain:

Amphibians

Pacific Treefrog

Reptiles and Turtles

Garter snakes

Fish

White sturgeon (Lower Fraser population), Cutthroat Trout, Salmon

Birds

Bald Eagle, Belted Kingfisher, Mallard, Green-winged Teal, Osprey, Shorebirds, Swallows, Warblers, Wood Duck

Mammals

Bats, Beaver, Mink, Muskrat, Raccoon, River Otter, Shrews, Columbia Black-tailed deer

4.4.3 WETLANDS (WN)

Wetland ecosystems are found where soils are saturated by water for enough time that the excess water and resulting low oxygen levels influence the vegetation and soil. The water influence is generally seasonal or year-round and occurs either at or above the soil surface or within the root zone of plants. Wetlands are usually found in areas of flat or undulating terrain. Three subclasses are recognized on Sumas Mountain: marshes (WN:ms), swamps (WN:sp), and shallow water (WN:sw) (Figure 26). Section 4.4.3.1 and 4.4.3.2 list common vegetation and wildlife species found in the wetland SE classes. (Metro Van Parks 2010)

WN:ms are characterized by permanent or seasonal flooding by nutrient-rich waters. Marshes on Sumas Mountain are primarily cattail wetlands (Figure 23). One of the most common types of low elevation wetlands in coastal and interior BC, these marshes are characterized by a thick cover of cattail with few other rooted species. Cattail marshes often cover extensive areas, ranging from the margins of lakes and shallow waters, to disturbed roadside ditches. Capable of converting high levels of nitrogen and phosphorus into biomass, they are often the dominate wetlands type in agricultural areas. (MacKenzie & Moran 2004; Metro Van Parks 2010)

WN:sp are wooded wetlands dominated by 25% or more cover of flood-tolerant trees or shrubs (Figure 24). They are characterized by periodic flooding and nearly permanent sub-surface waterflow through mixtures of mineral and organic materials, swamps are high in nutrient, mineral and oxygen content. Typical swamps on Sumas Mountain include site series Ws51 Sitka Willow – Pacific Willow – Skunk Cabbage, Ws52 Red Alder – Skunk Cabbage, Ws53 Western Redcedar – Swordfern – Skunk Cabbage, and Ws54 Western Redcedar – Western Hemlock – Skunk Cabbage. While swamps occur in a variety of landscape positions, they are most often found in small depressions in level areas, and gently sloping toes along creeks and streams. They are highly variable, but typically contain thick shrub layers and an irregular tree canopy. (MacKenzie & Moran 2004, Metro Van Parks 2010)

WN:sw wetlands are characterized by still or slow-moving water less than 2 m in depth in mid-summer (Figure 25). They are often transitional between deep water bodies and other wetland ecosystems. Vegetation is general limited to a few species of floating aquatic species (such as Yellow Pond Lily and Duckweed) and/or submerged aquatic species. (MacKenzie & Moran 2004, Metro Van Parks 2010)

Figure 23. Disturbed Cattail Marsh.

Figure 24. Typical Skunk Cabbage – Willow – Alder Swamp

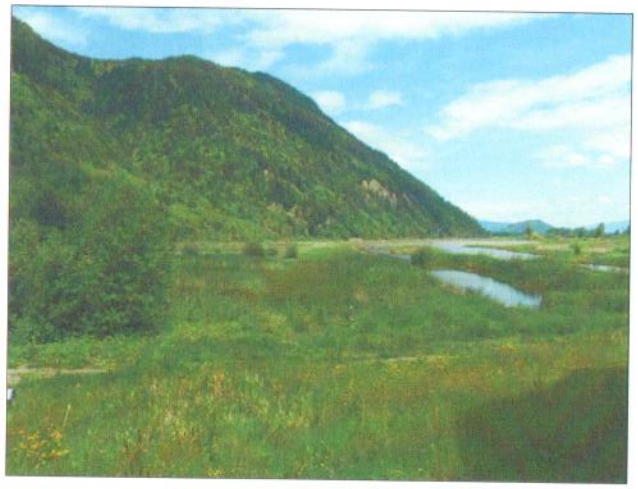


Figure 25. Modified Cattail Marsh – Shallow Water Complex.

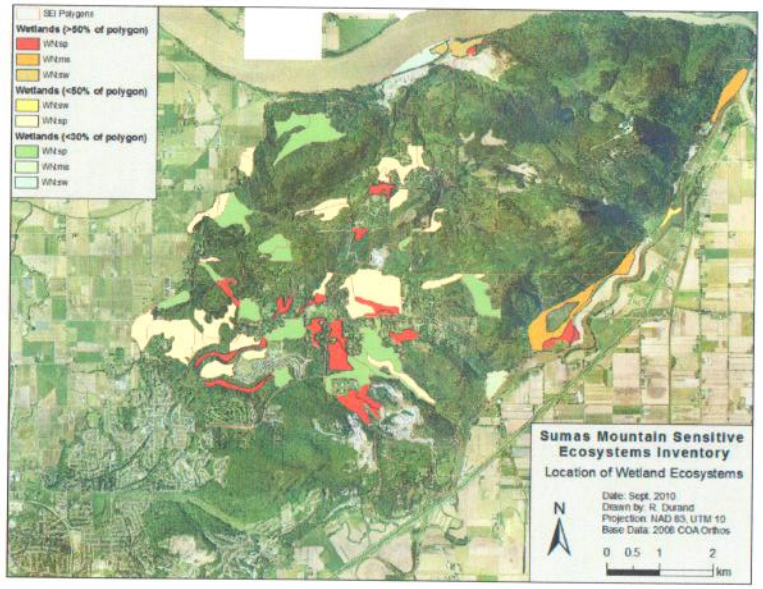


Figure 26. Distribution of Wetland Ecosystems.

4.4.3.1 Characteristic WN Vegetation

Table 12. Characteristic Vegetation of Wetland Ecosystems.

PLANT SPECIES BY LAYER	MARSH	SWAMP	SHALLOW WATER
Trees			
Black Cottonwood		x	
Red Alder		x	
Big-leaf Maple		x	
Western Redcedar		x	
Western Hemlock		x	
Shrubs			
Willows		x	
Salmonberry		x	
Devil's-club		x	

PLANT SPECIES BY LAYER	MARSH	SWAMP	SHALLOW WATER
Red-osier Dogwood		x	
Currants		x	
Black Twinberry		x	
Skunk Cabbage		x	
Herbs			
Lady Fern		x	
Horsetails		x	
Cattail	x		
Sedges	x	x	
Rushes	x		
Yellow Pond Lily			x
Duckweed			x

4.4.3.2 Characteristic WN Wildlife

The following wildlife species are typically found in riparian ecosystems on Sumas Mountain:

Amphibians

Pacific Treefrog

Reptiles and Turtles

Garter snakes

Fish

White sturgeon (Lower Fraser population), Cutthroat Trout, Salmon

Birds

Bald Eagle, Belted Kingfisher, Mallard, Green-winged Teal, Osprey, Shorebirds, Swallows, Warblers, Wood Duck

Mammals

Bats, Beaver, Mink, Muskrat, Raccoon, River Otter, Shrews, Columbia Black-tailed deer

4.4.4 *Sparsely Vegetation (SV)*

Sparsely Vegetated ecosystems are defined as areas of low vascular vegetation cover, generally 5 – 10 percent, but may be greater in some areas; may have high cover of mosses, liverworts and lichens (Figure 29). Three subclasses are recognized on Sumas Mountain; cliffs (SV:cl), rock outcrops (SV:ro) and talus (SV:ta) (talus is not found within the COA portion of Sumas Mountain). Section 4.4.4.1 and 4.4.4.2 contain lists of common vegetation and wildlife found in these SE classes. (Metro Van Parks 2010)

Cliffs are steep to vertical bedrock faces (Figure 27). On Sumas Mountain they are rarely extensive and are typically comprised of many discontinuous cliffs interspersed with a variety of vegetated ecosystems (mainly drier forest stands). Vegetation cover is sparse, but stunted conifers and a variety of herbs and shrubs growing on small ledges and cracks are common.

