

Terrestrial Ecosystem Mapping for the the *shíshálh swiya* Ts'unay (Deserted) Watershed (BAPID 6547)

PREPARED FOR

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Executive Summary

This report presents the results of Terrestrial Ecosystem Mapping (TEM) of Ts'unay (Deserted) watershed on the Sunshine Coast of British Columbia (BC) (the project area). This project is a joint initiative with the shíshálh Nation and Province of BC Land Use Planning Table (LUPT). The overall goal for this initiative is to develop a seamless, standardized Terrestrial Ecosystem Mapping (TEM) product for the entire land base of the shíshálh swiya (birthplace, world, lands, "Territory") to current TEM standards (RIC 1998 and RISC 2015), and BEC classification site series descriptions (Green and Klinka 1994).

Phase 1 of the project focused on assessing existing data. Based on approved funds, and an identified gap in TEM for the area, the Ts'unay (Deserted) watershed was selected as the priority assessment unit. Phase 2 of the project was the completion of a Project Plan for the Ts'unay (Deserted) Watershed TEM. This report is one of the deliverables of Phase 3, which included the completion of TEM and field verification.

The project area occurs within the *shíshálh swiya*, with a total mapped area of 16,201 ha. The project area is located within the CWH (dm, vm1, vm2), MH (mm1, mmp) and Coastal Mountain-heather Alpine (CMAun) biogeoclimatic zones. Ecosystem mapping was completed at a scale of 1:10,000 using the appropriate provincial standards and methods. PurVIEW software integrated within ArcGIS was used to view the final map product using on-screen aerial photography in stereo (3D).

Field verification of the map product was completed from November 21-27, 2019, and sampling was distributed across the project area on a wide range of ecosystems and site conditions. A total of 209 plots in 200 polygons were collected during field verification, resulting in a polygon sampling intensity of 16.4% (Level 4; 15-25%).

Based on the final linework, the average polygon size was 13.3 ha (1,219 polygons covering 16,201.4 ha). Forested ecosystems were the most common throughout the project area covering 8,600.0 ha (53.1%). Non-forested ecosystems, including sparsely vegetated ecosystems, occur on 46.9% (7,601.4 ha) of the project area.

All products were completed to provincial TEM standards. Experts in bioterrain and ecosystem mapping were hired to conduct 3rd party Quality Assurance. All QA input and feedback has been incorporated in the final product.

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Ecosystem linework was completed by Harry Williams, R.P.Bio., P.Ag., and Jennifer McEwen, R.P.Bio. of Madrone. Bioterrain linework was completed by Jessica Stewart, P.Geo., Roberta (Bobbie) Adams, P.Geo., and Harry Williams of Madrone.

Field work was carried out in November 2019 by Jessica Stewart, Harry Williams, Anna Yuill, Laurie Kremsater and Jennifer McEwen of Madrone. Madrone and crew would like to thank their helicopter pilot Tyler and everyone at Airspan Helicopters in Sechelt for keeping them safe in the field.

Internal Quality Assurance (QA) of the final linework was done by Jennifer McEwen, Tania Tripp, R.P.Bio., and Harry Williams, with QA of bioterrain by Gordon Butt, P.Geo. External (3rd party) QA of the ecosystem mapping was conducted by Del Meidinger. The GIS applications and digital products were completed by Anna Jeffries, B.A., ADGIS. Additional QA was completed in February 2022 by Jackie Churchill of the Ministry of Lands and Water Resource Stewardship (LWRS), and further updates were made to the final Ts'unay TEM product in June 2022.

List of Acronyms

Acronym	Description
ArcGIS	ESRI's Geographic Information System version 10.7
BC	British Columbia
BEC	Biogeoclimatic Ecosystem Classification
CMA	Coastal Mountain-Heather Alpine biogeoclimatic zone
CWH	Coastal Western Hemlock biogeoclimatic zone
EBM	Ecosystem-based management
GIS	Geographic Information System
ha	Hectares
LMH	Land Management Handbook
LMH28	Land Management Handbook #28 – A Field Guide for Site Identification and Interpretation of the Vancouver Forest Region
LMH52	Land Management Handbook #52 – Wetlands of British Columbia: A Guide to Identification
LUPT	Land Use Planning Team
LWRS	Ministry of Land and Water Resource Stewardship
m	Metres
MFLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
MH	Mountain Hemlock biogeoclimatic zone
PurVIEW	ArcGIS Desktop extension, 3D photo stereo-viewing software
QA	Quality Assurance
RISC	Resource Information Standards Committee
SIL	Survey Intensity Level
TEM	Terrestrial Ecosystem Mapping
TEIS	Terrestrial Ecosystem Information System
TRIM	Terrain Resource Information Management
TR068	Technical Report 068 – Biogeoclimatic Ecosystem Classification of Non-forested Ecosystems British Columbia
VRI	Vegetation Resource Inventory

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1 Introduction

This project was a joint venture between the *shíshálh* Nation and Province of BC Land Use Planning Table (LUPT) to better identify, protect and make shared decisions around resource stewardship and management within the *shíshálh swiya* (birthplace, world, lands, “Territory”). This project was initiated to obtain detailed coverage of Ecosystem Inventory and Mapping information in order to best inform land-based investments and resource management decision-making.

A TEM product with bioterrain attribution can provide a reliable and accurate measure of the baseline ecosystem conditions within the Ts’unay (Deserted) watershed. In combination with Vegetation Resource Inventory (VRI) and other data, this will enable ecosystem changes to be tracked and quantified over time to inform management strategies.

Primary applications that the TEM product will be used for:

- Assisting in providing information on the traditional heritage and forest features,
- Identifying aquatic habitats including fish habitat, active fluvial units, upland stream areas and sensitive watersheds,
- Providing insight on sensitive ecosystems that may be red- or blue-listed, and
- Informing land use decisions which may include forestry activities.

1.1 Study Area

The TEM project boundary included the terrestrial landbase within the Ts’unay (Deserted) watershed, covering 16,249 ha. Existing polygon linework and attributes within the watershed from the Jervis Inlet TEM (BAPID 4913; Timberline 2009) project were edited for consistency and incorporated into the final Ts’unay (Deserted) Watershed TEM product. One parcel of private land (207 ha) was excluded from the final TEM. Edge matching to existing mapping extended the mapped area beyond the project boundary by 153 ha. Therefore, the total area mapped for Ts’unay (Deserted) Watershed TEM was 16,201 ha (**Table 1**).

Table 1: Ts'unay (Deserted) Watershed.

Watershed Name	Ts'unay (Deserted River)
Landscape Unit	Jervis, Deserted
Watershed Area	16,249 ha
Excluded area (unmapped private lands)	207 ha
Edge matching areas included	153 ha
Existing mapping incorporated into final map area	3,209 ha
Total mapped area	16,201 ha

Topography in the Ts'unay (Deserted) watershed is highly variable and ranges from wide valley bottoms to steep mountains. The tallest mountain in the mapping area is Mount Crerar at 2,231 m, found southeast of the Deserted Bay. To the north of Mount Crerar is Mount Pearkes (2,162 m) and northeast of Mount Pearkes is Outrigger Peak (2,181 m). Amongst these mountains are a series of rugged peaks and ridges that surround the Ts'unay watershed: Abandoned Peak, Ponor N3, Ponor Peak, and Deserted Peak.

1.1.1 Biogeoclimatic Zones

The biogeoclimatic ecosystem classification (BEC) (zones, subzones, variants, and phases) of Ts'unay (Deserted) are summarized in Table 2. Most of Ts'unay watershed is in the Coastal Western Hemlock (CWH) Biogeoclimatic zone. Elevations above 800 metres are generally within the Mountain Hemlock (MH) and Coastal Mountain-Heather (CMA) Alpine zones. These broad biogeoclimatic zones are further subdivided into subzones and variants that reflect local climatic conditions.

It is important to note that the coastal BEC units are provided at a 1:250,000 scale and greater in version 11 of the BEC linework (BECv11)¹. This is not a useful scale for 1:20,000 and finer scale map products. The BEC lines for this project were initially adjusted to 1:20,000 using TRIM contours and selecting the elevation ranges outlined in Land Management Handbook #28 (*A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region*, 1994). The elevational breaks for the biogeoclimatic subzones and variants within the Ts'unay (Deserted) watershed based on LMH28 are shown in **Table 2**. The maximum elevation for the CWHdm / CWHvm1 was further adjusted to 660 m as the TRIM contours are in 20 m intervals (there is no 50 m contour). The representation of the biogeoclimatic subzones and variants in the Ts'unay (Deserted) watershed based on LMH28 refinements is shown in **Figure 1** and summarized in **Table 3**.

¹ <https://catalogue.data.gov.bc.ca/dataset/bec-map>

Table 2: BEC elevations within the Ts'unay (Deserted) Watershed (based on elevations outlined in LMH28).

BEC Unit	CWHdm	CWHvm1	CWHvm2	MHmm1	MHmmp	CMAun
Ts'unay (Deserted) Watershed	0 to 650 m	0 to 650 m	650 to 1,000 m	1,000 to 1,250 m	1,250 to 1,600 m	>1,600 m

Table 3: Summary of the Biogeoclimatic Units of the Ts'unay (Deserted) Watershed (based on refined linework).

BEC Unit	BEC Name (based on elevations from LMH28)	Land Area (ha)
CWHdm	Coastal Western Hemlock, dry maritime	1,478.8
CWHvm1	Coastal Western Hemlock, submontane very wet maritime	2,799.1
CWHvm2	Coastal Western Hemlock, montane very wet maritime	2,550.2
MHmm1	Mountain Hemlock, windward moist maritime	2,264.0
MHmmp	Mountain Hemlock, moist maritime parkland	3,512.5
CMAun	Coastal Mountain-heather Alpine, undifferentiated	3,956.9
Total		16,201.4


The study area includes both the dry maritime (CWHdm) and very moist submontane (CWHvm1) units, which occur at elevations below the CWHvm2 (from 0-650 m). As the names suggest, the CWHdm is drier than the CWHvm1, with the CWHdm occurring along the coastline where tidewater moderates the local climate, and the CWHvm1 occurring up into the cooler valleys.

1.1.2 Bedrock Geology








The general physiography of the Coast Mountains, also known geologically as the coast batholith, consists of bedrock composed of intrusive igneous rocks (plutonic). These are typically coarse crystalline rocks that range from syenite, to granitic types, and diorite. These rocks are resistant to weathering since they are composed of durable minerals such as quartz, hornblende, and feldspar. As a result, slopes in the mapping area are generally steep with rugged topography (Valentine et al. 1986).

Despite the resistance to weathering, some decomposition of plutonic rocks does occur - often as a result of frost shattering. Wide joint spacing in these rocks can result in large fragments dislodging and coarse rubble. This can result in rockslides (more common) and rockfall (less common). Physical and chemical weathering of granitic and dioritic rocks results in soils with a high sand content (Valentine et al. 1986).

Figure 1. Biogeoclimatic Zones, Subzones and Variants Within the Ts'unay (Deserted) Watershed

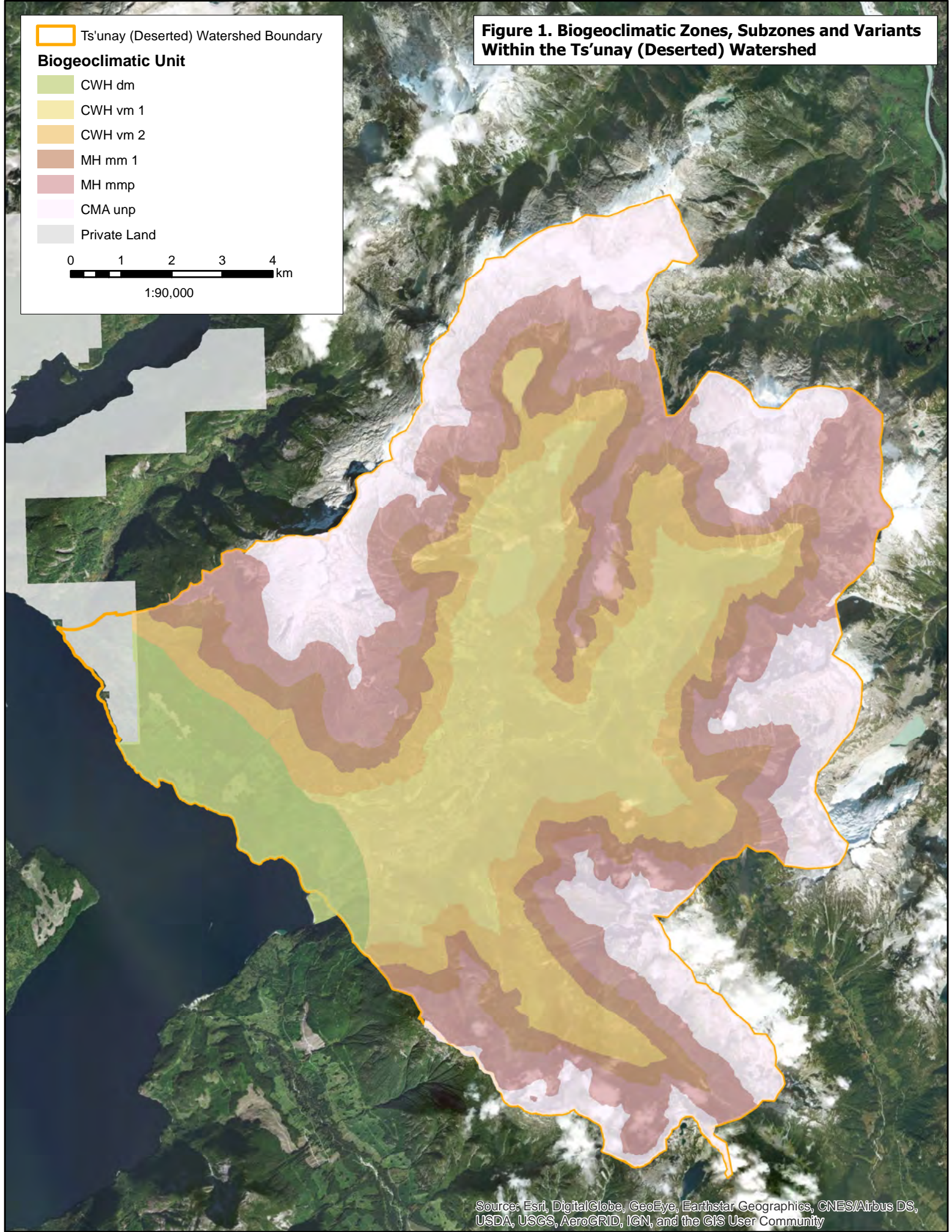
 Ts'unay (Deserted) Watershed Boundary

Biogeoclimatic Unit

-  CWH dm
-  CWH vm 1
-  CWH vm 2
-  MH mm 1
-  MH mmp
-  CMA unp
-  Private Land

0 1 2 3 4 km

1:90,000



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

1.1.3 Quaternary History – Glaciation

The Ts'unay valley was intensively glaciated during the last glaciation (Fraser glaciation), resulting in U-shaped valleys and some hanging tributary valleys. The steep topography is characterized by snow avalanche slopes, colluvium (talus slopes), erosion, and debris flows. Glaciation has resulted in rounded ridges and summits, and widespread morainal deposits on lower slopes and valley floors. In places rock drumlins and striations are present which indicate the direction of ice flow.

