KWEST INC.

SUNSHINE COAST PILOT MAPPING:

For Conservation & Climate Resilience Planning

Project Report
August 26, 2024 - Draft

Prepared for: CDFCP - UBC Botanical Gardens Action for Adaptation Project

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1 INTRODUCTION

Southwest BC's Georgia Basin lowlands host over 75% of BC's population and includes the Coastal Douglas-fir zone (CDF), home to the largest number of species and ecosystems at risk in the province. Per hectare, forests in the Basin have among the highest carbon storage capacity of any forest in BC, with those in old growth being some the highest carbon storing ecosystems in the world[1]. Georgia Basin ecosystems also provide critical ecosystem services, such as supplying water, controlling floods, improving air quality and providing salmon habitat, recreation and climate refuge. As the traditional territory of the Coast Salish and other First Nations, these ecosystems are also important to indigenous food security, and support a multitude of culturally important plants and animals.

However, increasing demand for residential development and timber are intensifying pressure on the Basin's natural assets and the ecosystem services they supply. These pressures are compounding as climate change increases the intensity and frequency of heat, droughts, flooding, and wildfires, threatening the well-being of BC's south coast communities, and their capacity and long-range options for adapting to climate change.

In response to these pressures, in 2022 the UBC Botanical Gardens and the Coastal Douglas-fir Conservation Partnership (CDFCP) formed a joint project called *Action for Adaptation*. The Project aims to support local government and First Nation planners and decision-makers by enhancing mapping and policy tools needed to accelerate nature-based climate adaptation in the Georgia Basin.

Sensitive Ecosystems are those deemed rare, ecologically fragile, and provide habitat for Species at Risk. The BC Conservation Data Centre (CDC) tracks the occurrences of ecological communities (aka plant communities) to assess and assign conservation status: red or blue are considered 'at-risk' (MOE 2006).

Although a Sensitive Ecosystems Inventory (SEI) and various Terrestrial Ecosystem Mapping (TEM) projects have been carried out in the study area, stakeholder engagement undertaken by Action for Adaptation (2022, 2023) identified a number of limitations associated with publicly available at-risk and sensitive ecosystem mapping, including:

- Limited/incomplete coverage,
- Often old/outdated,
- Expensive and time consuming to update/create,
- Considerable barrier for smaller local & First Nations governments,
- Does not directly address *hydrology & watershed health*,
- Does not address *climate related issues.*

As part of the *Action for Adaptation* project, KWEST Inc. was contracted to explore options for 'mining' publicly available spatial data to help bridge the above limitations, using the Sunshine Coast as a pilot study area. The focus was on deriving spatial layers to represent the following themes:

- Potential ecological communities at risk.
- Potential sensitive ecosystems.
- Hydroriparian areas.
- Climate microrefugia.

- Natural range of variability & risk.
- Disturbance (to help update the above layers).

This report contains a literature review rationalizing the derived spatial layers, and a summary of data sources and methods that were used. It also outlines how these features can be used for conservation planning on the Sunshine Coast, with a specific focus on planning climate-resilient green infrastructure and/or conservation networks.

2 STUDY AREA

The study area is located on the Sunshine Coast portion of the Georgia Basin. It is delineated by the Sunshine Coast Regional District and qathet Regional Districts (**Figure 1**), and lies within the territories of the Klahoose, Tla'amin, shishalh, and Squamish First Nations. The study area spans four different biogeoclimatic (BEC) zones, and five subzones (**Figure 1**). Starting from sea level and working upwards in elevation, these include:

- Coastal Douglas-fir Zone (CDF)
    - Moist Maritime Subzone (CDFmm)
- Coastal Western Hemlock Zone (CWH)
    - Very Dry Maritime Subzone (CWHxm1)
    - Dry Maritime Subzone (CWHdm),
    - Very Wet Maritime subzone (CWHvm1,2),
    - Southern Dry Submaritime Subzone/Variant (CWHds1[1])
    - Southern Moist Submaritime Subzone/Variant (CWHms1[2])
- Mountain Hemlock Moist Zone (MH)
    - Moist Maritime Subzone (MHmm1, MHmm2)
- Coast Mountain Heather Alpine Zone (CMA)

For reference purposes a regional description of the study area is located in **Appendix A**, including physiographic history, climate and biogeoclimatic zones, and regional hydrology.