Rock outcrops are generally gently to moderately sloped and often occur on upper slopes and crests (Figure 28). Vegetation cover is highly variable and ranged from species tolerant of thin soil and very dry conditions, to wet seepages with lush herb and moss cover. The majority of the rocky outcrops on Sumas Mountain are small and heavily impacted by invasive species. They often occur in complexes with dry woodland forests (small outcrops that are less than the 0.5 hectare minimum polygons size of the SEI mapping are generally included in the woodland classifications).

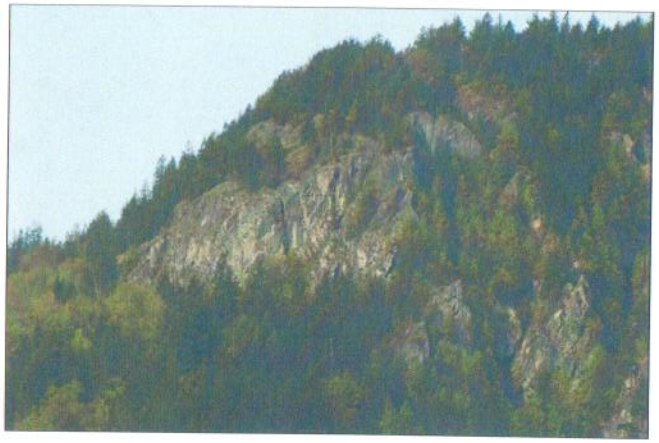


Figure 27. Example of Cliff Ecosystems.

Figure 28. Example of Small Rock Outcrop Ecosystem.

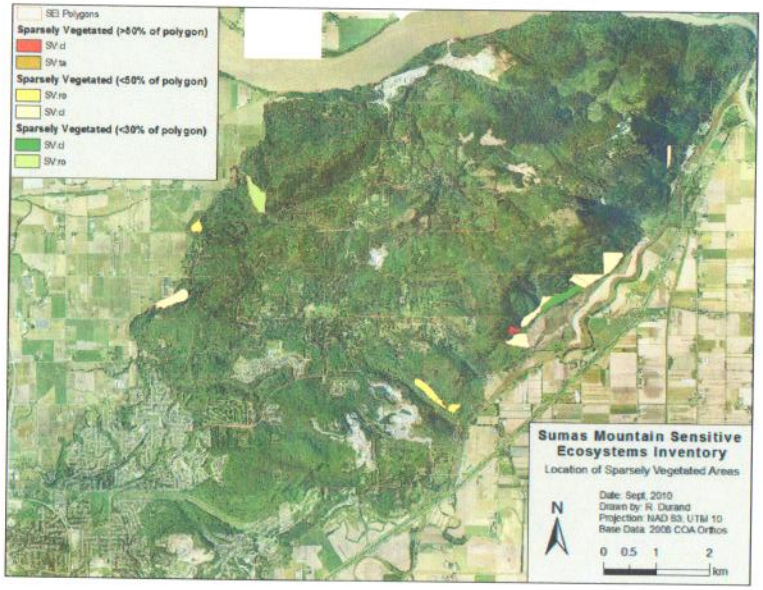


Figure 29. Distribution of Sparsely Vegetated Ecosystems.

4.4.4.1 Characteristic SV Vegetation

Table 13 lists common vegetation found in sparsely vegetated ecosystems. Due to difficulty and safety associated with accessing most of these ecosystem types, vegetation lists are not comprehensive.

Table 13. Characteristic Vegetation of Sparsely Vegetated Ecosystems.

PLANT SPECIES BY LAYER[5]	CLIFFS	ROCK OUTCROPS
Trees		
Western Redcedar	x	
Western Hemlock	x	
Douglas-fir	x	
Lodgepole Pine	x	
Shrubs		
Thimbleberry		x
Salmonberry		x
Tall Oregon Grape		x
Oceanspray		x
Common Snowberry		x
Spirea		x
Baldhip rose		x
Herbs		
Stonecrop spp.		x
Blue Wildrye		x
Brome spp.		x
Parsley fern		x
Yarrow		x
Small-flowered blue-eyed		x
California Oatgrass		x
Harvest brodiaea		x

4.4.4.2 Characteristic SV Wildlife

The following lists of characteristic sparsely vegetated wildlife species was adapted from Summers and Ryder (1996) and Ryder (2010)[6].

Invertebrates

Sara's Orangetip, Red Admiral, Painted Lady

Reptiles and Turtles

Northern Alligator Lizard

[5] Sources include Fuller (2004), P. Lilley, pers. Comm. 2010.
[6] Primary source: Summers, K. and G. Ryder (1996); Glenn Ryder, pers. Comm. (2010)

Birds

Turkey Vulture, American Kestrel, Merlin, Black Swift, Sharp-shinned Hawk, Golden Eagle, Cliff Swallow

Mammals

Western Long-eared Myotis, Little Brown Bat, Yuma Bat, Common Pika, Bushy-tailed Woodrat, Coyote, Cougar

4.5 Other Important Ecosystems (OIE)

Other Important Ecosystems (OIE) are mapped to identify important elements of biodiversity or recruitment sites for ecosystems at risk or important wildlife habitat requiring recovery or restoration. Two classes of OIE are recognized on Sumas Mountain: Mature Forest and Young Forest (Figure 30).

4.5.1 Mature Forest (MF) Class

Mature broadleaf forests (MF:bd) are deciduous dominated stands generally >80 yrs old and < 250 yrs old (Figures 31 and 32). These mature forests are not as valuable as old forests as far as representing the at-risk ecosystems, but can be important habitat areas for many wildlife species and serve as primary connections between ecosystems in a highly fragmented landscape. They are not classified as SE as many of these forests are expected to be disclimax stands that may not reach old conifer states (the expected climatic composition of most forested ecosystem in BC) due to past disturbances, edaphic conditions, or disturbance regimes. (Metro Van Parks 2010)

While not considered to be SE, MF:bd are important on Sumas Mountain for a variety of species at risk habitat. Endangered species such as the Oregon Forestsnail are almost exclusively found in these forest types, with Sumas Mountain containing the highest known populations (Durand 2006).