Glaciation resulted in a wide range of surficial materials from which most forest soils have formed. Till (also known as morainal deposits or mantles), and transported colluvium make up most of the glacial deposits in the area. The lower mountain slopes are covered in morainal mantle of variable thickness, and in steeper areas colluvium is more common.

The valley bottom areas within the study area have glaciofluvial (glacial river deposits) or glaciomarine deposits (sediments deposited in a marine setting), however extensive fluvial deposits along streams are more common. Very localized lacustrine deposits occur adjacent to the small lakes in the area.

1.1.4 Soils

The rocky, sandy soils are not inherently rich, but productivity is enhanced by forest litter, ground water, abundant riparian ecosystems, well-drained colluvial and alluvial fans, frequent soil mixing from windthrow, avalanching, and debris flows. Due to high precipitation and moderate to cool temperatures, the soils are generally wet, and tend to not freeze in the winter due to the insulating properties of deep snow. Soil moisture is available throughout much of the growing season, except on the drier south-facing slopes. Prolonged bedrock weathering has resulted in a soil that is acidic and coarse-textured (sandy). Humo-Ferric Podzols are the primary soil type in the study area.

Soils are generally well to moderately well-drained and composed of gravelly sand, often with a minor component of silt. Soil textures range from sandy loam (SL) to loamy sand (LS). Forest floors tend to have well-developed Mor humus forms reflecting the predominantly coniferous forest cover. More information on soils is found in Section 3.7.

2 Methodology

Standardized Terrestrial Ecosystem Mapping methods (RISC 1998) were applied to the map product for the Ts'unay (Deserted) Watershed TEM. Forested ecosystems were mapped using the Site Identification and Interpretation for the Vancouver Forest Region (LMH 28) (Green and Klinka 1994). Non-forested ecosystems were classified based on the BEC of Non-forested Ecosystems in BC (Mackenzie 2012) and wetlands were classified based on the Wetlands of BC: A Guide to Identification (Mackenzie and Moran 2004). Non-vegetated, sparsely vegetated and anthropogenic units were classified using the two-letter codes outlined in the RIC (1998) standards.

2.1 Review of Existing Data

The most recent version of the Vegetation Resource Inventory (VRI 2019) was downloaded from the BC Data Catalogue and referenced for the TEM. In particular, the age information in VRI was queried to compare the location of old growth with that mapped in the final TEM. Other data incorporated into the map was the 2,304 ha of existing linework and attributes from BAPID 4913 (Jervis LU TEM; Timberline 2009). All of the existing polygons in the study area were reviewed, edited and re-labeled where appropriate. This was to ensure consistency throughout the final product. **Table 4** provides a summary of data sources referenced in the final TEM product.

Table 4: Summary of Data Sources Referenced for TEM in the Ts'unay (Deserted) Watershed.

Data	Contact Person	Data Source	Notes
2005 Orthophotos	Angus Christian	Ortho photos via DataBC	Purchased ortho photos from DataBC to be converted for use in stereo (3D)
Vegetation Resource Inventory (VRI)	N/A	Data Catalogue	Madrone downloaded VRI2019 from public source (LRDW). This is the main source of VRI coverage for the swiya at this time.
BECv11	N/A	Data Catalogue	Downloaded BECv11 and used as a reference, but BEC for the project area was refined to reflect elevations in LMH28 and observations from the field.
Applicable TRIM	FLNRORD	TRIM contours via GTS	TRIM was obtained for contours, streams, etc.
Geology of the area	On-line, and Madrone files	Various	
FWA Streams, Rivers, Wetlands, Coastline	N/A	Data Catalogue	Downloaded the FWA layers.
Private Ownership (parcels)	N/A	<i>shishálh</i> Nation	Provided ownership layer
Jervis LU TEM (BAPID 4913)	MOECCS	TEI Unit	Linework and attribute data clipped to the study area

2.2 Imagery

For this project, 2005 orthophotos were purchased from DataBC and converted into stereo (3D) files by IGI Consulting Inc. for use with PurVIEW software integrated with ArcGIS. Significant challenges in compatibility of the data lead to mapping delays. To meet project deadlines, it was decided that the most recent colour imagery taken by Digital Globe and available through ESRI's BaseMap would be used with contours to map the Ts'unay (Deserted) Watershed TEM in 2D. The Digital Globe images were captured in 2016 and also provided a more recent overview of the study area. The 2005 orthophotos provided further clarity in areas covered by cloud in the Digital Globe images and the final QA of the map product was viewed in Stereo (3D) using the 2005 orthophotos.

2.3 Bioterrain Linework and Attribution

The primary objective of bioterrain attribution is to provide a thematic base map which captures the dominant physical parameters influencing ecological diversity across the landscape. Bioterrain polygon delineation is based on terrain elements: material type and texture, landform (including material thickness, and slope), and geological processes, and soil drainage. Polygon delineation also accounts for other factors that influence ecology such as aspect and slope morphology.

Applied bioterrain mapping principles involves the delineation of polygons based on surficial geological features as described in Howes and Kenk (1997). For example:

- Colluvial cones
- Alluvial fans
- Bedrock, at or near surface
- Glacial or modern fluvial deposits
- Till deposits (moraine, morainal mantel)
- Hummocky terrain
- Organic soil (wetlands)
- Major slope breaks

Bioterrain polygons incorporate observations such as surficial material, large surface boulders and blocks, gully morphology, signs of mass movement, erosion, and land use (e.g., gravel pits). Geological processes that are active in the mapped area can influence ecosystem development over time.

Surface expression provides an indication of material, thickness and slope. These landforms, in turn, influence rooting depth, the movement of moisture and nutrients through the landscape,

and the storage capacity for nutrients and moisture. In addition, the interpretation of landforms provides information on the mode of deposition, the material type, the age of the deposit, the glacial history, and the disturbance history.

Linework and labeling was completed at a scale of 1:10,000 within ArcGIS. Initial bioterrain labels were applied by Jessica Stewart and Roberta Adams of Madrone. Upon completion of the field work, adjustments were made to the bioterrain labels. Specifically, field data provided information concerning the presence of till (more common on gentle to moderate slopes), the downhill extent of colluvial slopes, presence of fluvial-glacial and small lacustrine deposits, location of debris flows, presence of organic soils (uncommon), and geological processes such as active or inactive colluvial slopes. Additional adjustments were made to some labels upon completion of the final QA by Gordon Butt.

2.4 Ecosystem Linework and Attribution

On completion of the bioterrain linework and attribution, polygons were split into smaller polygons (where applicable) based on the biological parameters of microclimate (e.g. warm and cool aspect slopes) and vegetation structural stages including:

- Productive vs. non-productive forests (dark green vs. pale green forests as seen on imagery),
- Logged vs. unlogged forests (logging generally occurs in more productive forests),
- Elevational changes in vegetation (crest, upper, lower, toe, etc.), and
- Alpine krummholz, shrub and meadow areas.

Each ecosystem polygon was labeled using provincial standards to describe the vegetation, site conditions, structural stage, stand composition, and disturbance (BCMOF and BCMOE 2010). The provincial TEIS long table format from the 2019 Contractor Package² was used for the project database, which includes a series of domains (drop-down lists) to assign relevant data to each column (*i.e.*, attribute the polygons). Due to limitations in the 2019 long table that were corrected in 2020, the project data was transferred into to the 2020 TEI long table format (Contractor_Package_20200319) in June 2022 based on QA feedback provided from LWRS.

Polygons were assigned up to three ecosystem types (components), each comprising a quantified proportion of the polygon area using deciles that add to 100% (e.g., decile one indicates 50% of ecosystem Type A, decile two indicates 30% of ecosystem Type B, and decile

² Contractor_Package_20190429

three could then indicate 20% of ecosystem Type C). Pure polygons (100% of one ecosystem type) were mapped whenever possible.

Preliminary ecosystem mapping for forested site series was based on the 2-digit classification coding and descriptions in the Vancouver Forest Region Field Guide (Green and Klinka 1994).

Non-forested, sparsely vegetated/non-vegetated, and anthropogenic units were classified using two upper case letters (TEI Unit 2020) or the two-letter group/realm and class classification system (TR068; Mackenzie 2012). Floodplain and wetland units with a structural stage of 4 or greater are classified as forested and were mapped with the appropriate numbered site series from LMH28. These units in a shrub (3a/3b) structural stage are considered non-forested and were attributed based on the classification in TR068 (e.g., F1 for low-bench floodplain units).

Wetlands, where they could be further described into their site association, are classified using a four-character code where the first two characters are letters which describe the type of wetland (the first letter uppercase, and the second lower), while the second two characters are numbers that represent the wetland site association (such as Wf01) (LMH52; Mackenzie and Moran 2004).

2.4.1 Site Modifiers

As described in the 1998 TEM standards, site modifiers (a set of descriptive terms for certain site conditions) are used to describe conditions specific to an ecosystem. For example, if a site series happens to occur on a warm or cool aspect, a warm (w) or cool (k) modifier code will be applied in the data base. In the geologically active Ts'unay watershed, site modifiers have been applied to a number of landforms including active floodplain, alluvial fans or colluvial cones, hummocky terrain, gentle slopes, steep slopes, gullies, ridges, terraces, shallow and very shallow soils, peaty soils, and coarse-textured soil. Ecosystem site modifiers applied in the mapping are provided in Appendix I.

2.4.2 Structural Stages

A numerical structural stage designation (1 through 7; indicating exposed soil/sparsely vegetated through old forest) was assigned to each mapped ecosystem (BCMOF and BCMOE 2010). A structural stage modifier (a single lower-case letter) further characterizes the structural stages (Appendix I).

Structural stage designations followed current standards. One variation is that old forests that have naturally stunted trees (due to poor site conditions) were given a structural stage of 7 (non-productive), while more productive (typical), old forests were assigned 7a (>250 years) or 7b (>400 years).

Krummholz forests in the MHmmp and CMA were mapped as 3b (tall shrub) despite the fact that individual stems are often greater than 100 years old. This approach provides a simple way to distinguish between these very different looking types of forest (from a structural perspective, and as it relates to wildlife values).

2.4.3 Stand Composition

A stand composition (appearance) modifier (single upper-case letter) is used to differentiate forest stands (structural stages greater than 4) based on whether they are dominated by conifers, broad-leafed trees, or mixed (C, B, or M) (Appendix I). Forested ecosystems were classified as coniferous or broadleaf when 75% or greater of the stand consisted of coniferous or deciduous tree species, respectively. The mixed stand modifier was assigned when neither the coniferous nor deciduous tree species were dominant.

2.4.4 Polygon Size

Terrestrial ecosystem mapping standards specify a minimum polygon size of 10 ha for a 1:10 000 scale TEM product (RISC 1998). However, in order to capture biologically important features, some polygons smaller than 10 ha were mapped, including:

- Old forests, especially when they occurred as islands within an extensively logged area,
- Wetlands (bogs, fens, marshes, and riparian areas),
- Alluvial fans,
- Sub-alpine features, and
- Avalanche tracks.

2.5 Field Assessment

In order to meet the standard for a Survey Intensity Level (SIL) 4 in the preliminary product used for field verification, the number of polygons visited in the field must be 15-25% of the total number of polygons mapped. Typically, the estimated ratio of the field sampling is for 5% full plots, 20% ground plots and 75% visual checks (by ground or air)(RIC 1998). However, for this project, to attempt to meet the plot sampling goal, full plots were only to be collected where/if necessary, to describe new or unusual ecosystems encountered in the field. The rationale for excluding full plots was that they would add significant time to the sampling, resulting in fewer plots being collected. As a result, the ratio for full plots was adjusted to 0% and the ratio for ground plots increased to 25%. This variance from the TEM standards was approved by the *shishálh* Nation and LUPT project team but was not submitted to the Regional Ecologists for approval.

Data collection followed the standard ecological data collection techniques and methodologies as defined in the Field Manual for Describing Terrestrial Ecosystems (2010). Field crews

completed the provincial standard forms for data capture (FS1333 for Ground and Visual plots). Handheld GPS units as well as iPads were used to record the spatial location of each plot. Some plots observations were conducted from a distance (i.e., air calls, or visuals across a landscape) and were marked on field maps and written on plot cards.

2.6 Database Completion

On completion of the field sampling, the Madrone TEM database (based on the TEI standardized file geodatabase format) was updated to reflect site observations for each polygon visited. Plot data was then used during final mapping to apply corrections and updates to the database.