The study area makes up the lower two thirds of the Sunshine Coast Forest District, and is comprised of the following Forest Landscape units, as shown in **Figure 1**.

- Brem*
- Toba*
- Homfray*
- Powell Daniels
- Skwawka
- Bunster
- Powell Lake
- Haslam
- Texada
- Lois
- Brittain
- Jervis
- Deserted
- Narrows
- Salmon Inlet
- Howe
- Sechelt
- Chapman

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[1] Within the study area, CWHds1 is only found in upper valleys of the Toba Landscape Unit.

[2] Within the study area, CWHms1 is only found in upper valleys of the Toba Landscape Unit.

*Terrestrial Ecosystem Mapping (TEM) was not available for these landscape units, limiting the features that could be mapped.

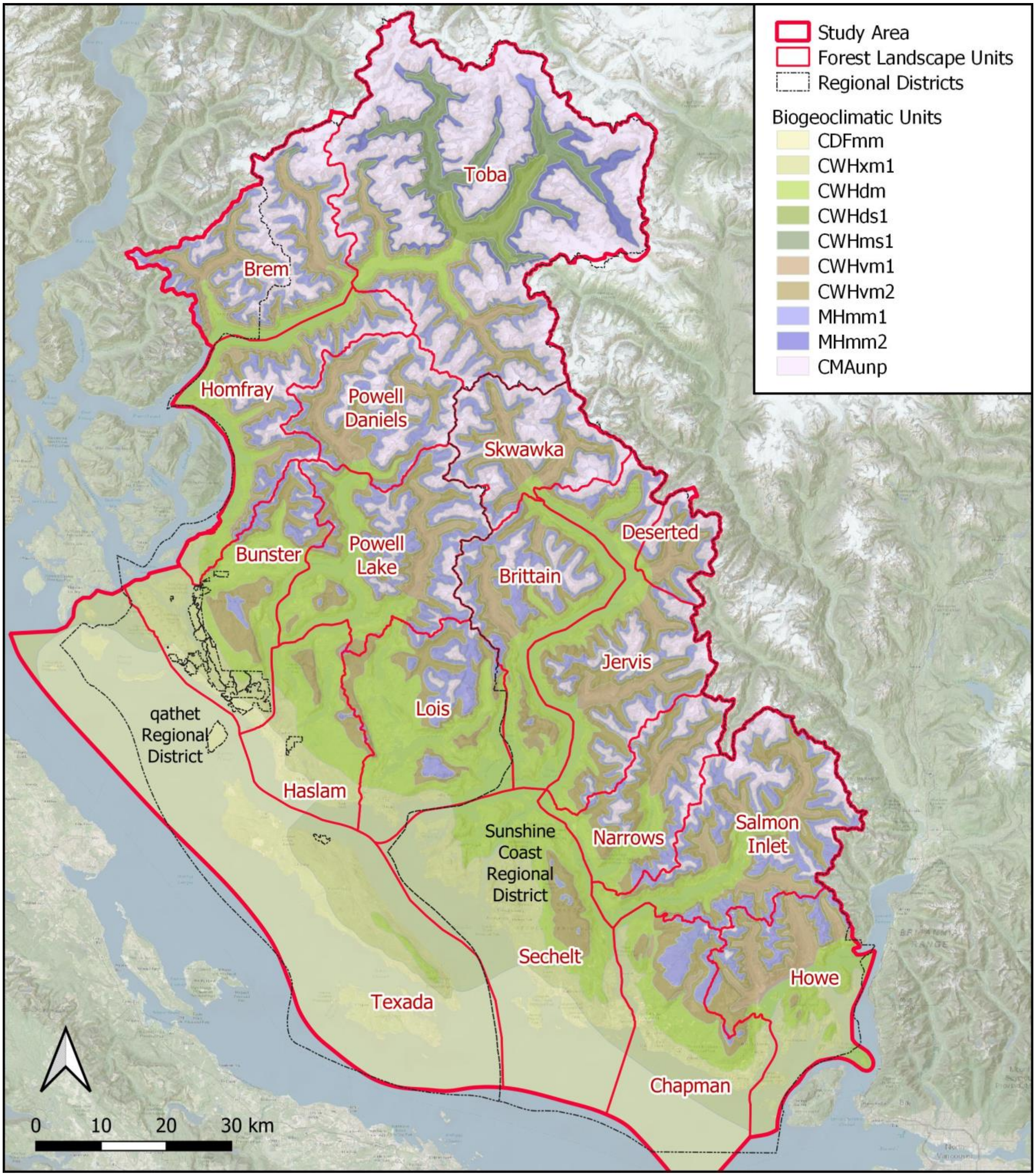


Figure 1. Study area with landscape units, Regional Districts, and biogeoclimatic zones indicated.