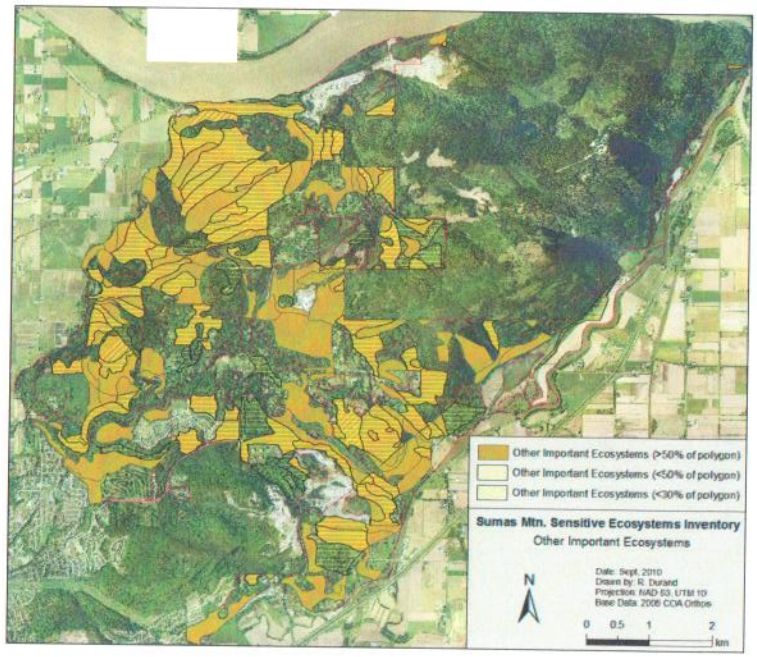


Figure 30. Distribution of OIE Ecosystems.

Figure 31. OIE Mature Forests (MF:bd).

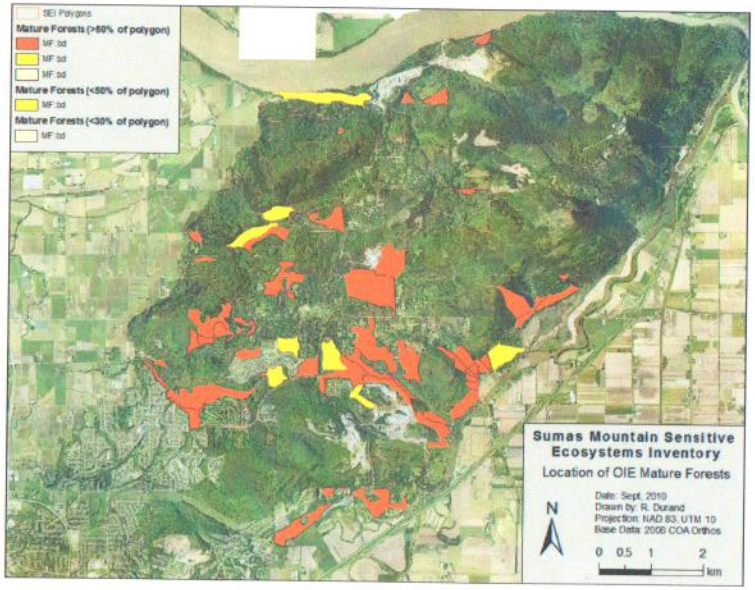


Figure 32. Distribution of OIE Mature Forests.

4.5.1.2 *Young Forest (YF) Class*

Young Forests are generally >30 – 40 yrs old and < 80 yrs old (Figure 33 and 34). They can be important habitat areas for many wildlife species and serve as primary connections between ecosystems in a highly fragmented landscape. Over time, if no additional disturbances occur, many of these ecosystems may develop into a MF and eventually OF classes. Three subclasses are recognized on Sumas Mountain; YF:co, YF:mx and YF:bd. YF:co are conifer dominated (> 75% coniferous species). YF:mx mixed conifer and deciduous (<75% coniferous and < 75% broadleaf composition). YF:bd are broadleaf dominated (>75% broad-leaved species). (Metro Van Parks 2010)

As shown in Figure 35, YF ecosystems are common on Sumas Mountain, covering some 938.3 hectares (24.1%) of the 3,900.2 study area. The vast majority of YF ecosystems are recovering from relatively recent disturbances.

Figure 33. Example of a Young Forest (YF:co).

Figure 34. Example of a Young Forest (YF:bd).

Figure 35. Distribution of OIE Young Forests.

4.6 Not Sensitive (NS)

All TEM ecosystem polygons not classified as SE or OIE are considered to be NS (Figure 37). The majority of NS polygons are those that are permanently disturbed (such as roads, mine, urban and residential developments, and railways) or have recently been heavily disturbed (primarily logging and other types of extensive clearing) (Figure 36). NS polygons also include disturbed areas that are dominated by shrubs. While these areas may still provide limited wildlife habitat or serve as movement corridors, they are generally expected to have limited biodiversity values.

Figure 36. Example of a Disturbed NS Ecosystem.

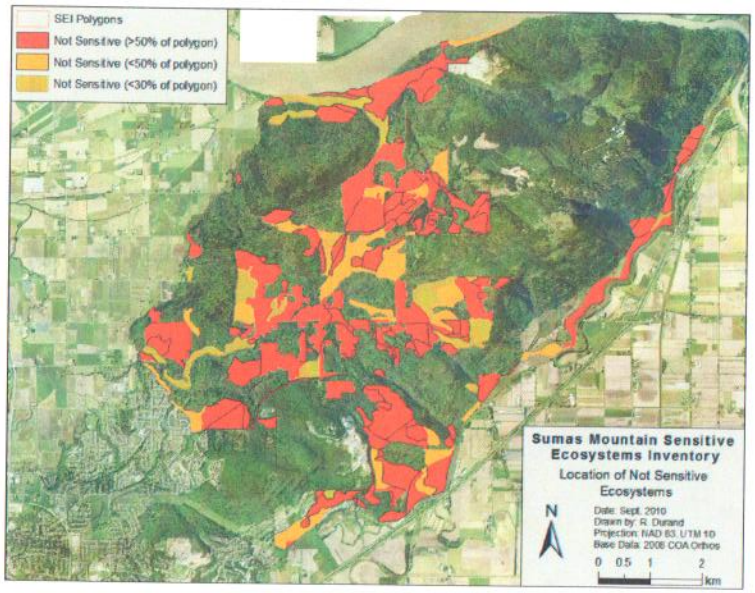


Figure 37. Distribution of Not Sensitive Ecosystems.

4.7 Wildlife Habitat Suitability Ratings

Sumas Mountain habitats within the City of Abbotsford sustain high, moderate, low and nil rated habitats for targeted species-at-risk. Three (3) of the 12 targeted species (i.e. western toad, western screech owl, and snowshoe hare) did not have sufficient data to establish a habitat rating. Maps (Figure 38 to 44) depicting Wildlife Habitat Suitability Ratings for 9 of the 12 identified species-at-risk are provided below.

Table 14 presents the total area mapped (hectares) for the 9 species-at-risk mapped. Totals for amphibians mapped with SHIM modeling are not included.

Table 14. Target Species at Risk.