2.7 Project Team

Our project team members and their roles and responsibilities for the Ts'unay (Deserted) Watershed TEM are summarized in **Table 5**. The team consisted of a project manager, professional (senior) terrain/bioterrain specialists, professional terrestrial ecosystem ecologists, junior ecosystem mappers, and GIS analyst.

Table 5: Ts'unay (Deserted) Watershed TEM Project Team.

Team Member (Madrone)	Role/Responsibility
Tania Tripp	Project Management, Professional Terrestrial Ecosystem Ecologist, Reporting, Internal Review and Quality Assurance
Harry Williams	Professional Terrestrial Ecosystem Ecologist, Bioterrain Mapper, Field Crew Member
Jennifer McEwen	Professional Terrestrial Ecosystem Ecologist, Data Management, Quality Assurance, Field Crew Member
Roberta Adams	Professional Bioterrain Specialist
Jessica Stewart	Professional Bioterrain Specialist, Field Crew Member
Laurie Kremsater	Professional Terrestrial Ecosystem Ecologist, Field Crew Member
Anna Yuill	Junior Ecosystem Mapper, Field Crew Member
Anna Jeffries	GIS Analyst
Other (3rd Party)	
Del Meidinger	Professional Terrestrial Ecosystem Ecologist, Quality Assurance
Gordon Butt	Professional Bioterrain Specialist, Quality Assurance

2.7.1 Quality Assurance and Internal Review

Internal (Tania Tripp, Harry Williams, and Jennifer McEwen) and external QA (Del Meidinger) of the ecosystem linework and labels was conducted prior to the completion of this product (Appendix II). Third party QA comments were addressed by the ecosystem mapper, and then reviewed by the other mappers to ensure consistency throughout the project area. A thorough

final QA was completed to capture and change any errors in the database. A table outlining some of the steps taken during the final QA process can be found in Appendix II.

Bioterrain labels were applied to all polygons by Harry Williams and Jessica Stewart of Madrone. To maintain the integrity of TEM standards, the final linework and bioterrain attribution was reviewed by Senior Terrain mapper, Gordon Butt (P. Geo), who randomly selected polygons and QA'd approximately 15% of the bioterrain polygons. QA comments were incorporated by Harry Williams and Jessica Stewart.

2.8 Final Products

The final GIS product, created in ArcGIS 10.7, represents a seamless digital feature class with corresponding attributes for each polygon. All digital files have gone through internal quality control including topology using ArcGIS 10.7, to ensure accuracy of both the polygon delineation and the integrity of the datasets. The digital files also went through the various processes and tools located within the TEIS Environment (Contractor_Package_20200319) for digital submission. The spatial databases are in accordance with the current *Terrestrial Ecosystem Information Digital Data Submission Standard – Draft for Field Testing (Database and GIS Data Standards)* and other RISC standards where applicable (RISC 2015).

A seamless polygon coverage was produced, containing the polygons with the corresponding digital polygon attribute database, including all core TEM attributes. Additional polygon attributes were included as User Defined tables in the project geodatabase. Each feature within the spatial data has an appropriate feature code and a unique identifier (POLYPROJID) linking spatial features to the attribute database(s).

The following is a list of the deliverables:

- Project Plan (tem_6547_pp.pdf)
- Digital data submission of the updated TEM linework as a digital product (i.e., TEIS polygons long-table format as per current digital data submission standards (2015) (as provided in the 2020 contractor package) (TEI_Long_Tbl, TEI_Project_Details, TEI_Sample_Site_Points, TEI_User_Dfn_Data, and TEI_User_Dfn_Fields within Operational_Data_6547.gdb)
- Field data including photos and scanned plot cards (tem_6547_eci.zip)
- Project report outlining applied methods and results for the Ts'unay (Deserted) Watershed (this report – tem_6547_rpt.pdf)
- Working Legend (tem_6547_wl.xls)
- Signed Project Completion Certificate (tem_6547_cert.pdf)

All project deliverables are signed-off by a Registered Professional Biologist, a Professional Geoscientist and GIS Project Manager.

3 Results

A total of 1,219 ecosystem polygons were delineated in the TEM product, covering 16,201.4 ha. Upon completion of the field assessment, bioterrain attribution, and ecosystem linework and attribution updates, the average polygon size was 13.3 hectares. Due to the topography and higher diversity of landforms, smaller polygons were more frequently mapped along the steep upper sides of the mountains in the CWHvm2, MHmm1 and MHmmp (**Table 6**).

Table 6: Average polygon size mapped by BEC within the Ts'unay (Deserted) Watershed TEM.

	CMAun	CWHdm	CWHvm1	CWHvm2	MHmm1	MHmmp
Average Polygon Size (ha)	18.2	21.8	14.3	14.0	10.0	10.6

The majority of the mapped polygons (6,832.9 ha; 42.2%) were in the CWH zone; with 37.4% (6057.3 ha) in the MH zone and 20.4 % (3,311.2 ha) in the CMA zone. The MHmm1 represented the largest subzone mapped with 3,445.3 ha or 21.3 % of the total project area (**Table 7**).

Table 7: Ecosystem Unit Area (hectares) Proportion Summary by BEC Unit Mapped Within the Ts'unay (Deserted) Watershed TEM.

Ecosystem Unit	CMAun	CWHdm	CWHvm1	CWHvm2	MHm1	MHmmp
01	-	526.8	917.1	840.3	1,448.0	51.6
02	-	9.0	17.6	104.4	614.9	383.9
03	-	153.1	200.2	281.2	118.7	1.8
04	-	50.9	56.5	50.2	98.1	0.8
05	-	406.1	637.8	292.0	113.0	-
06	-	6.1	41.5	75.0	9.2	-
07	-	155.8	214.1	87.1	8.0	6.0
08	-	63.3	153.2	99.0	-	-
09	-	51.5	76.7	19.9	5.7	-
10	-	22.1	111.7	10.6	-	-
11	-	-	-	2.9	-	-
12	-	6.3	-	-	-	-
14	-	-	0.5	-	-	-
Af	2,211.5	-	-	-	-	5.9
Ah	520.8	-	-	-	15.7	353.0
As	1.2	-	-	-	-	-
Fa	-	-	8.7	-	1.0	-
Fl	-	-	12.8	-	-	-
Fm	-	-	2.0	-	-	-
LA	-	-	123.4	58.8	-	82.9
PD	2.7	-	-	-	-	13.0
PS	434.3	-	-	-	-	-
Rc	-	-	8.2	43.9	81.8	134.4
RI	-	-	14.7	10.6	-	-
Ro	-	1.2	17.2	62.3	46.7	288.0
Rt	-	6.9	41.9	90.5	234.4	532.1
Sk	92.6	-	-	-	24.1	275.6
Vh	5.5	-	2.3	12.6	22.9	54.8
Vs	37.6	-	122.8	366.0	549.7	408.0
Vt	-	-	10.4	43.9	47.6	12.4
Wf	-	3.1	-	-	0.7	-
Wf50	-	-	-	3.7	1.5	-
Wm01	-	-	3.3	-	-	-
Wm50	-	-	1.3	-	-	-
Ws	-	18.0	-	-	-	-
Ww	5.0	2.0	-	-	3.7	7.8
Total	3,311.2	1,482.2	2,795.6	2,555.1	3,445.3	2,611.9

3.1 Field Sampling (Plot Data)

Field verification of the map product was completed from November 21 to 27, 2019 (refer to Table 5 for a list of field crew members). Due to the remote location of the Ts'unay watershed, a helicopter was chartered for the field verification. Field verification sites were limited by the helicopter's ability to safely drop off and pick-up field crews in steep, mountainous terrain. As field verification occurred in November, daylight was severely limited, reducing the amount of sampling time for field crews. To achieve the overall survey intensity goals, there was a need to increase the number of visual plots collected over ground plots, which are more time intensive. A total of 209 plots were collected in the field including ground plots and visual inspections. No full plots were sampled in the field. An additional 13 polygons were verified from the helicopter, but these were not official plots and have not been included in the plot count below. A summary of the plots can be found in **Table 8**.

Table 8: Plot Sampling Summary by Project Area and BEC Unit in the Ts'unay (Deserted) Watershed TEM.

BEC Unit	Ground plots	Visual plots	Plot Total
Requirements for SIL4	25%	75%	100%
Minimum plot counts for SIL4 (15%) *based on the final linework (1,219 polygons)	46	137	183
Madrone Plots			
CWHdm	19	22	41
CWHvm1	4	41	45
CWHvm2	11	29	40
MHm1	6	59	65
MHmmp	-	15	15
CMAun	-	3	3
Total Plots	40	169	209
Percentage of Total Plots Collected	19.1%	80.9%	100%

Upon completion of the final mapping, some of the plots collected were located in the same polygon. This resulted in the verification of 200 polygons for 16.4% verification overall (SIL 4).

3.2 Biogeoclimatic Classification

Determining where the CWHdm ends and the CWHvm1 begins is often based on the presence of amabilis fir (*Abies amabilis*) and Alaskan blueberry (*Vaccinium alaskaense*) in the CWHvm1, and the lack of these two species in the CWHdm. As it is often difficult to interpret this from imagery alone, the information gathered from the plots, VRI2019 and experience informed the


adjustments to the BEC between the CWHdm and CWHvm1. Specifically, in areas where the CWHdm occurs on steep warm aspects, this subzone extends higher in elevation and abuts the CWHvm2 at about 660 m. In the Ts'unay river valley, the CWHdm extends up about 2km along the river, to a point where the valley narrows and enters cooler mountainous terrain.


While mapping, it was noted that productive forest extended into areas that were identified within the moist maritime parkland zone (MHmmp), especially on slopes with a warm aspect. As closed-canopy (fully stocked) forested ecosystems should not occur in the parkland, discussions between Madrone and *shishálh* Nation, and 3rd party QA (Del Meidinger) resulted in agreement that the BEC boundary between the MHmmp and the moist maritime unit (MHmm1) should be refined to better match the ecological boundaries observed. Similarly, the boundary between the MHmmp and CMAun required refinement, where applicable. **Table 9** provides the changes in the areas mapped by BEC within the Ts'unay (Deserted) Watershed TEM. As a result of the edits, more of the study area was mapped as the forested MHmm1, with less mapped as MHmmp. There was also a reduction in the total amount of area mapped in the alpine (CMAun). **Figure 2** provides a visual representation of the distribution of field plots in the study area by the final (revised) BEC.

Table 9: Approximate Elevational Breaks and Summary of Area by BEC Within the Ts'unay (Deserted) Watershed TEM.








BEC Unit	CWHdm	CWHvm1	CWHvm2	MHmm1	MHmmp	CMAun
Elevation from LMH28	0 to 650 m	0 to 650 m	650 to 1,000 m	1,000 to 1,250 m	1,250 to 1,600 m	>1,600 m
Final BEC (adjusted)	0 to 660 m	0 to 660 m	660 to 1,000 m	1,000 to 1,600 m	1,260 to 2,000 m	1,600 to >2,000m
Area mapped (pre-adjustment)	1,482.2 ha	2,795.7 ha	2,551.2ha	2,264.0 ha	3,512.5 ha	3,595.9 ha
Area mapped (post-adjustment)	1,482.2 ha	2,795.7 ha	2,555.1 ha	3,445.3 ha	2,611.9 ha	3,311.2 ha

Figure 2. Polygon Field Verification Coverage (plot locations during November 2019).



 Ts'unay (Deserted) Watershed Boundary

 TEM Polygon

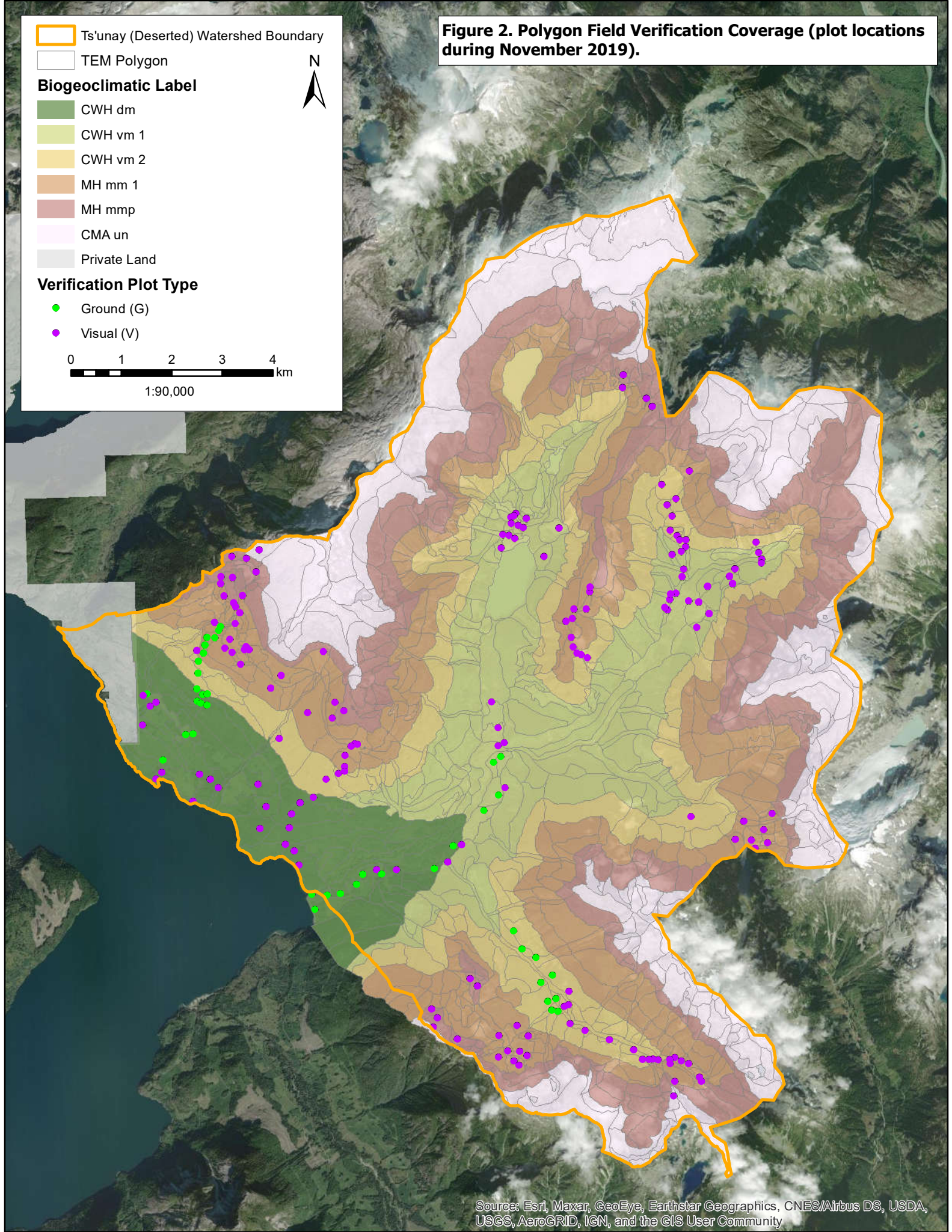

Biogeoclimatic Label

-  CWH dm
-  CWH vm 1
-  CWH vm 2
-  MH mm 1
-  MH mmp
-  CMA un
-  Private Land

Verification Plot Type

-  Ground (G)
-  Visual (V)

0 1 2 3 4 km
1:90,000



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

3.3 Forested Ecosystems

Forested ecosystems represented over half of the ecosystems on the landscape, 8,600.0 ha (53.1%). Forested ecosystem representation within each of the BEC units is summarized in the following sub-sections. For each BEC unit, the red- or blue-listed designation (BC CDC site accessed February 2020) of the forested units is identified and could apply to forests that are in old forest condition (>250 years) or floodplain units at any stage (Banner et. al 2019).