Species	SEI Area Mapped (ha)			
	High	Mod.	Low	Nil
Amphibians				
Coastal Giant Salamander		769.13	866.87	2264.20
Coastal Tailed Frog			1900.38	1999.81
Red-legged Frog			2371.20	1528.99
Western Toad	-	-	-	-
Birds				
Great Blue Heron	245.49	48.05	148.87	3457.79
Western Screech Owl	-	-	-	-
Invertebrates				
Oregon Forestsnail	1833.44	418.62	210.30	1437.83
Pacific Sideband	1833.44	418.62	210.30	1437.83
Mammals				
Mountain Beaver	1493.51	5.70	931.02	1469.97
Pacific Water Shrew (TEM)	204.23	417.52	2713.59	564.86
Snowshoe Hare	-	-	-	-
Townsends Big-eared Bat	314.65	152.14	1775.84	1657.56

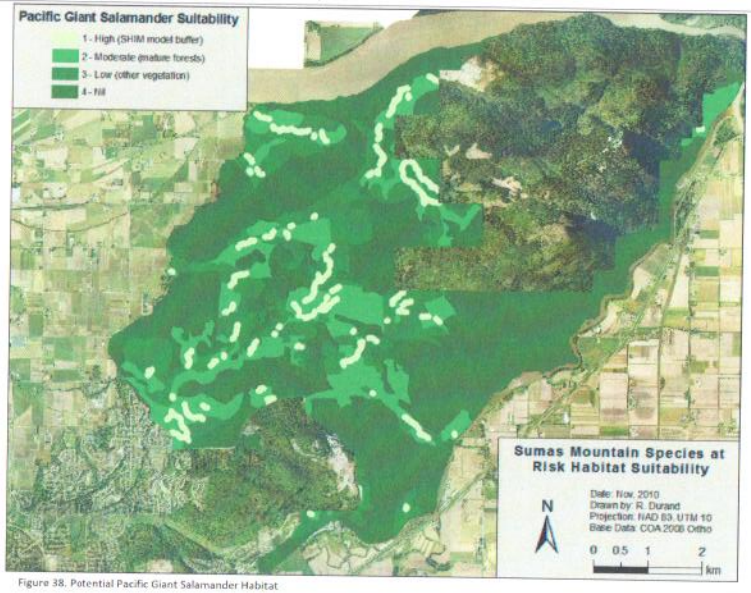


Figure 38. Potential Pacific Giant Salamander Habitat

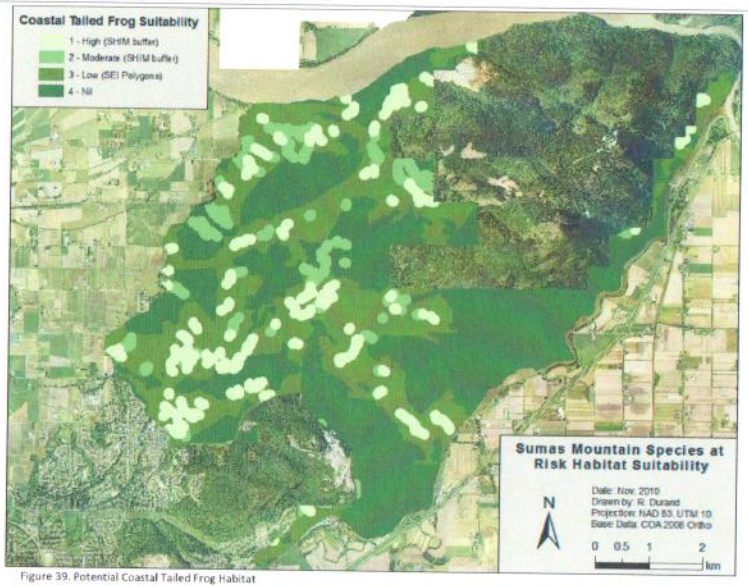


Figure 39. Potential Coastal Tailed Frog Habitat

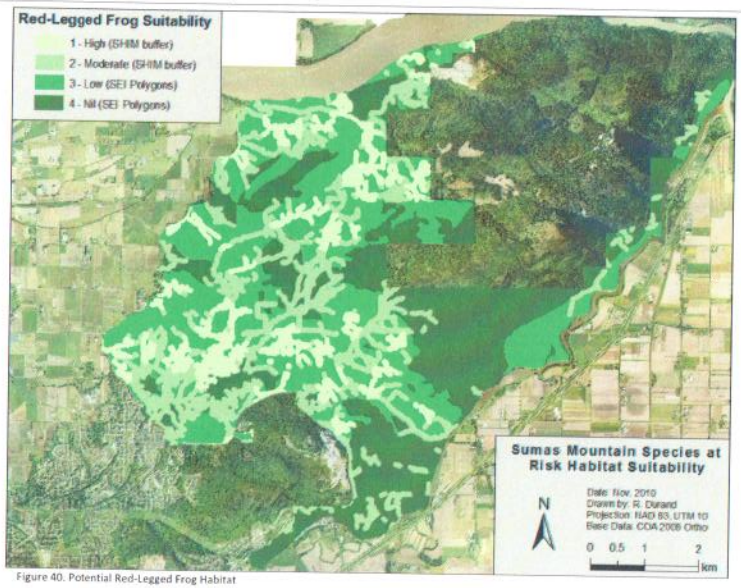


Figure 40. Potential Red-Legged Frog Habitat

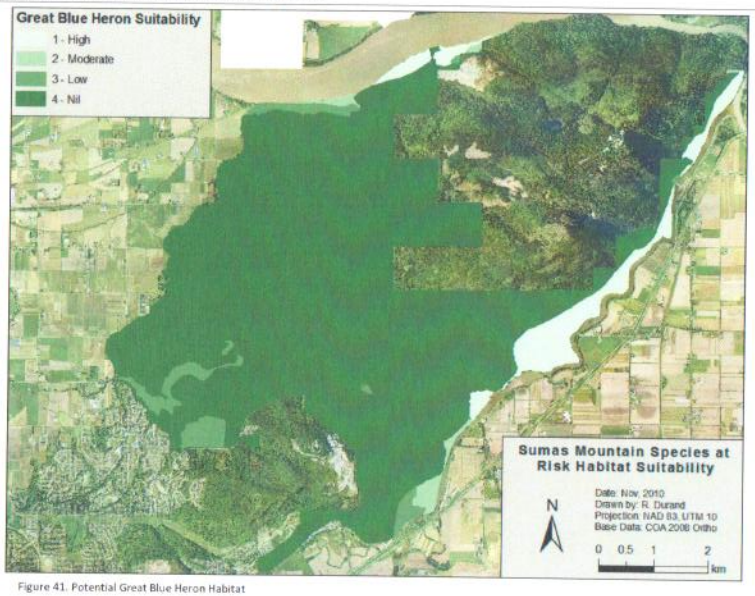


Figure 41. Potential Great Blue Heron Habitat

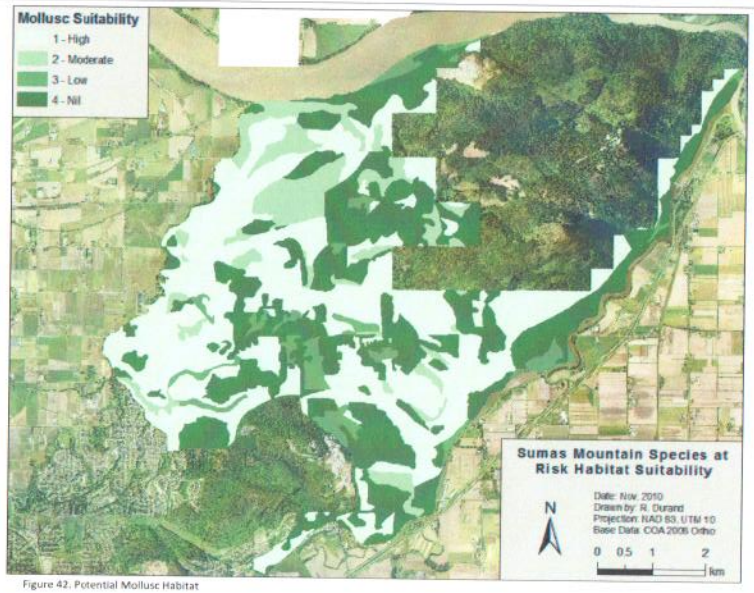


Figure 42. Potential Mollusc Habitat

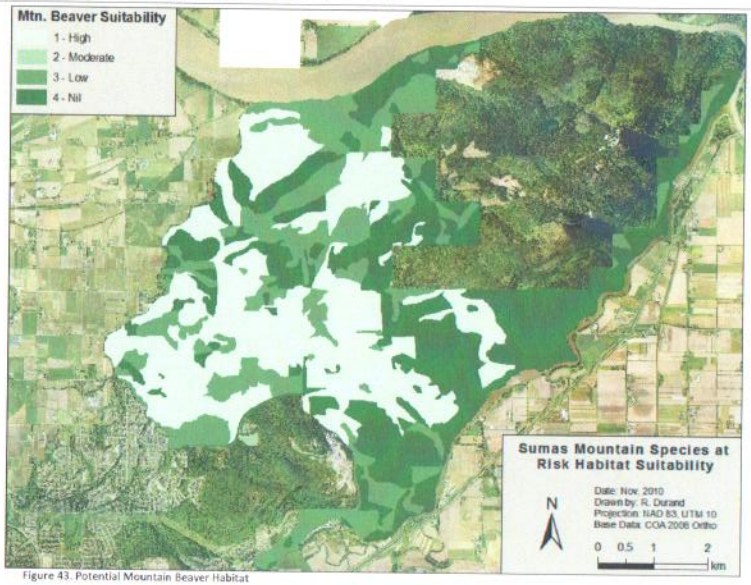


Figure 43. Potential Mountain Beaver Habitat

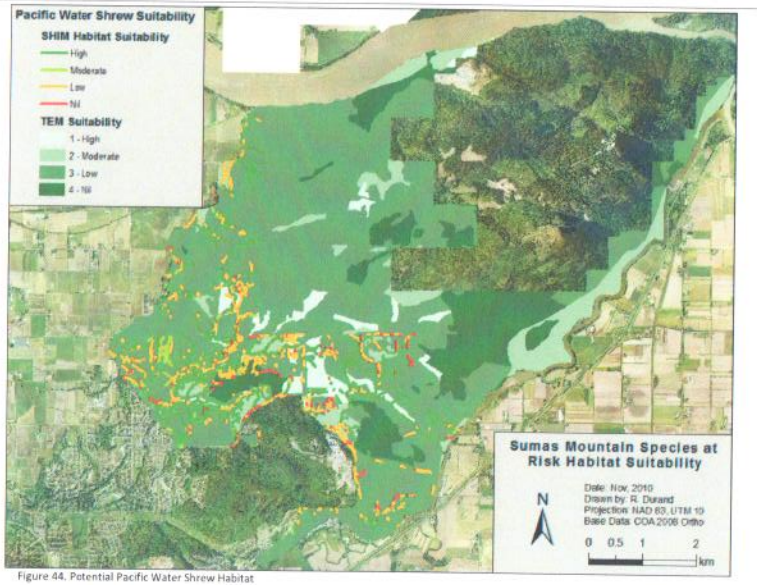


Figure 44. Potential Pacific Water Shrew Habitat

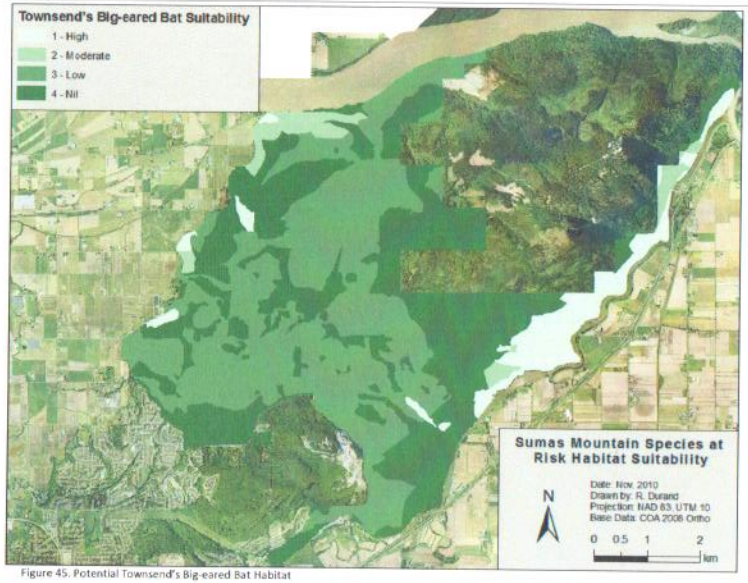


Figure 45. Potential Townsend's Big-eared Bat Habitat

5.0 FUTURE DIRECTIONS