A list of the ecosystem units mapped in the project area is provided in Appendix III and includes names, descriptions, characteristic vegetation and ecological conditions.

The most common trees species at low elevation (CWHdm and CWHvm1) are Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), western red-cedar (*Thuja plicata*), with occasional western white pine (*Pinus monticola*), and lodgepole pine (*Pinus contorta*).

At mid to high elevations (CWHvm2, MHmm1) the main species are amabilis fir (*Abies amabilis*), yellow cedar (*Chamaecyparis nootkatensis*), sub-alpine fir (*Abies lasiocarpa*) and mountain hemlock (*Tsuga mertensiana*). Stunted trees (yellow cedar, mountain hemlock, and sub-alpine fir) are found in the MHmmp.

Deciduous trees are most common at lower elevations, and include red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and black cottonwood (*Populus trichocarpa*).

3.3.1 CWHdm

The forested ecosystems within the CWHdm covers 9.0% (1,451ha) of the total mapped area, and 97.9% of the BEC unit. Within the CWHdm, the most common ecosystem is the mesic zonal Western hemlock (Hw) – Flat moss forest (Site Series 01) occurring over 35.5% (526.8 ha) of the BEC unit. Other common forested units in the CWHdm included the Western redcedar (Cw) – Sword fern (05), Western redcedar – Foamflower (Site Series 07), and the Douglas-fir - Western hemlock (FdCw) – Salal (Site Series 03), representing the following respective areas 27.4%, 10.5% and 10.3% (**Table 9**).

Trends specific to the CWHdm across the Ts'unay watershed include:

- On warm aspects close to tidewater the CWHdm extends up in elevation to 650 m.
- While the mesic Western Hemlock – Flat moss forest (01) is the most common ecosystem, the slightly richer Western Redcedar – Sword fern (05) is also common (more common than initially mapped).
- Very dry lodgepole pine stands were found on rocky outcrops close to the inlet.

- The richer Western redcedar – Foamflower (07) is common along small creeks and gullies.
- The most common floodplain unit seen during field work was the mid-bench floodplain on small creeks (09). The low bench (10) was over-attributed.
- Although not obvious from the imagery, there are frequent small dry rocky areas where the Douglas-fir - Western hemlock (FdCw) – Salal (03) occurs.

Table 9: Forested Ecosystems Mapped in the CWHdm of the Ts'unay (Deserted) Watershed TEM.

Site Series	Ecosystem name	Potential for Rare Ecosystem	Area (ha)	% of BEC Unit	% of Area Mapped
01	Hw – Flat moss	Blue*	526.8	35.5	3.3
02	FdPI – Cladina		9.0	0.6	0.1
03	FdHw – Salal	Red*	153.1	10.3	0.9
04	Fd – Sword Fern	Red*	50.9	3.4	0.3
05	Cw – Sword fern	Red*	406.1	27.4	2.1
06	HwCw – Deer fern	Red*	6.1	0.4	<0.1
07	Cw – Foamflower	Blue**	155.8	10.5	1.0
08	Ss – Salmonberry (high-bench)	Red***	63.3	4.3	0.4
09	Act – Red-osier dogwood (mid-bench)	Blue***	51.5	3.5	0.3
10	Act – Willow (FI50 – Sitka willow – False lily-of-valley) (low-bench)	Blue***	22.1	1.5	0.1
12	CwSs – Skunk cabbage	Blue*	6.3	0.4	<0.1
Total Area within the CWHdm			1,451.0	97.9	9.0

*This site series/ecosystem is considered a red- or blue-listed ecological community when in old forest condition (structural stage 7/7a/7b).

**This site series/ecosystem was present on the landscape in an old forest condition (structural stage 7/7a/7b).

***This site series/ecosystem is considered a red- or blue-listed ecological community regardless of structural stage

3.3.2 CWHvm1

A total of 2,426.7 hectares of forested units were mapped in the CWHvm1, representing 15.0% of the total area within the Ts'unay watershed, and 86.8% of the BEC unit. The most common ecosystem within the CWHvm1 was the mesic zonal Western hemlock - Amabilis fir (HwBa) – Blueberry (01) forest occurring over 32.8% of this unit. The second most common forested unit was the Amabilis fir - Western redcedar (BaCw) – Foamflower (05), which comprised 22.8% of the CWHvm1 (**Table 10**). All other ecosystems ranged between 0.6% - 7.7% of the CWHvm1.

Trends specific to the CWHvm1 across the Ts'unay watershed included:

- Productive forests
- Deciduous species only on warm aspects

Table 10: Forested Ecosystems Mapped in the CWHvm1 of the Ts'unay (Deserted) Watershed TEM.

Site Series	Ecosystem name	Potential for Rare Ecosystem	Area (ha)	% of BEC Unit	% of Area Mapped
01	HwBa – Blueberry		917.1	32.8	5.7
02	HwPl – Cladina		17.6	0.6	0.1
03	HwCw – Salal	Blue*	200.2	7.2	1.2
04	CwHw – Sword fern	Blue*	56.5	2.0	0.3
05	BaCw – Foamflower		637.8	22.8	3.9
06	HwBa – Deer fern	Blue*	41.5	1.5	0.3
07	BaCw – Salmonberry	Blue*	214.1	7.7	1.3
08	BaSs – Devil's club	Blue*	153.2	5.5	0.9
09	Ss – Salmonberry (high-bench)	Red**	76.7	2.7	0.5
10	Act – Red-osier dogwood (mid-bench)	Blue**	111.7	4.0	0.7
14	CwSs - Skunk Cabbage (Ws54 - CwHw - Skunk cabbage)		0.5	<0.1	<0.1
Total Area within the CWHvm1			2,426.7	86.8	15.0

*This site series/ecosystem was present on the landscape in an old forest condition (structural stage 7/7a/7b).

**This site series/ecosystem is considered a red- or blue-listed ecological community regardless of structural stage

3.3.3 CWHvm2

A total of 1,862.8 hectares of forested units were mapped in the CWHvm2, representing 11.5% of the total area mapped, and 72.9% of the BEC unit. The most common forested ecosystem typed within the CWHvm2 with was the zonal Western hemlock - Amabilis fir (HwBa) – Blueberry (01) forest which comprised 32.9% of the BEC subzone/variant. Other common forested sites included the Amabilis fir - Western redcedar (BaCw) – Foamflower (05) and the Western hemlock -Western redcedar (HwCw) – Salal (03) ecosystems which account for 11.4% and 11.0%, respectively (**Table 11**).

Trends specific to the CWHvm2 across the Ts'unay watershed included:

- Steeper terrain and more amabilis fir than at lower elevations
- Only deciduous species is red alder (*Alnus rubra*)
- Avalanche and talus slopes from higher elevation often extend into this subzone
- Less HwBa - Deer fern (06) observed in the field than initially mapped
- BaCw – Salmonberry was more common than initially mapped
- Similarly, there was less BaSs - Devil's club than initially mapped
- Douglas-fir common on warm aspects
- Western white pine (*Pinus monticola*) present in a few locations
- Access was difficult in this subzone

Table 11: Forested Ecosystems Mapped in the CWHvm2 of the Ts'unay (Deserted) Watershed TEM.

Site Series	Ecosystem name	Potential for Rare Ecosystem	Area (ha)	% of BEC Unit	% of Area Mapped
01	HwBa – Blueberry		840.3	32.9	5.2
02	HwPl – Cladina		104.4	4.1	0.6
03	HwCw – Salal	Blue**	281.2	11.0	1.7
04	CwHw – Sword fern	Blue**	50.2	2.0	0.3
05	BaCw – Foamflower		292.0	11.4	1.8
06	HwBa – Deer fern	Blue**	75.0	2.9	0.5
07	BaCw – Salmonberry	Blue**	87.1	3.4	0.5
08	BaSs – Devil's club	Blue**	99.0	3.9	0.6
09	CwYc – Goldthread	Red*	19.9	0.8	0.1
10	Pl – Sphagnum	Blue*	10.6	0.4	0.1
11	CwYc – Skunk cabbage (Ws54 – CwHw – Skunk cabbage)	Blue*	2.9	0.1	<0.1
Total Area in the CWHvm2			1,862.8	72.9	11.5

*This site series/ecosystem is considered a red- or blue-listed ecological community when in old forest condition (structural stage 7/7a/7b).

**This site series/ecosystem was present on the landscape in an old forest condition (structural stage 7/7a/7b).

3.3.4 MHmm1

A total of 2,415.6 hectares of forested units were mapped in the MHmm1, representing 14.9% of the total area mapped, and 70.1% of the BEC unit. The most common ecosystem within the MHmm1 was the zonal Mountain hemlock - Amabilis fir (HmBa) – Blueberry (01) forest which comprised 42.0 % of the BEC subzone/variant mapped. The drier Mountain hemlock - Amabilis fir (HmBa) – Mountain heather (02) forested ecosystems were also commonly mapped (17.8%) within MHmm1 (**Table 12**). Other forested ecosystems with the MHmm1 ranged from 0.2% - 3.4% contributing to a very small portion of the MHmm1.

Trends specific to the MHmm1 across the Ts'unay watershed included:

- The MHmm1 forested areas were refined to better match the ecological boundaries observed within the field.
- Productive forests composed of mountain hemlock, sub-alpine fir, yellow cedar, and western redcedar were common
- Very few of the 03, 04, 05, 06, or 07 ecosystems were seen.
- Access was difficult in this subzone.
- Western white pine (*Pinus monticola*) present in a few locations

Table 12: Forested Ecosystems Mapped in the MHmm1 of the Ts'unay (Deserted) Watershed TEM.

Site Series	Ecosystem name	Potential for Rare Ecosystem	Hectares (ha)	% of BEC Unit	% of Area Mapped
01	HmBa - Blueberry		1,448.0	42.0	8.9
02	HmBa - Mountain-heather		614.9	17.8	3.8
03	BaHm - Oak fern		118.7	3.4	0.7
04	HmBa - Bramble		98.1	2.8	0.6
05	BaHm - Twistedstalk		113.0	3.3	0.7
06	HmYc - Deer-cabbage		9.2	0.3	0.1
07	YcHm - Hellebore		8.0	0.2	<0.1
09	YcHm – Skunk cabbage		5.7	0.2	<0.1
Total Area within the MHmm1			2,415.6	70.1	14.9

3.3.5 MHmmp

Forest ecosystems mapped within the MHmmp comprised of approximately 2.7 (444.0 ha) of the total landbase. To preserve fluidity of the BEC linework some of the areas mapped as parkland contained forested ecosystems. Forested ecosystems that occurred within the MHmmp were mapped using the site series descriptions for the MHmm1, and largely consisted of drier forested sites on exposed slopes and ridge crests indicative of the Mountain hemlock - Amabilis fir (HmBa) – Mountain-heather (02) site series (86.5% of the forests mapped and 14.7% of the BEC unit). The Mountain hemlock - Amabilis fir (HmBa) – Blueberry (01), Amabilis fir – Mountain hemlock (BaHm) – Oak fern (03), Mountain hemlock - Amabilis fir (HmBa) – Bramble (04) and Yellow-cedar - Mountain hemlock (YcHm) – Hellebore (07), were the other forested units mapped, comprising 2.0%, 0.1%, <0.1% and 0.2% of the total area mapped in the MHmmp respectively (**Table 13**).

Trends noted from the MHmmp included:

- The MHmmp occurred at elevations higher than anticipated, between 1,260 to 2,000m
- Forested classifications were used to describe sites with well-developed conifer stands, but within the MHmmp
- Shrubby ecosystems were common
- Impressive “tree islands” of yellow-cedar and mountain hemlock are present

Table 13: Forested Ecosystems Mapped in the MHmmp of the Ts'unay (Deserted) Watershed TEM.

Site Series	Ecosystem name (from MHmm1)	Potential for Rare Ecosystem	Hectares (ha)	% of BEC Unit	% of Area Mapped
01	HmBa - Blueberry		51.6	2.0	0.3
02	HmBa - Mountain-heather		383.9	14.7	2.4
03	BaHm – Oak fern		1.8	0.1	<0.1
04	HmBa - Bramble		0.8	<0.1	<0.1
07	YcHm - Hellebore		6.0	0.2	<0.1
Total Area within the MHmmp			444.0	17.0	2.7

3.4 Non-forested Ecosystems

The following results summarize the non-forested ecosystems mapped in the Ts'unay (Deserted) watershed project area by BEC subzone and variant (**Table 14**). A list of the ecosystem units mapped is provided in Appendix III and includes names, descriptions, characteristic vegetation and project area conditions. Mapcodes for the non-forested and sparsely vegetated units were updated in June 2022 to reflect the most recent standards (TEI Unit 2020)

3.4.1 Non-Forested Ecosystems

Non-forested ecosystems, including sparsely vegetated ecosystems and wetlands, represented 46.9% (7,601.4 ha) of the project area mapped. Within each BEC unit, the representation of non-forested ecosystems included:

- CWHdm (31.2 hectares; representing 2.1% of the BEC unit)
- CWHvm1 (368.9 hectares; representing 13.2% of the BEC unit)
- CWHvm2 (692.3 hectares; representing 27.1 of the BEC unit)
- MHmm1 (1,029.7 hectares; representing 29.9% of the BEC unit)
- MHmmp (2,168.0 hectares; representing 83.0 % of the BEC unit)
- CMAun (3,311.2 hectares; representing 100.0% of the BEC unit)

Wetland ecosystems represented 0.3% (50.0 ha) of the total area mapped. Swamps were the most common wetland type mapped. Shallow open water wetlands, fens, and marshes were also mapped throughout the project area (**Table 14**). None of the wetland units mapped are red- or blue-listed ecological communities within the BEC zones in Ts'unay watershed, however, they are still considered sensitive ecosystems and are recognized as blue- or red-ecosystems within other BEC units in BC.

Table 14: Non-forested Ecosystems Mapped Within the Ts'unay (Deserted) Watershed TEM (summarized by BEC Unit and total area).

Ecosystem Unit	CMAun (ha)	CWHdm (ha)	CWHvm1 (ha)	CWHvm2 (ha)	MHm1 (ha)	MHmmp (ha)	TEM (ha)	% of Area Mapped
Af	2,211.5	-	-	-	-	5.9	2,217.5	13.7
Ah	520.8	-	-	-	15.7	353.0	889.6	5.5
As	1.2	-	-	-	-	-	1.2	<0.1
Fa	-	-	8.7	-	1.0	-	9.6	0.1
Fl	-	-	12.8	-	-	-	12.8	0.1
Fm	-	-	2.0	-	-	-	2.0	<0.1
LA	-	-	123.4	58.8	-	82.9	265.0	1.6
PD	2.7	-	-	-	-	13.0	15.7	0.1
PS	434.3	-	-	-	-	-	434.3	2.7
Rc	-	-	8.2	43.9	81.8	134.4	268.3	1.7
RI	-	-	14.7	10.6	-	-	25.3	0.2
Ro	-	1.2	17.2	62.3	46.7	288.0	415.3	2.6
Rt	-	6.9	41.9	90.5	234.4	532.1	905.8	5.6
Sk	92.6	-	-	-	24.1	275.6	392.3	2.4
Vh	5.5	-	2.3	12.6	22.9	54.8	98.0	0.6
Vs	37.6	-	122.8	366.0	549.7	408.0	1,484.1	9.2
Vt	-	-	10.4	43.9	47.6	12.4	114.3	0.7
Wf	-	3.1	-	-	0.7	-	3.7	<0.1
Wf50	-	-	-	3.7	1.5	-	5.2	<0.1
Wm01	-	-	3.3	-	-	-	3.3	<0.1
Wm50	-	-	1.3	-	-	-	1.3	<0.1
Ws	-	18.0	-	-	-	-	18.0	0.1
Ww	5.0	2.0	-	-	3.7	7.8	18.5	0.1
Totals	3,311.2	31.2	368.9	692.3	1,029.7	2,168.0	7,601.4	46.9

Active (Fa), low (Fl) and mid-bench (Fm) floodplain, river (RI), lake (LA), and pond (PD) units represented 573.5 ha (3.5%) of the study area.

In the alpine and parkland, non-forested and sparsely vegetated ecosystems included permanent snow (PS), krummholz (Sk), alpine heath (Ah), alpine nivation (late snowbed) (As) and alpine fellfield (Af), representing 24.3% (3,934.9 ha) of the project area.

Rock (Ro/Rc/Rt) and ecosystems regularly impacted by avalanching (Vt/Vs/Vh) were also commonly mapped in all areas except the CWHdm (Table 15). Collectively, the avalanche ecosystems (Vt/Vs/Vh) accounted for 10.5% (1,696.5 hectares) of the study area and the rock ecosystem (Ro/Rc/Rt) accounted for 9.8% (1,589.5 ha).

3.5 Structural Stages

Evidence of logging can be seen throughout the Ts'unay watershed, with structural stage 5 (indicative of young forests; <80 years since disturbance) occurring over 3,045.6 ha; representing 18.8% of the total mapped area (**Table 15**). Other structural stages associated with logging including shrub/herb (structural stage 3), pole-sapling (structural stage 4) and mature forests (structural stage 6) comprised 1.4% (231.7 ha), 3.4% (555.6 ha) and 8.9% (1,441.9 ha) of the mapped area respectively.

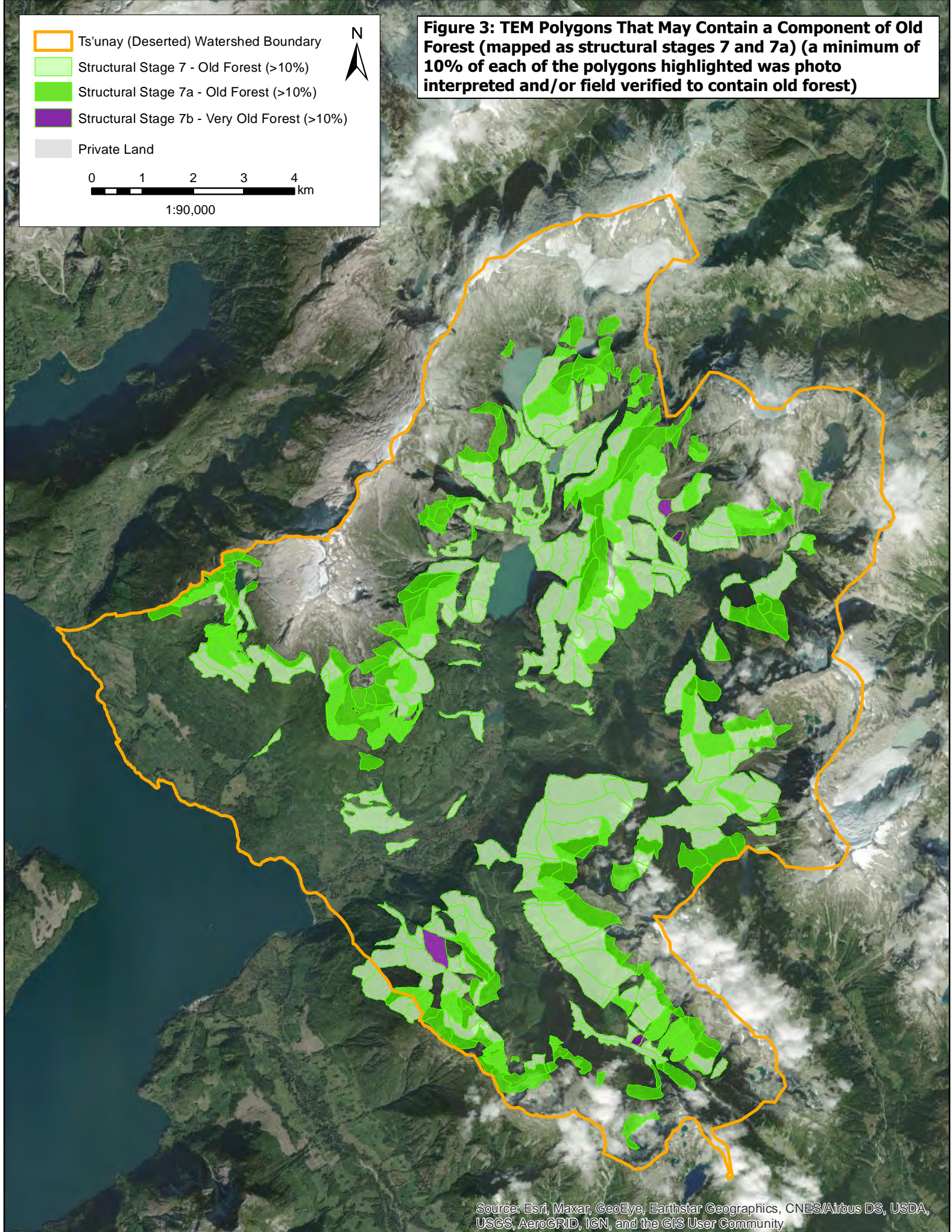
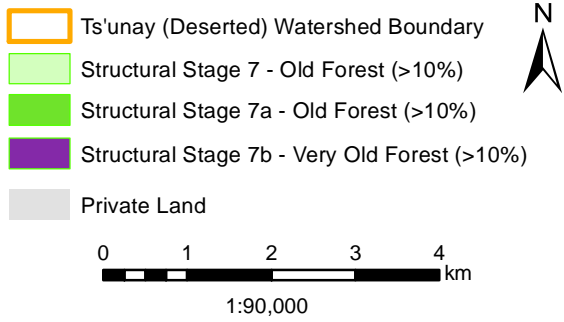
Table 15: Summary of structural stages mapped within the Ts'unay (Deserted) watershed TEM

Structural Stage	Total (ha)	% of Area Mapped
Not Applicable (0)	763.2	4.7%
Sparse (1a)	3,723.9	23.0%
Bryoid (1b)	90.6	0.6%
Forb-dominated (2a)	95.2	0.6%
Graminoid-dominated (2b)	17.6	0.1%
Aquatic (2c)	2.0	0.0%
Dwarf shrub-dominated (2d)	889.6	5.5%
Shrub/Herb (3)*	231.7	1.4%
Low shrub (3a)	563.8	3.5%
Tall shrub (3b)	1,455.5	9.0%
Pole/Sapling (4)*	555.6	3.4%
Young Forest (5)*	3,045.6	18.8%
Mature Forest (6)*	1,441.9	8.9%
Old Forest (7)*	834.8	5.2%
Old Forest (7a)*	2,469.7	15.2%
Very Old Forest (7b)*	20.8	0.1%
Totals	16,201.4	100.0%

*Structural stages associated with forested sites

Old forest (all structural stages combined) represented 20.5% of the mapped area, with the majority mapped in the CWHvm2 and MHmm1. Old forest was typically confined to steep slopes, gullies, and other areas where forest harvesting was constrained. Of the area mapped as forested (8,600.0 ha), 29.0% (2,490.5 ha) was mapped as “productive” old forest (7a and 7b), with 9.7% (834.8 ha) mapped as low productivity forests (assigned structural stage “7”) for a total of 38.7% of the forested ecosystems. **Figure 3** shows the distribution of old forest throughout Ts'unay (Deserted) watershed; the figure indicates which polygons contain a minimum of 10% old forest. Structural stage definitions are provided in Appendix I.

Figure 3: TEM Polygons That May Contain a Component of Old Forest (mapped as structural stages 7 and 7a) (a minimum of 10% of each of the polygons highlighted was photo interpreted and/or field verified to contain old forest)



3.6 Disturbance

Logging is the most common type of forest disturbance observed in the mapping area. Almost all the low-lying areas within the mapping area have been logged at least once over the last 100 years. Early logging close to tidewater was done by hand-loggers, which was followed by logging by rail up into the Ts'unay Valley (evidence of the rail line is still visible in places). When logging moved up the mountain sides, trucks were used to transport the logs to the booming grounds. In more recent years, helicopter logging has been done in places – generally at higher elevation.

Most of the forest harvesting has been done by clear-cut logging, although in some blocks, selection logging has been done (group or single tree retention). All harvested blocks appear to be fully stocked with trees – mostly in the 20 to 60-year range. The only places where rapid re-growth is not occurring are on steep rocky slopes, and poorly drained areas that are naturally less productive.

The only other disturbance noted to forested stands was caused by terrain events (e.g., landslides, debris flow). A list of disturbance codes can be found in Appendix I

3.7 Bioterrain

The breakdown of bioterrain types by genetic material as observed and mapped in the Ts'unay (Deserted) Watershed TEM is summarized in **Table 16**.

The most common bioterrain type over the entire project area, including alpine areas, is colluvium (C), with a cover of 62.1%. The thickness of the colluvium varies from very thin (<30 cm), to veneer (<1m), to blanket (>1m). Of these three, veneers are the most common. Colluvial avalanche and talus slopes are prevalent, often extending from alpine areas down into the mid-slope areas, and in cases right to the valley floor. Bedrock (R) is also common (14.4%) and mostly found at high elevations (CMA and MHmmp).

Extensive active and inactive floodplains cover valley floors, particularly the main stem of the Ts'unay River (about 3.5% of the study area). The floodplain fluvial deposits (F) generally consist of fine to medium sands and gravels with variable lenses of silty sand or silt. Soils that have developed on fluvial materials are moderately well to poorly drained. Soils on active floodplains (such as low and medium bench floodplains) are poorly developed, but soils on high-bench and inactive floodplains are often deep and highly productive (if they are not too wet) and can support fast-growing conifers and deciduous trees (such as red alder).

Table 16: Surficial Material of Bioterrain Types Mapped in Ts'unay (Deserted) Watershed TEM.

Surficial Material	Area (ha)	Study Area Proportion (%)
Anthropogenic (A)	39.5	0.2
Colluvium (C)	10,064.3	62.1
Weathered bedrock (D)	63.6	0.4
Fluvial (F) (active and inactive)	565.7	3.5
Glaciofluvial (FG)	26.1	0.2
Ice (I)	422.8	2.6
Lacustrine (L)	8.0	<0.1
Morainal (M)	2,320.6	14.3
Not Classified (N)	294.8	1.8
Organic (O)	37.3	0.2
Bedrock (R)	2,331.0	14.4
Glaciomarine (WG)	27.7	0.2
TOTAL	16,201.4	100

See Appendix I for further descriptions of the surficial materials, terrain textures and surface expressions.