This report should be considered to be a baseline study from which numerous other assessments can be conducted. In particular, the mapping can be used to identify areas in which more detailed assessments can be completed, and to begin landscape level conservation planning. The following species future directions are recommended:

- Additional sampling in under-sampled areas,
- Additional SAR surveys by species specialists,
- Future analyses with the mapping and inventory data (change over time, etc.), and
- Mapping of key landscape level linkages.

6.0 REFERENCES

Abbotsford Weather Page. Accessed May 30, 2009. URL: http://www.abbotsfordwx.com/climate.html

Austin, M.A., D.A. Buffett, D.J. Nicholson, G.G.E. Scudder and V. Stevens (eds.) 2008. Taking Nature's Pulse: The Status of Biodiversity in British Columbia. Biodiversity BC, Victoria, BC. 268 pp. Available at www.biodiversitybc.org.

B.C. Conservation Data Centre. 2010. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Available at: http://a100.gov.bc.ca/pub/eswp/ (accessed Apr 22, 2010).

BC Ministry of Environment. British Columbia Ministry of Environment. 2009. Living Water Smart: British Columbia's Water Plan. Available online at www.livingwatersmart.ca.

BC Ministry of Environment, Lands and Parks and Ministry of Forests. 1998. Field Manual for Describing Terrestrial Ecosystems. BC Ministry of Environment, Lands & Parks and Ministry of Forests, Victoria, BC.