Morainal till (M) is common on gentle to moderate slopes from sea level to mid-elevations. Localized pockets of till also occur at higher elevations (*i.e.*, over 500 m a.s.l). Ice (I) is common in alpine areas, covering 2.6% of the project area.

Glaciomarine (WG) deposits are uncommon (0.2%). These deposits are formed when sediments settled on low-lying land that was under water (marine) due to isostatic depression shortly after the retreat of ice. Following retreat of ice, the land rebounded, and these deposits can now be found well above sea level. These deposits contain more silt and clay than morainal or floodplain soils. While surface glaciomarine deposits are uncommon, it is suspected that they are present beneath organic accumulations in fens or swamps, or under other materials in the valley floor.

Organic accumulations in wetlands are less common than other genetic materials (in 0.2% of the study area). Organic soils were observed along the margins of water bodies and in the form of wetlands occupying low-lying areas within the landscape. All such soils were poorly or very poorly drained.

4 Discussion

4.1 Ecosystems at Risk

One of the primary applications of the TEM product is to support an understanding of the current distribution and representation of ecosystems, including ecosystems at risk. For this project, we considered which ecosystems throughout the study area could be associated with a red- or blue-listed designation based on the current ranking by the BC Conservation Data Centre (BC CDC site accessed February 2020). Red- or blue-listed ecological communities include those forested site series that have reached old ages (>250 years) or are mature forest with enough old attributes to be sufficiently established to represent a red-listed plant community. Due to recent harvesting pressures within the Great Bear Rainforest on BC's North Coast, a series of criteria were established to help determine whether a stand is "Sufficiently Established" enough to represent a red-listed community (Banner et. al. 2019). Stands that are considered to be Sufficiently Established include:

- Stands that are at least 250 years and older,
- Low, mid, or high-bench floodplain ecosystems at any age,
- Stands ≥ 140 years with Veteran Overstorey Trees (VOTs) ≥ 15 stems per hectare (sph), and
- Stands ≥ 80 but ≤ 140 years with VOTs ≥ 20 sph.

For practical purposes, VOTs are at least 200 years old and have a minimum diameter at breast height (dbh) of either 50 cm on dry sites (relative soil moisture regime 2 or lower) or 70 cm on all other sites. Where the numbers of VOTs do not meet the initial thresholds noted above, the Forest Attribute Score (FAS) could be considered. The FAS is a detailed process that considers the density of VOTs, density of snags, vertical canopy differentiation, understorey shrub and herb cover, coarse woody debris and disturbance history. Stands with more veteran overstorey trees, more snags, more down wood, multiple canopy layers and well-established understorey vegetation have higher FAS scores and are more likely to be classified as red-listed communities. If the total FAS > 6 , then the FAS is a PASS, which means it meets the criteria for red- or blue-listed status (Banner et al. 2019).

Ecosystems listed as high, medium and low bench floodplain units are by default Sufficiently Established, regardless of age, because they are disturbance-maintained forests that cycle more frequently than 200-250 years (Banner et al. 2019). In the CWHdm, this includes the 08/09/10 units and in the CWHvm1, the 09 unit.

In this report, forests mapped as >250 years or mapped as one of the above-mentioned floodplain units would meet the criteria for red- or blue-listed based on the current status of that ecosystem in BC. As noted, other forests may also be Sufficiently Established, but the process to determine this was beyond the scope of this project.

5 Conclusion

The project area contains a diverse range of forested and non-forested ecosystems within the various BEC zones/subzones/variants encountered. The majority of mapped polygons were in the three CWH subzones combined (447 polygons; 36.7% of the total), though the MHmm1 represented the largest subzone mapped (343 polygons; 28.1% of the total). Disturbance was relatively low in the project area and was primarily due to forest harvesting (clearcut/selective) and terrain-related effects (terrain failures).

Overall, this project gained significant improvement in the coverage of Ecosystem Inventory and Mapping within the *shíshálh swiya* with a total of 1,219 ecosystem polygons delineated over 16,201.4 ha. This information will be used in order to best inform land base investments and resource management decision-making in the future.

6 References

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APPENDIX I: TEM Data Dictionary

Ecosections (ECO_SEC)

Code	Description
SPR	Southern Pacific Ranges

Biogeoclimatic Units (BGC_VLD)

Code	Description
CWHdm	Coastal Western Hemlock, Dry Maritime
CWHvm1	Coastal Western Hemlock, Submontane Very Wet Maritime
CWHvm2	Coastal Western Hemlock, Montane Very Wet Maritime
MHmm1	Mountain Hemlock, Windward Moist Maritime
MHmmp	Mountain Hemlock, Moist Maritime Parkland
CMAun	Coastal Mountain-heather Alpine, Undifferentiated

Realm (REALM)

(As per *Biogeoclimatic Ecosystem Classification of Non-forested Ecosystems in British Columbia, 2012*)

Code	Name	Description
O	Freshwater	Freshwater or inland brackish waters deeper than 2 m or shallow waters with < 10% rooted vegetation cover
T	Terrestrial	Upland sites characterized by vascular and non-vascular plants
W	Wetland	Semi-terrestrial sites with wetland soil and vegetation indicators or vegetated still waters < 2m in depth

Group and Class (GROUP and CLASS)

(As per *Biogeoclimatic Ecosystem Classification of Non-forested Ecosystems in British Columbia*, 2012)

Group	Class	Description
A	f	Alpine Group, Fellfield Class
A	h	Alpine Group, Heath Class
A	s	Alpine Group, Nivation Class
F	a	Flood Group, Active Class
F	h	Flood Group, High Bench Class
F	l	Flood Group, Low Bench Class
F	m	Flood Group, Mid Bench Class
M	s	Mineral Wetland Group, Swamp Class
M	w	Mineral Wetland Group, Shallow Water Class
P	b	Peat Wetland Group, Bog Class
P	f	Peat Wetland Group, Fen Class
R	c	Rock Group, Cliff Class
R	o	Rock Group, Outcrop Class
R	t	Rock Group, Talus Class
S	k	Subalpine (shrub) Group, Krummholz Class
T		Treed Group
V	h	Avalanche Group, Herb Meadow Class
V	s	Avalanche Group, Shrub Thicket Class
V	t	Avalanche Group, Treed Class

Ecosystem Site Modifiers (SITE_MA; SITE_MB)

(As per *Standard for Terrestrial Ecosystem Mapping in BC – RISC*, 1998)

Modifier	Description
a	active floodplain
c	coarse-textured soil
g	gullying
h	hummocky
j	gentle slope
k	cool aspect (285 – 135°) slope (26% – 100%)
n	fan/cone
p	peaty material
q	very steep (>100%) cool aspect (135 – 285°) slope
r	ridge
s	shallow
t	terrace
v	very shallow soils (less than 20 cm)
w	warm aspect (135 – 285°) slope (26% – 100%)
z	very steep (>100%) warm aspect (135 – 285°) slope

Structural Stage (STRCT_S)

(As per *Land Management Handbook 25: Field Manual for Describing Terrestrial Ecosystems*, 2010)

Structural Stage	Description
0 Not Applicable	For use with ecosystems where a structural stage value is not applicable (e.g. lakes, rivers, glaciers).
Post-disturbance stages or environmentally induced structural development	
1 Sparse/cryptogam	Initial stages of primary and secondary succession; bryophytes and lichens often dominant, can be up to 100%; time since disturbance less than 20 years for normal forest succession, may be prolonged (50–100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover less than 20%; total tree layer cover less than 10%.
Substages	
1a Sparse	Less than 10% vegetation cover;
1b Bryoid	Bryophyte-dominated communities (greater than ½ of total vegetation cover).
1c Lichen	Lichen-dominated communities (greater than ½ of total vegetation cover).
Stand initiation stages or environmentally induced structural development	
2 Herb	Early successional stage or herbaceous communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree layer cover less than 10%, shrubby layer cover less than or equal to 20% or less than 1/3 of total cover; time since disturbance less than 20 years for normal forest succession; may herbaceous communities are perpetually maintained in this stage.
Substages	
2a Forb-dominated	Herbaceous communities dominated (greater than ½ of the total herb cover) by non-graminoid herbs, including ferns.
2b Graminoid-dominated	Herbaceous communities dominated (greater than ½ of the total herb cover) by grasses, sedges, reeds, and rushes.
2c Aquatic	Herbaceous communities dominated (greater than ½ of the total herb cover) by floating or submerged aquatic plants; does not include sedges growing in marshes with standing water (which are classed as 2b).
2d Dwarf shrub	Communities dominated (greater than ½ of the total herb cover) by dwarf woody species.
3 Shrub/Herb	Early successional stage or shrub communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by shrubby vegetation; seedlings and advance regeneration may be abundant; tree layer cover less than 10%; shrub layer cover greater than 20% or greater than or equal to 1/3 of total cover.

Substages	
3a Low shrub	Communities dominated by shrub layer vegetation less than 2 m tall; may be perpetuated indefinitely to environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 20 years for normal forest succession.
3b Tall shrub	Communities dominated by shrub layer vegetation that are 2–10 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 40 years for normal forest succession.
Stem exclusion stages	
4 Pole/Sapling	Trees greater than 10m tall, typically dense stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually greater than 10–15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy – this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stand at the same structural stage; time since disturbance is usually less than 40 years for normal forest succession; up to 100+ years for dense (5,000 - 15,000+ stems per hectare) stagnant stands.
5 Young Forest	Self-thinning has become evident and the forest canopy has begun differentiation into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the pole/sapling stage; time since disturbance is generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions.
Understorey reinitiation stage	
6 Mature Forest	Trees established after the last disturbance have matured; a second cycle of shade tolerant trees may have become established; understorey becomes well developed as the canopy opens up; time since disturbance is generally 80–250 years for stands within the CWH.
Old-growth stage	
7 Old Forest	Stands of old age with complex structure; patchy shrub and herb understorey are typical; regeneration is usually of shade-tolerant species with composition similar to the overstorey; long-lived seral species may be present in some ecosystem types or edaphic sites. Old growth structural attributes will differ across biogeoclimatic units and ecosystems.
Substages	
7a Old Forest	Stands with moderately to well-developed structural complexity; stands composed mainly of shade-tolerant and regenerating tree species, although older seral and long-lived trees from a disturbance such as fire may still dominate the upper canopy; fire-maintained stands may have a 'single-storied' appearance; time since stand replacing disturbance generally greater than 250 years for stands within the CWH.
7b Very Old Forest	Very old stands having complex structure with abundant large-sized trees, snags and coarse woody debris; snags and coarse woody debris in all stages of decomposition; stands are comprised entirely of shade-tolerant overstorey species with well-established canopy gaps; time since stand replacing disturbance generally greater than 400 years for stands within the CWH.

Stand Composition (STAND_A)

(As per *Land Management Handbook 25: Field Manual for Describing Terrestrial Ecosystems*, 2010)

Stand Composition	Description
<i>A description of the leaf-types of trees in a stand (only for structural stages 4-7)</i>	
C	Coniferous (>75% of total tree cover is coniferous)
B	Broadleaf (>75% of the total tree cover is broadleaf)
M	Mixed (neither coniferous or broadleaf account for >75% of the total tree cover)

Disturbance Codes (DISTCLS)

(As per *Land Management Handbook 25: Field Manual for Describing Terrestrial Ecosystems*, 2010)

Code	Description
L	Forest harvesting (clearcut/selective)
T	Terrain-related effects (terrain failures)

Terrain Texture Codes (TTEX_A, TTEX_B, TTEX_C)

(As per *Land Management Handbook 25: Field Manual for Describing Terrestrial Ecosystems*, 2010)

Code	Name (size in mm)	Other Characteristics
a	blocks (>256)	angular particles
b	boulders (>256)	rounded and subrounded particles
c	clay (<0.002)	
d	mixed fragments (>2)	mix of rounded and angular particles
e	fibric	well-preserved fibre; (40%) identified after rubbing
g	gravel (>2)	mix of boulders, cobbles and pebbles
k	cobble (64-256 mm)	rounded and subrounded particles
m	mud (<0.062)	mix of clay and silt
r	rubble (2-256)	angular particles
s	sand (0.062-2.000)	
u	mesic	intermediate composition between fibric and humic
x	angular (>2)	mix of block and rubble
z	silt (0.002-0.0062)	

Surficial (genetic) Material Codes (SURFM)

(As per *Land Management Handbook 25: Field Manual for Describing Terrestrial Ecosystems*, 2010 and TEI Digital Data Standards, 2015)

Code	Name	Assumed Status	Description
A	Anthropogenic	(A)	Artificial or human-modified material
C	Colluvium	(A)	Products of mass wastage
D	Weathered bedrock	(A)	In situ, decomposed bedrock
F	Fluvial	(I)	River deposits
FG	Glaciofluvial	(I)	Ice contact fluvial material
I	Ice	(A)	Permanent snow, glaciers, and icefields
L	Lacustrine	(I)	Lake sediments; includes wave deposits
M	Morainal	(I)	Material deposited directly by glaciers
N	Not Classified		Used for areas that are not mapped for a variety of reasons
O	Organic	(A)	Accumulation/decay of vegetative matter
R	Bedrock	(-)	Outcrops/rocks covered by less than 10 cm of soil
WG	Glaciomarine	(I)	Ice contact marine sediments

Surface Expression Codes (SURF_EA, SURF_EB, SURF_EC)

(As per *Land Management Handbook 25: Field Manual for Describing Terrestrial Ecosystems*, 2010)