BC Ministry of Forests and Range Coast Forest Region Research Section – Ecology Website. Accessed January 20, 2010. URL: http://www.for.gov.bc.ca/rco/research/eco/

B.C. Ministry of the Environment. Frogwatch Program Fact Sheet: Red-legged Frog (*Rana aurora*). Accessed at http://www.env.gov.bc.ca/wld/frogwatch/whoswho/factshts/redleg.htm. 09/10/10

Blood, Donald A. 1995. Wildlife in British Columbia at Risk: Townsend's Big-eared Bat. Prepared for the British Columbia Ministry of the Environment, Lands and Parks. Victoria.

Blood, Donald A. 1995. Wildlife in British Columbia at Risk: Pacific Watershrew. Prepared for the British Columbia Ministry of the Environment, Lands and Parks. Victoria.

Canadian Wildlife Service and Canadian Wildlife Federation. 2003. Hinterlands Who's Who. Accessed September 10th, 2010 at http://www.hww.ca/ .

COSEWIC 2006. COSEWIC Assessment and Update Status Report on the Pacific Watershrew (*Sorex Bendirii)* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa vi + 28 pp.

COSEWIC 2004. Assessment and Update Status Report on the Red-legged Frog (*Rana aurora*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. Vi + 46 pp.

COSEWIC 2002. COSEWIC Assessment and Status Report on the Oregon Forestsnail (*Allogana townsendiana*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa vi + 20 pp.

COSEWIC 2002. COSEWIC Assessment and Update Status Report on the Western Screech Owl (*Otus kennecotti*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa vi + 31pp.

COSEWIC 2002. Assessment and Status Report on the Western Toad (*Bufo boreas*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa vi + 31 pp.

Biodiversity Conservation Strategy Partnership. 2008. Strategic Directions for Biodiversity Conservation in the Metro Vancouver Region.

Boyle, C.A., L.M. Lavkulich, H. E. Schreier and E. Kiss. 1997. Changes in land cover and subsequent effects on lower Fraser ecosystems from 1827-1990. Environmental Management 21: 185-196.

Brosofske, K.D., Chen, J., Naiman, R.J., Franklin, J.F., 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. Ecol. Appl. 7, 1188–1200.

Dukes, J.S. and H.A. Mooney. 1999. Does global change increase the success of biological invaders? TREE Vol. 14(4): pp.135–139.

Dunster, J.A. and K.J. Dunster. 1996. Dictionary of Natural Resource Management. UBC Press. Vancouver, B.C.

Durand, R. 2006. Habitat Assessment of the Endangered Oregon Forestsnail, *Allogona Townsendiana*, in the Lower Fraser Valley of British Columbia. Unpublished report for the Fraser Valley Conservancy. Abbotsford, BC.

Environmental Law Institute. 2008. The Planner's Guide to Wetland Buffers for Local Government. Available from www.elistore.org.

Environment Canada, Canadian Wildlife Service. 2006. 2nd Edition. How Much Habitat is Enough? Available online at http://www.on.ec.gc.ca/wildlife/docs/pdf/habitatframework-e.pdf.

Environment Canada. 2003. Wetlands and climate change. Available at www.ec.gc.ca/water/en/nature/wetlan/e_clim.htm.

Environment Canada. 2003. Water – vulnerable to climate change. Available at http://www.ec.gc.ca/eau-water/default.asp?lang=en&n=7958DBOA-1.

Forysth, Robert. Pacific Sideband: Introduction to Land Snails of British Columbia. In Klinkenberg, Brian (Editor) 2010. . E-fauna BC: Electronic Atlas of BC (www.efauna.bc.ca). Lab for Advanced Spatial Analysis, Department of Geography, UBC, Vancouver (Accessed 9/7/2010).

Fraser Valley Conservancy. 2009. Towards a Fraser Valley Regional Biodiversity Strategy: Supporting the Fraser Valley Stewardship Outreach Activities of the South Coast Conservation Program and Other Groups.

Fraser Valley Regional District. 2003. Fraser Valley Regional District Official Community Plan for Electoral Area "H", Sumas Mountain Bylaw No. 0584.

Fraser Valley Regional District. 2004. Choices for Our Future: Regional Growth Strategy for the Fraser Valley Regional District.

Fuller, R. 2004. Draft Site Report: Sumas Mountain. Garry Oak Ecosystem Recovery Team (GOERT) Priority Site Polygon Boundary Delineation and Inventory report prepared for GOERT Conservation Planning and Site Protection Recovery Action Group.

Gitay, H., A. Suarez, and R.T. Watson. 2002. Climate change and biodiversity: IPCC Technical Paper V. Intergovernmental Panel on Climate Change. Geneva. As quoted in Fraser, J. 2004. Climate Change Impacts on Biological Systems. In: Hooper, T. 2004. Proceedings of Pathways to Recovery Species at Risk Conference, Victoria, BC.

Granger, T., T. Hruby, A. McMillan, D. Peters, J. Rubey, D. Sheldon, S. Stanley, E. Stockdale. April 2005. Wetlands in Washington State - Volume 2: Guidance for Protecting and Managing Wetlands. Washington State Department of Ecology. Publication #05-06-008. Olympia, WA.

Green, R.N. & K. Klinka. 1994. Land Management Handbook 28: A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region. BC Ministry of Forests. Victoria, BC.

Griffith, Hugh. 2010. Mountain Beaver (*Aplodontia rufa*). In Klinkenberg, Brian (Editor) 2010. E-Fauna BC: Electronic Atlas of BC (www.efauna.bc.ca) Lab for Advanced Spatial Analysis, Department of Geography, UBC, Vancouver: 9/7/2010.

Hamann, A. & T. Wang. 2006. Potential effects of climate change on ecosystem and tree species distribution in British Columbia. Ecology, 87(11), 2006, pp. 2773–2786. Ecological Society of America.

Hebda, R. 1997. Impact of climate change on biogeoclimatic zones of British Columbia. Pages 1-15 in E. Taylor and B. Taylor (eds.). Responding to Global Climate Change in British Columbia and Yukon: Vol. 1 of the Canada Country Study: Climate Impacts and Adaptation. Environment Canada, Vancouver, BC and Ministry of Environment, Lands and Parks, Victoria, BC.

Johnston, Barbara E. 2004. Coastal Giant Salamander: *Dicamptodon tenebrosus*. In Accounts: Measures for Managing Identified Wildlife V.2004. Ministry of Environment, Victoria.

Iverson, K. and C. Cadrin. 2003. Sensitive Ecosystems Inventory: Central Okanagan, 2000 – 2001. Volume 1: Methodology, Ecological Descriptions, Results and Conservation Tools. Technical Report Series No. 399, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Kipp, S. and C. Callaway. 2002. On the Living Edge: Your Handbook for Waterfront Living. Published by Federation of British Columbia Naturalists (now BC Nature).

Knopp, Denis. 2009-2010. Pers. Comm. Environmental Consultant, BC's Wild Heritage Environmental Consultants, Sardis.

Lester, D. Date unknown. Gap Analysis Predicted Distribution Map; Mountain Beaver (*Aplodontia rufa*). Accessed Feb. 10, 2010. URL: http://depts.washington.edu/natmap/maps/wa/mammals/WA_mountain_beaver.html

Lilley, Patrick. 2010. Pers. Comm., Environmental Consultant, Raincoast Applied Ecology, Vancouver.