Code	Name	Description
a	Moderate slope	Unidirectional surface; >25% to <50%
b	Blanket thick	A mantle of unconsolidated materials; >1 m
c	Cone(s)	A cone or segment of a cone; >25%
f	Fan(s)	A segment of a cone; up to 150
h	Hummock(s)	Hillocks and hollows, irregular in plan; 25% - 70%
j	Gentle slope	Unidirectional surface; >5% and <25%
k	Moderately steep slope	Unidirectional surface; >50% and <70%
m	Rolling	Elongate hillocks; 5-25%; parallel forms in plan view
p	Plain	Unidirectional surface; up to 5%
r	Ridge(s)	Elongate hillocks; 25-70%; parallel forms in plan view
s	Steep slope	Steep slopes; >70%
t	Terrace(s)	Step-like topography
u	Undulating	Hillocks and hollows; up to <25%; irregular in plan view
v	Veneer	Mantle of unconsolidated material; 0.1 to 1.0 m thick
w	Mantle of variable thickness	A layer or discontinuous layer of surficial materials of variable thickness that fills or partially fills depressions in an irregular substrate. The thickness ranges from 0 to 3 m
x	Thin veneer about 2-20cm thick	A dominance of very thin surficial materials

Geomorphological Processes (GEOP_1)

(As per *Land Management Handbook 25: Field Manual for Describing Terrestrial Ecosystems*, 2010)

Code	Name	Description
A	Avalanches	Terrain modified by snow avalanches
F	Slow mass	Slow downslope movement of masses of cohesive or non-cohesive material
R	Rapid mass movements	Rapid downslope movement of dry, moist, or saturated debris
U	Inundation	Seasonally underwater because of high water table
V	Gully erosion	Parallel/subparallel ravines caused by running water

Drainage

(As per *Land Management Handbook 25: Field Manual for Describing Terrestrial Ecosystems*, 2010)

Code	Name	Description
x	very rapidly drained	Water is removed from the soil very rapidly in relation to supply. Water source is precipitation and available water storage capacity following precipitation is essentially nil. Soils are typically fragmental or skeletal, shallow or both.
r	rapidly drained	Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Water source is precipitation. Soils are generally coarse textured.
w	well drained	Water is removed from the soil readily, but not rapidly. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. Water source is precipitation. On slopes, subsurface flow may occur for short durations, but additions are equalled by losses. Soils are generally intermediate in texture and lack restricting layers.
m	moderately well drained	Water is removed from the soil somewhat slowly in relation to supply because of imperviousness or lack of gradient. Precipitation is the dominant water source in medium- to fine- textured soils; precipitation and significant additions by subsurface flow are necessary in coarse-textured soils.
i	imperfectly drained	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major source. If subsurface water or groundwater (or both) is the main source, the flow rate may vary but the soil remains wet for a significant part of the growing season. Precipitation is the main source if available water storage capacity is high; contribution by subsurface or groundwater flow (or both) increases as available water storage capacity decreases. Soils generally have a wide range of texture, and some mottling is common.
p	poorly drained	Water is removed so slowly in relation to supply that the soil remains wet for much of the time that it is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface or groundwater flow (or both), in addition to precipitation, are the main water sources. A perched water table may be present. Soils are generally mottled and/or gleyed.
v	very poorly drained	Water is removed from the soil so slowly that the water table remains at or near the surface for most of the time the soil is not frozen. Groundwater flow and subsurface flow are the major water sources. Precipitation is less important, except where there is a perched water table with precipitation exceeding vapotranspiration. Typically associated with wetlands. For organic wetlands, also evaluate the soil moisture subclass, and when entering on the form, separate from drainage by a slash. For example, v/ac.

Drainage Separator codes

(As per *Standard for Digital Terrain Data Capture, 1998* and *Terrain Classification System for British Columbia, 1997*)

Map symbol	Definition
,	'w, i' indicates that no intermediate classes between well and imperfectly drained are present
-	'w-i' indicates that all intermediate classes between well and imperfectly drained are present.
.	components on either side of the symbol are of approximately equal proportion
/	r/p' rapid drainage is dominant, poor drainage is sub-dominant
//	'r//p' rapid drainage is significantly dominant, poor drainage is minor

APPENDIX II: Quality Assurance

Summary of QA comments from 3rd Party Professional: Del Meidinger (Ecosystems)

Biogeoclimatic mapping: Implementing 'better' biogeoclimatic boundaries would take a bit of time, but the ecosystem changes would be relatively straightforward, due to the nature of the grids for these units. I recommend that in future projects in this area that field crews observe key tree species distributions to try to confirm/modify BGC boundaries. The provincial linework is definitely not directly applicable in this area.

Specifically, the dm to vm1 boundary in the main valley should be adjusted to better represent the mapping area. The existing plot data collected is inconclusive on some of these issues (see notes following). It is possible that VRI data could help, as follows:

dm to vm2 on warm slope. It is conceptually unlikely that the dm does go directly into vm2, but the slope is relatively steep and the plot data inconclusive. One plot above the present boundary did not have amabilis fir (Ba), and one further up, did. No yellow cedar (Yc) occurred in the vm2 plots on this slope (that I looked at). The vm1 should have Ba and Alaskan blueberry, in comparison to dm; and the vm2 increasing amounts of Yc (and possibly scattered mountain hemlock, increasing towards the MHmm boundary). The elevation sequences could be looked at over the main slopes of the map area and then modified, where necessary. It may not be possible to be sure of the vm1 to vm2 boundary on the slopes above dm, but as noted, conceptually, there should be vm1. At the scale of the provincial mapping, it is not possible to draw both but at this scale it is.

dm to vm1 in main river valley. I looked at all the plots up that main river valley, and only one plot has Ba (LKG039). It would be possible to use this location to run the dm up the valley further. I noted the valley polygon that could be included in the new dm (in my QA notes). Then, the slope polygons could be assigned to dm to angle the elevation from the higher elevation on the main valley slopes down to the river valley. VRI data might indicate some changes to this proposal but I was not able to evaluate the value, if any, of VRI. In this valley, the elevation of the dm to vm1 is likely to be lower than the inlet due to cold air, more snow, etc.

MHmm1 to MHmmp. In a few areas, it seemed that the parkland boundary was too low. This boundary would need to be assessed more broadly over the map area to be certain. I noted some polygons but didn't do the overall assessment.

Other comments:

vm 07 vs 01. In many cases, I felt that there should be more 07 on the lower slopes. My experience is that these long slopes, especially on cooler aspects, have more 07 that was mapped. The soil drainage components in the bioterrain also do not pick this up. I noted some polygons, but my overall feeling is that the 07 could be increased in many lower slope polygons.

Dry, nutrient rich site units, e.g., 04. I wondered about these as the area is mostly granitic bedrock, but I was not sure if small pockets of more nutrient rich bedrock/till could occur. The field crews would have observed this. One caution, of course, is that sword fern can be more abundant in sites with deciduous components, but that may not reflect site as much as stand history.

Af vs Ro in Alpine. The 'alpine' rock outcrops and talus/scree are to be mapped as alpine fellfield (Af) instead of Ro/Rt (according to NBEC -- non-forested BEC technical report). The report notes that subclasses can be used for rock vs talus, etc. but codes are not provided. Some standard codes could be proposed and used. If the parkland boundary was refined, this convention might also be used there as parkland is a transition zone where many ecosystems have alpine characteristics.

Summary of QA comments from 3rd Party Professional: Gordon Butt (Bioterrain)

Overall: I found the bioterrain mapping to be good. I reviewed approximately 15% of the total polygons, making comments on about 10%.

Linework: The linework was generally good; there were a few (<10) polygons in which I suggested sub-dividing to provide smaller polygons with more uniform bioterrain attributes. I also recognized that in a few places some compromise was made between biogeoclimatic lines and bioterrain lines, but these did not detract significantly from the bioterrain mapping.

Drainage: In many polygon labels, there was no drainage delimiter. In many bioterrain polygons there will be a range of drainage classes, for example w/m or w//r. I suggested to Harry that where two classes are present, the delimiter should be used, especially where there are two genetic materials. The most common scenario is on mid slope polygons containing a mix of M and C. C usually has a w to r drainage, and this should be reflected in the attribution.

Fluvial landforms: In the BC Terrain Classification System, fluvial landforms are assumed to be inactive, so inactive floodplains require just a 'F' symbol, and not 'FI', but active floodplains should be designated 'FA'. This is an important piece of information, but it may be difficult to distinguish on imagery. Where possible the active floodplains should be pulled out; but in other cases where this is not possible, I suggest mapping a complex of F/FA.

Valley sidewall polygons: In my experience till and colluvium are the most common genetic materials, and most sidewall polygons contain a complex of both. The study area has many very steep slopes, so colluvium is more common. Nevertheless, I thought that till (M) was

under-mapped, and so I suggested adding it as a minor component in a number of polygons. In addition, polygons on the ridge tops or in upper topographic positions (where this is no source of colluvium) are usually M-dominant. I made comments on several polygons to reflect this.

Valley bottom polygons: The main valley bottoms are complex geologically and may contain complexes of glaciomarine (WG), glaciofluvial (FG), fluvial fans (FAf) and other modern materials (F, FA), as well as in one polygon modern lacustrine (L). In these polygons I deferred to field-checked polygons, but even there it may be difficult to characterize the complex geology with one hastily excavated soil pit. Even with on-site assessment it is difficult to distinguish between say WG and FG. Fortunately, this does not have a major effect on ecosystem interpretation. Close attention to the correct drainage class or classes is more important.

Weathered bedrock ('D'). This is a rare material confined to alpine areas or other periglacial environments. They are also known as '*felsenmeer*' or *blockfields*. I am doubtful that they actually occur in this study area. I have only seen them in the Yukon and NWT.

Subsurface Material. Although important in terrain stability mapping, it does not have a strong influence in bioterrain, but I always like to add it where applicable. It is not necessary to add it on slopes with a blanket, veneer or mantle, unless there is an extensive component of undulating or hummocky bedrock where adding the shape of the R has an influence on the ecosystem interpretation.

Glaciomarine: WG should not be a subsurface material anywhere but valley bottoms. Also, it should not be mapped above elevations of 150-200 m, which is the maximum level of isostatic depression.

Texture: I generally have not added texture to polygons that have not been field assessed, but I noted that it was added to virtually all polygons in the mapping I checked. The most common texture for coastal tills is a silty diamicton sand (zds) (or where abundant clasts: zsd, but this cannot be ascertained from imagery alone), and so it may be appropriate to add zds for non-assessed polygons for till only. For colluvium it is appropriate to use 'x', rather than ra or ar, which should be used if the polygon has been inspected on the ground.

Internal steps taken during the polygon and database QA process

For Each Ecosystem and Terrain decile:

- Ecosystem Decile check – make sure they total to 10 – flag those which don't and update label
- Change Ro/Rt/Rc in the CMAun to Af as per Del's QA
- Site series check – make sure the correct information is in this field. Non-forested ecosystems should be in this field
- Mapcode check
 - two-letter mapcodes for forested units leftover from imported mapping were removed.
 - For non-forested units, ensure code from site series (e.g. Ro) is repeated in this field (as per pers. comm with J. Churchill)
- Ecosystem modifier (1 and 2)
 - Check that each modifier in column 1 isn't repeated in column 2 – delete duplicate from column 2
 - If mod 1 is blank, move any mod 2 label to mod 1 column
 - Ensure modifiers are in alphabetical order
- Structural stage
 - check that structural stages are appropriate for the mapped unit as some are very specific (e.g. Ww must be 2c or 0, Ah must be 2d, Vh should only be 2a or 2b, Vs should only be 3a or 3b, Vt should be 3b, etc.)
 - check that structural stage has been applied if there is an eco label. If a forested unit has been mapped with a non-forested structural stage, check or change. There were a couple of forested bog units mapped as 3b – changed to Wb with 3b instead.
 - Check "7a" labels – changed to "7" for forested units in the parkland. Also, changed "7" in the lower elevation units to 7a, except for 02
- Canopy Composition
 - ensure all forested units mapped as structural stage and above are assigned a canopy composition.
 - remove canopy composition for any unit mapped as non-forested (>STS 4).
- Disturbance – for forested units with structural stage of 3 but no disturbance, checked imagery and added L for logging.
- Terrain Decile check – make sure they total to 10 – flag those that don't and have bioterrain mapper adjust
- Terrain Texture (3 fields)
 - remove erroneous values (e.g. "1")
 - check each field and make sure that value hasn't been repeated in one of the other texture fields - remove duplicate values
- Surficial Material check – make sure this has been populated for every polygon
- Surface Expression (2 fields)

- remove erroneous values (e.g. "1")
- check each field and make sure that value hasn't been repeated in one of the other surface expression fields - remove duplicate values
- Sample Type
 - make sure that this has been assigned for every plot that was field verified and make sure it matches the verification type (e.g., V for Visual plots).
 - Add "P" for polygons that were airphoto interpreted
- Plot Number
 - check that every polygon with a plot collected in it was attributed with the corresponding plot name (e.g. JSV012). If more than one plot was collected in the polygon, use the most detailed plot (e.g. Ground vs. Visual) and put the other plot name(s) into the POLY_COM field.
 - Ensure that there are no duplicate plot names



APPENDIX III: Map Codes

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
CWHdm							
CWHdm	01		Hw - Flat moss	significant slopes; middle slope position; deep medium textured soils (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHdm	02		FdPI - Cladina	gentle slope; crest position; shallow soil	j, r, s	2,3,4,5,6,7	M,C
CWHdm	03		FdHw - Salal	significant slope, middle to upper slope position; warm aspect; deep medium textured soils	d, m, w	2,3,4,5,6,7	M,C
CWHdm	04		Fd - Sword fern	significant slopes deep medium - textured soils; richer nutrient regime (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHdm	05		Cw - Sword fern	significant slope, middle slope position, deep medium - textured soils; richer nutrient regime (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHdm	06		HwCw - Deer fern	gentle slope; lower slope position, receiving moisture, deep medium - textured soils	d, j, m	2,3,4,5,6,7	M,C
CWHdm	07		Cw - Foamflower	gentle slope; lower slope position; richer nutrient regime, receiving moisture, medium - textured soil	d, j, m	2,3,4,5,6,7	M,C
CWHdm	08		Ss - Salmonberry	active floodplain, high fluvial bench, deep medium - textured soil	a, d, j, m	2,3,4,5,6,7	M,C
CWHdm	09		Act - Red-osier dogwood	active floodplain, middle fluvial bench, deep medium - textured soil	a, j, m	2,3,4,5,6	B
CWHdm	10		Act - Willow (F150 - Sitka willow - False lily-of-the-valley)	active floodplain, low bench, deep coarse - textured soil	a,c,d,j	2,3,4,5,6	B
CWHdm	12		CwSs - Skunk cabbage	treed swamp, poorly drained, level to depression, medium - textured mineral soil	d, j, m	2,3,4,5,6,7	M,C

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
CWHvm1							
CWHvm1	01		HwBa - Blueberry	gentle slope, middle slope position; deep medium- textured soils	d, j, m	2,3,4,5,6,7	M,C
CWHvm1	02		HwPl - Cladina	gentle slope; crest position, medium textured, shallow soils	j, m, r, s	2,3,4,5,6,7	M,C
CWHvm1	03		HwCw - Salal	upper slope position; gentle slope on medium textured shallow soils	j, m, s	2,3,4,5,6,7	M,C
CWHvm1	04		CwHw - Sword fern	significant slope, upper slope position; deep medium textured soils of colluvial (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHvm1	05		BaCw - Foamflower	significant slope, middle slope position; deep medium- textured soils; richer nutrient regime (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHvm1	06		HwBa - Deer fern	significant slope, lower slope position; deep medium - textured soils, seepage (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHvm1	07		BaCw - Salmonberry	gentle lower receiving slope, deep, medium - textured soil	d, j, m	2,3,4,5,6,7	M,C
CWHvm1	08		BaSs - Devil's club	gentle receiving slopes; deep, medium - textured soil; seepage	d, j, m	2,3,4,5,6,7	M,C
CWHvm1	09		Ss - Salmonberry	active floodplain, high bench , deep medium - textured soil	a, d, j, m	2,3,4,5,6,7	M,C
CWHvm1	10		Act - Willow	active floodplain, low bench flood , deep medium - textured soils		2,3,4,5,6	B
CWHvm1	14		CwSs - Skunk Cabbage CwHw - Skunk cabbage)	(Ws54 - swamp forest; level to depression, deep, medium - textured soil; poorly drained	d, j, m	4,5,6,7	M,C

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
CWHvm2							
CWHvm2	01		HwBa - Blueberry	gentle slope, middle slope position; deep medium - textured soils.	d, j, m	2,3,4,5,6,7	M,C
CWHvm2	02		HwPl - Cladina	gentle slope, crest position; shallow soils	j, r, s	2,3,4,5,6,7	M,C
CWHvm2	03		HwCw - Salal	gentle slope, upper slope position; medium textured shallow soils	j, m, s	2,3,4,5,6,7	M,C
CWHvm2	04		CwHw - Sword fern	significant slope, ; upper slope position; deep medium - textured soil, richer nutrient regime (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHvm2	05		BaCw - Foamflower	significant slope, deep medium - textured soils; richer nutrient regime (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHvm2	06		HwBa - Deer fern	significant slope, deep medium - textured soils, seepage (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
CWHvm2	07		BaCw - Salmonberry	gentle slope, lower slope receiving position, deep medium - textured soil; southern and central portion of variant	d, j, m	2,3,4,5,6,7	M,C
CWHvm2	08		BaSs - Devil's club	gentle receiving slopes; deep, medium - textured soil; seepage	d, j, m	2,3,4,5,6,7	M,C
CWHvm2	09		CwYc - Goldthread	lower slope; organic bog forest	d, j, p	2,3,4,5,6,7	M,C
CWHvm2	10		Pl - Sphagnum	treed bog; organic	d, j, p	2,3,4,5,6,7	M,C
CWHvm2	11		CwYc - Skunk cabbage CwHw - Skunk cabbage	(Ws54 - treed swamp, depression or flat, medium - textured mineral soil, poorly drained (Vancouver Region)	d, j, m	4,5,6,7	M,C

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
MHmm1							
MHmm1	01		HmBa - Blueberry	significant slopes; deep medium-textured soils; (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
MHmm1	02		HmBa - Mountain-heather	gentle slopes; crest position; shallow soils	j, r, s	2,3,4,5,6,7	M,C
MHmm1	03		BaHm - Oak fern	significant slopes; deep medium - textured soils; richer nutrient regime (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
MHmm1	04		HmBa - Bramble	significant slopes; deep medium - textured soils; middle to lower slope position, seepage (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
MHmm1	05		BaHm - Twistedstalk	significant slopes; deep medium - textured soils; middle to lower slope position, seepage; richer nutrient regime (use aspect modifiers)	d, m	2,3,4,5,6,7	M,C
MHmm1	06		HmYc - Deer-cabbage	gentle slopes, receiving sites; deep medium- textured soils	d, j, m	2,3,4,5,6,7	M,C
MHmm1	07		YcHm - Hellebore	lower slope position; gentle slopes; deep medium - textured soil, wet, richer nutrient regime	d, j, m	2,3,4,5,6,7	M,C
MHmm1	09		YcHm - Skunk cabbage	treed swamp, deep, medium - textured soils; poorly drained	d, j, m	4,5,6,7	M,C

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
Wetland and Floodplain Units (Applicable to lower elevation BEC zones)- Descriptions from Wetlands of BC Guidebook or Non-forested BEC (TR068)							
CWHvm1 MHmm1	Fa	Fa	Active Floodplain Class	Occur on sites that are annually flooded, and often scoured for prolonged periods. Sites are usually immediately adjacent to the river channel at lower water conditions. On unstable substrates, such as gravel bars and islands, ecosystems are usually dominated by annuals or herb-layer species with extensive root systems. Bryoid communities are more typical on active channel sites with more stable substrates.	a	0	N/A
CWHvm1	FI	FI	Low bench floodplain Class	Occur on sites that are flooded for moderate periods (<40 days) of the growing season - conditions that limit the canopy to tall shrubs, especially willows or alders. Annual erosion and deposition of sediments generally limit the understorey and humus development. Commonly associated with fluvial systems but also occur on wave-washed beaches of larger lakes.	a	3a,3b	N/A
CWHvm1	Fm	Fm	Mid bench floodplain Class	Occur along lakes, streams, and rivers, on sites that are briefly flooded (10–25 days) during freshet, which allows tree growth, but forests are dominated by flood-tolerant broadleaf species, usually black cottonwood, and sometimes trembling aspen. Soils usually have some horizon development, usually with buried layers resulting from repeated flooding. Nutrient availability is usually very high due to continuous inputs of oxygenated water through subirrigation.	a	3a,3b	N/A
CWHdm MHmm1	Wf	Wf	Fen Class	Fens are nutrient-medium peatlands dominated by sedges and brown mosses, where mineral-bearing groundwater is within the rooting zone and mesotrophic plant species are common. Fens develop along lake margins and adjacent to slow-moving streams, where the water table is usually at or just below the peat surface for most of the growing season. Fens often occur in association with swamp ecosystems.	p	2,3,3a,3b	N/A

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
CWHvm1 'MHmm1	Wf50	Wf50	Narrow-leaved cotton-grass - Peat-moss	Describes a wide range of ecosystems of montane and subalpine areas where there is some surface seepage . Many sites are sloping but this unit also occurs on level sites with a permanent, high waterables. Sites are microtopographically heterogeneous and therefore a mosaic of vegetation is common. Tree and shrub species, if they occur, are on raised sites. Groundwater seepage pools or surface drainage channels are common.	p	2,3,3a,3b	N/A
CWHvm1	Wm01	Wm01	Beaked sedge – Water sedge	The most common marsh ecosystem across British Columbia. It occurs on seasonally flooded sites with some late-season drawdown near ponds, along lake margins, on floodplains with slow-moving flood water, and in flooded basins.	N/A	2b	N/A
CWHvm1	Wm50	Wm50	Sitka sedge - Pacific water-parsley	Common at low elevations in basins, and along slow-moving streams, ponds and lakeshores. Monoculture of sitka sedge occurs on many sites, but occasionally other species are also prominent. Tolerates variable hydrology and disturbance and occurs on mineral substrates or shallow peat veneers	N/A	2,2a,2b	N/A
CWHdm	Ws	Ws	Swamp Class	Nutrient-rich wetland where significant groundwater inflow, periodic surface aeration and/or elevated microsites allow the growth of trees or tall shrubs under subhydic conditions. Often have surface standing water and may be underlain with peat, but it is well decomposed, woodey and dark coloured. Swamps tend to occur at the periphery of peatland ecosystems in the transition to upland.	N/A	3,3a,3b	N/A
CWHdm MHmm1 MHmmp CMAun	Ww	Ww	Shallow-water Class	Aquatic ecosystems that are permanently flooded by still or slow moving water and are dominated by rooted, submerged, and floating aquatic plants. Occur most commonly where standing water is <2 m deep in midsummer. Aquatic plants may root in mineral soils or in well-humified sedimentary peat.	N/A	0, 2c	N/A

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
Alpine and Parkland Units							
MHmmpC MAun	Af	Af	Alpine Fellfield Class	Ecosystems of exposed locations where the dynamics of frost and of wind give rise to characteristic low plant cover in a rocky or mineral soil matrix. Thin snowpack leads to active freeze-thaw cycles that act to push plants out of the soil. High porosity or lack of soil makes fellfield a difficult place for plants to grow. Commonly populated by cushion plants and cryptogams.	k, r, w	1,2	N/A
MHmm1M HmmpCM Aun	Ah	Ah	Alpine Heath Class	Mountain-heather dominated snowbed ecosystems that are widespread and common throughout BC in snow-accumulating sites and sable substrates. Moderate snow accumulations are of intermediate depth between tundra and nivation ecosystems. Mountain-heather species are always prominent. Site conditions are typically mesic and drier.	k	2d	N/A
CMAun	As	As	Alpine Nivation (Late Snowbed) Class	Occur under very deep or persistent snowpacks that last well into the growing season and are commonly of low cover and low species diversity . Few species can tolerate the short growing season and environmental conditions. Erosion during snowbed melting (nivation) and growing-season cryoturbation is extreme due to lack of vegetation cover and high soil moisture.	j, k	1,2	N/A
MHmm1M HmmpCM Aun	Sk	Sk	Krummholz Class	Conifer-dominated ecosystems that occur near treeline, where extreme climatic conditions, including low growing-season temperatures, cold winter temperatures, and wind damage, limit trees to shrub stature (<10m). Ecosystems where conifers are climatically limited to grow less than tree heights and is extended to examples within the alpine where conifers are reduced to low shrub height. Trees often have stout boles that taper rapidly or are highly branched, twisted and contorted shrubs due to repeated leader mortality.	k, r, w, s	3,3a,3b	N/A

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
Anthropogenic and other non-forested Units (Applicable to all BEC zones)							
CWHvm1 CMHvm2 MHmmp		LA	Lake	A naturally occurring static body of water, 10 ha or greater in size and at least 2 m deep in some portion.	N/A	N/A	N/A
MHmmp CMAun		PD	Pond	A small, naturally occurring static body of water, less than 10 ha in size and at least 2 m deep in some portion. Not large enough to be classified as a lake but typically larger/deeper than shallow water wetlands and are non-vegetated.	N/A	N/A	N/A
CMAun		PS	Permanent Snow	Snow or ice that is not part of a glacier but is found during summer months on the landscape.	N/A	N/A	N/A
CWHvm1 CWHvm2 MHmm1 MHmmp	Rc	Rc	Cliff Class	Cliff ecosystems are vertical rock sites, commonly with high bryophyte cover (rock crusts), but small pockets of soils may support vascular vegetation.	q, z	1,2,3,3a,3b	N/A
CWHvm1 CMHvm2		RI	River	A watercourse formed when water flows between continuous, definable banks. The flow may be intermittent or perennial. An area that has an ephemeral flow and no channel with definable banks is not considered a river	N/A	N/A	N/A
all except CMAun	Ro	Ro	Rock Outcrop Class	Bluffs and knobs of bedrock with limited soil development and high cover of exposed rock. Drought-tolerant cryptogams are often prominent and vascular plants are limited.	k, r, w	1,2,3,3a,3b	N/A
all except CMAun	Rt	Rt	Talus Class	Slopes covered by angular rocks and stones that have been moved by gravity downslope from rock outcrops.	k, r, w	1,2,3,3a,3b	N/A
all except CWHdm	Vh	Vh	Avalanche Herb Meadow Class	Ecosystems in avalanche tracks that are dominated by forbs, graminoids, and/or dwarf woody shrubs. These ecosystems often occur in the central track or run-out zone of avalanche paths where snow accumulates or where mobile substrates limit the establishment of shrubs or trees	k, r, w	2,2a,2b	N/A
all except CWHdm	Vs	Vs	Avalanche Shrub Thicket Class	Ecosystems in avalanche tracks that are dominated by deciduous shrubs and are most frequently associated with the track and lateral run-out portions of the avalanche path where deep snow lay occurs infrequently but site conditions are fresh or wetter	k, r, w	3,3a,3b	N/A

BGC Subzone	Site Series (LMH28)	Mapcode (if applicable)	Name	Description	Assumed or Typical Site Modifiers	Allowed Structural Stages	Stand Composition
CWHvm1 CWHvm2 MHmm1 MHmmp	Vt	Vt	Avalanche Treed Class	Dominated by shrub-sized trees that are continually pruned by snow slides and are prevented from becoming forest. Does not include young forests that are regenerating from single extreme events. Trees in Vt ecosystems show evidence of pruning and bark damage from chronic avalanche events. Site conditions are typically dry.	k, r, w	4,5	C (M,B)