Madrone Environmental Services Ltd. 2006. Terrestrial Ecosystem Mapping, McKee Peak. Abbotsford, BC. Unpubl. Rept. Prepared for City of Abbotsford.

Madrone Environmental Services Ltd. 2007. Rare Element Survey and Habitat Ranking, McKee Peak, Abbotsford, BC. Unpubl. Rept. Prepared for City of Abbotsford.

Metro Vancouver Regional Parks (Josephine Clark and Janice Jarvis). Pers. Comm. 2010. Proposed Metro Vancouver Parks Sensitive Ecosystems Inventory Classification.

Mallory. 2004. Coastal Giant Salamander: *Dicamptodon tenebrosus*. In Accounts: Measures for Managing Identified Wildlife V.2004. Ministry of Environment, Victoria.

McAllister, Dan. D.A. McAllister and Associates. Pers. Comm.. 2010. Terrain Mapping of Sumas Mountain for Taara Environmental.

McIntosh, Terry. 2010. Environmental Consultant, Biospherics Environmental Inc., Vancouver.

McPhee, M., P. Ward, J. Kirkby, L. Wolfe, N. Page, K. Dunster, N.K. Dawe and I. Nykwist. 2000. Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands, 1993-1997. Volume 2: Conservation Manual. Technical Report Series No. 345, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Michelfelder, Volker. Ryan Van der Marel and Ken Dunsworth. 2008. Proposed Wildlife Habitat Areas for Coastal Tailed Frog (*Ascaphus truei*) on the Central Coast of British Columbia. Prepared for Ministry of Environment. Hagensborg, B.C.

Montgomery, D.R., 1999. Process domains and the river continuum. J. Amer.Water Resour. Assoc. 35, 397–410.

Olewiler, Nancy. 2004. The Value of Natural Capital in Settled Areas of Canada. Published by Ducks Unlimited Canada and the Nature Conservancy of Canada.

Olson, D.H.; Anderson, P.D.; Frissell, C.A.;Welsh, H.H., Jr.: Bradford, D.F. 2007. Biodiversity management approaches for stream-riparian areas: perspectives for Pacific Northwest headwater forests, microclimate and amphibians. Forest Ecology and Management/ 246(1): 81-107.

Olson, D.H. & Burnett, K.M. 2009. Design and management of linkage areas across headwater drainages to conserve biodiversity in forest ecosystems. Forest Ecology and Management. 258S: S117-S126.

Pacific Giant Salamander Recovery Team. 2010. Recovery Strategy for Pacific Giant Salamander (*Dicamptodon tenebrosus*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, B.C. 42 pp.

Payne, J. 1989. Sumas Soda Feldspar Property, Sumas Mountain BC, New Westminister Mining Division. A Feldspar Prospect for Jack Lee. John G. Payne Consultants Ltd. North Vancouver, BC.

Perry, D., R. Oren, and S. Hart. 2008. Forest Ecosystems; 2nd Edition. The Johns Hopkins University Press. Baltimore, Maryland.

Pojar, Jim. 2010. A New Climate for Conservation: Nature, Carbon and Climate Change in British Columbia. Report prepared for Working Group on Biodiversity, Forests and Climate.

Quadra Planning Consultants Ltd. 1998-2000. Fraser Valley Regional District Regional Growth Strategy Environment and Ecological Working Paper. Part I: Environmental Overview. Part II: Potential Impacts of Growth on Environmental and Ecological Health in the FVRD. Part III: Environmental Policy Framework. Prepared by Quadra Planning Consultants Ltd. in association with Coast River Environmental Services Ltd. and Ken Summers Biological Services.

Resource Inventory Standards Committee (RISC). 2006. Standard for Mapping Ecosystems at Risk in British Columbia; An Approach to Mapping Ecosystems at Risk and Other Sensitive Ecosystems. Prepared by BC Ministry of Environment Ecosystems Branch for the Resources Information Standards Committee.

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

Resources Inventory Committee. 1996. Guidelines and Standards to Terrain Mapping in British Columbia. Resources Inventory Committee, Surficial Geology Task Group, Earth Sciences Task Force. Victoria, BC.

Ritland, K., L.D. Meagher, D.G.W. Edwards and Y.A. El-Kassaby. 2005. Isozyme variation and the conservation genetics of Garry oak. Canadian Journal of Botany. 83(11): 1478-1487.

Ryder, Glenn. 2010. Pers. Comm. Naturalist and environmental consultant.

SEI Website (date unknown). http://www.env.gov.bc.ca/sei/

Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, S. Stanley, and E.

Stockdale. March 2005. Wetlands in Washington State - Volume 1: A Synthesis of the

Science. Washington State Department of Ecology. Publication #05-06-006. Olympia, WA

Sumas Mountain Local Resource Use Plan Committee. 1992. Sumas Mountain Local Resource Use Plan.

Summers, K. and G. Ryder. 1996. Wildlife Review of Proposed Sumas Mountain Regional Park. Unpublished report for Greater Vancouver (now Metro Vancouver) Regional District Parks.

Taara Environmental. 2005 to 2009. Sensitive Habitat Inventory Mapping for the City of Abbotsford.

Vennesland, Ross. 2009. Pers. Comm. Species at Risk Recovery Specialist, Parks Canada, Western and Northern Service Centre.

Vennesland, Ross G. 2004. Great Blue Heron in Accounts and Measures for Identified Wildlife Accounts V. 2004. Ministry of Environment, Victoria.

Vold, T. and D.A. Buffett (eds.). 2008. Ecological Concepts, Principles and Applications to Conservation, BC. Available at www.biodiversitybc.org.

Wetland Stewardship Partnership. 2009. Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia. Available from http://www.env.gov.bc.ca/wld/documents/bmp/wetlandways2009/wetlandways_docintro.html

Wilkinson, Kathleen (K. Wilkinson Consulting) and Durand, R. (Taara Environmental). 2010. The Need for a Sumas Mountain Conservation Strategy. Unpubl. Rept. For Fraser Valley Conservancy.

Wilson, Sara J. and Richard J. Hebda. 2008. Mitigating and Adapting to Climate Change through the Conservation of Nature in British Columbia. Report prepared for The Land Trust Alliance of British Columbia.

Zevit, Pamela. 2010. Snowshoe Hare (*Lepus americanus*). In Klinkenberg, Brian (Editor) 2010. E-Fauna BC: Electronic Atlas of BC (www.efauna.bc.ca) Lab for Advanced Spatial Analysis, Department of Geography, UBC, Vasncouver: 9/7/2010

APPENDIX 1. SPECIES-AT-RISK OF SUMAS MOUNTAIN

SPECIES NAME	Habitat Type	Secondary Habitat Types	Riparian	Wetland & Pond	Conifer	Broadleaf	Mixed	Cliff	Rocky Outcrop	Grass/Herb	Shrub Ecotone
Invertebrates:											
Johnson's Hairstreak (*Callophrys johnsoni*)	Mature or old western hemlock with dwarf mistletoe and with openings for flowering plants).				x						
Dragonflies/Damselflies											
Blue Dasher (*Pachydiplax longipennis*)	Pond and lake edges with abundant vegetation on edge and in water.			x						x	
Molluscs											
Oregon Forestsnail (*Allogona townsendiana*)	Mature bigleaf maple – stinging nettle.	Bigleaf maple wetland fringe, red alder pole sampling – stinging nettle, disturbed hardwood areas.				x	x				
Pacific Sideband (*Monadenia fidelis*)	Mature Douglas-fir, cedar, maple forests with thick leaf litter.	Various – disturbed, pure hardwood, etc. – not wetlands.			x	x	x				
Amphibians:											
Coast Tailed Frog (*Ascaphus truei*)	Clear, mountain stream cascades		x		x	x	x				
Western Toad (*Bufo boreas*)	Breeding – muddy bottomed ponds	Living– various adjacent types with good thermal cover – several km from ponds.	x	x	x	x	x				
Pacific Giant Salamander (*Dicamptodon tenebrosus*)	Fast-flowing mountain streams – generally permanent flow	Moist areas of adjacent forests – prefer mature and old growth with high LWD.	x		x	x	x				
Red-legged Frog (*Rana aurora*)	Breeding – shallow ponds, slow shaded streams	Living – wetlands and adjacent moist, shady forests several km from breeding sites.	x	x	x	x	x				
Reptiles and Turtles											

Rubber Boa (*Charina bottae*) Historic Record	Wooded shaded areas (but can be anywhere) – avoid heat. Soft soils for burrows.				x	x	x				
Fish											
White Sturgeon (Lower Fraser population) (*Acipenser transmontanus* pop.4)	Fraser River	Side channels, sloughs, and in the confluence of larger tributaries.	x								
Cutthroat Trout (*Oncorhyncus clarkii* ssp. *clarkii*)	Creeks and streams	Connected ponds and ditches	x								
Birds											
Northern Goshawk ssp. *laingi* (*Accipiter gentilis laingi*)	Large intact patches of mature conifer forests. High canopy cover with well spaced trunks.	Trees with deformities and snags preferred for nesting			x						
Western Grebe (*Aechmophorus occidentalis*)	Migratory resting areas include backwaters and sloughs.		x	x							
Great Blue Heron *fannini* ssp. (*Ardea herodias fannini*)	Breeding – mature cottonwood stands.	Living – wetlands, wet grassy areas, margins of rivers, ponds, and creeks.	x	x		x					
American Bittern (*Botaurus lentiginosus*)	Marshes, lakes or wetlands with high emergent vegetation	dry grassy uplands if wetlands unavailable	x	x						x	
Marbled Murrelet (*Brachyramphus marmoratus*) Historic record	Mature to old conifer forest with thick, mossy upper branches.				x						
Olive-sided Flycatcher (*Contopus cooperi*)	Indicator species, conifers, large snags	Small ponds and waterbodies			x		x				x
Sooty Grouse (*Dendragapus fuliginosus*)	Fire or weather modified conifer forests. Breeding – downed woody debris or conifer shrubs.	Edge species, requires forest edge adjacent to open areas, like meadow or grassland.			x					x	
Peregrine Falcon (*Falco peregrinus anatum/tundrius*)	Cliff ledges or crevices.	Confluence of rivers, valleys, streams for hunting.					x			x	
Barn Swallow (*Hirundo rustica*)	Partially open habitat proximate to water bodies.		x	x			x	x			

Western Screech-owl (*Megascops kennicottii* ssp. *kennicottii*)	Requires mature trees large enough for nest cavities.	Riparian zones preferred.	x	x	x	x	x				
Lewis' Woodpecker (*Melozerpes lewisi*) Georgia Basin population Historic record	Open riparian woodland, or modified forest (Forest fire or logged).	Open canopy, large, decayed trees or snags. Black cottonwood.	x		x	x					
Band-tailed Pigeon (*Patagioenas fasciata*)	Douglas fir, hemlock, cedar and spruce dominated stands.				x	x	x				
Double-crested Cormorant (*Phalacrocorax auritus*)	Low level areas adjacent to Fraser River or cliff edges adjacent to Fraser River.		x								
Barn Owl (*Tyto alba*)	Open areas, marsh, grasslands, human made structures, such as farm buildings.	Dense grassed areas, meadows, fields.	x						x	x	
Mammals											
Mountain Beaver (*Aplodontia rufa*)	Moist riparian habitat or seepage sites. High shrub and herb cover. Patchy crown closure. Generally N and E aspects.		x	x	x	x	X				
Townsend's Big-eared Bat (*Corynorhinus townsendii*) Historic record	Mesic habitats characterized by coniferous and deciduous forests. Nest/roost in cool, well ventilated areas – caves and buildings – not crevices or cracks.			x	x	x	x	x			
Snowshoe Hare (*Lepus americanus* ssp. *washingtonii*)	Dense shrub under canopy, and mixed forests. Prefers ecotones. Abundant herbs in summer.	Some use of swamps and fens.		x	X	x				x	x
Keen's Myotis (*Myotis keenii*) Historic record	Warm caves and crevices. Some use of loose bark/snags suspected. Small home range.	Forage in riparian areas.	x		x		x	x	x		
Townsend's Mole (*Scapanus townsendii*)	Grassy habitat with medium textured soil.									x	
Pacific Water Shrew (*Sorex bendirii*)	Streamside riparian zones, marshes, wetlands, and dense wet forests. LWD is important factor. Conifer and hardwood forests. Natural and modified streams.		x	x	x	x					

Trowbridge's Shrew (*Sorex trowbridgii*)	Mature forest (dry or moist) with abundant ground litter, forested canyons and ravines, and swampy woods; deep rank grass near salmonberry thickets; riparian fringe areas (but not streamside); under chaparral (at southern edge of range); cut forest if sufficient ground cover present.		x		x	x	x				
Vascular Plants											
Vancouver Island Beggarticks (*Bidens amplissima*)	Ditches, wet fields, edge habitat of standing water.		x	x							
Tall Beggarticks (*Bidens vulgata*)	Ditches, wet fields, edge habitat of standing water.		x	x							
Bearded Sedge (*Carex comosa*)	Shorelines, wet meadows.		x	x							
Fox Sedge (*Carex vulpinoidea*)	Wet meadows, swamps, marshes, and stream banks.		x	x							
Phantom Orchid (*Cephalanthera austiniae*)	Dense, moist to mesic coniferous forests.				x		x				
Farewell-to-spring (*Clarkia amoena* var. *caurina*)	Dry, grassy areas									x	
Pacific Waterleaf (*Hydrophyllum tenuipes*)	Mature to old mixed or deciduous forest.	Trail edges or clearings.	x			x	x				
Western Rush (*Juncus occidentalis*)	Moist exposed sites.		x	x							
False-pimpernel (*Lindernia dubia* var. *anagallidea*)	River or stream banks.	Lowland areas.	x	x							
Water-pepper (*Persicaria hydropiperoides*)	Saturated soils, shorelines and shallow water.		x	x							
Northern Water-meal (*Wolffia borealis*)	Ponds, lakes, slow moving streams.		x	x							
Mosses											
Silver Hair Moss (*Fabronia pusilla*)	Rock walls, crevices, dry areas.							x			

1.1 Appendix 2. Sumas Mountain SEI Map