METHODOLOGY

2.1 Approach

A three-step approach was used for this analysis:

1. Literature was reviewed to identify:

- Projected climate-driven ecosystem shifts and impacts on biodiversity, hydrology and aquatic ecosystems in the study area;
- Ecological risk thresholds for BEC units in the study area (based on ***Natural Range of Variability***; Section 6);
- Best practices for riparian buffers for fish, riparian health, amphibians and climate resilience (e.g. stream temperature; Section 7);
- Characteristics of potential climate microrefugia and corridors in the study area (as per Ashcroft 2010; Section 8).

2. Spatial layers were assembled representing the following features:

- Known and potential distributions of at risk ecological communities (aka plant communities) listed by the BC Conservation Data Centre (CDC) ;
- Potential distribution of sensitive ecosystems;
- Distribution of old and mature forest, big-tree old/mature forest, and ancient forest;
- Deviation of old forest percentages relative to natural range of variability, and associated risk to species and ecosystem services (by BEC - landscape unit combination);
- Hydroriparian elements important for sustaining aquatic ecosystems and fish habitat;
- High value near-shore marine habitats;
- Locations of potential climate microrefugia and corridors for species and ecosystems.

3. The above information was synthesised to make recommendations on ecosystem elements and buffers for consideration by planners and land managers, specifically in relation to:

- Sensitive ecosystems and at ecological communities;
- Requirements for fish habitat and aquatic ecosystems;
- High value near shore marine ecosystems;
- Climate corridors and microrefugia needed for the long-term persistence of species, ecosystems and ecosystem services in the study area.

2.2 Data Coverage

Analysis was limited by the availability of existing spatial data**. Table 1** summarises the main data sources used for the analysis and their coverage in the study area. Note that no TEM was available for the Brem, Toba and Homfray landscape units, therefore no mapping derived from TEM data could be generated for these areas. Also note that TEM/SEI, VRI, and OGSR TAP mapping was *not* wall-to-wall for the study area (**Figures 2-5**), with the largest notable coverage gaps on private lands and within parks. The Sunshine Coast SEI coverage is limited to selected features in the CDMmm, CWHxm and CWHdm subzones (lower elevation areas).

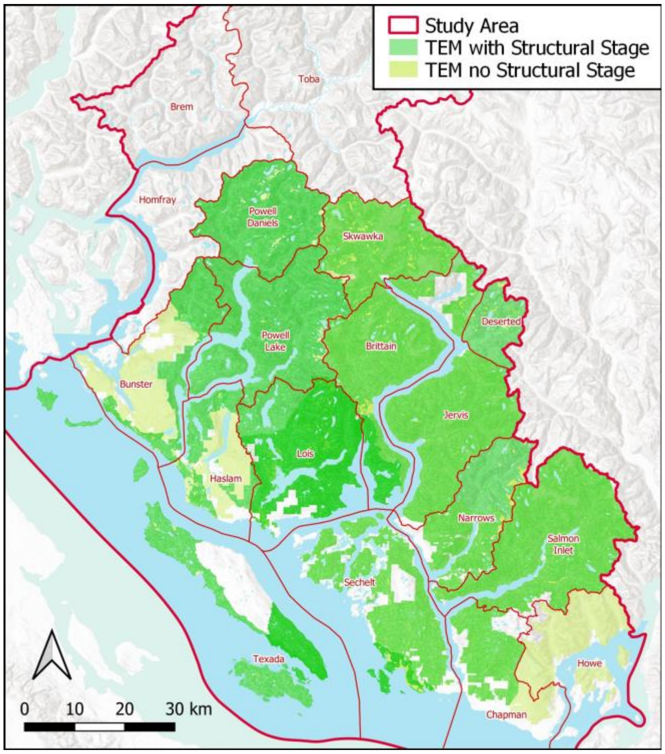


Figure 2. Terrestrial Ecosystem Mapping (TEM) coverage in the study area.

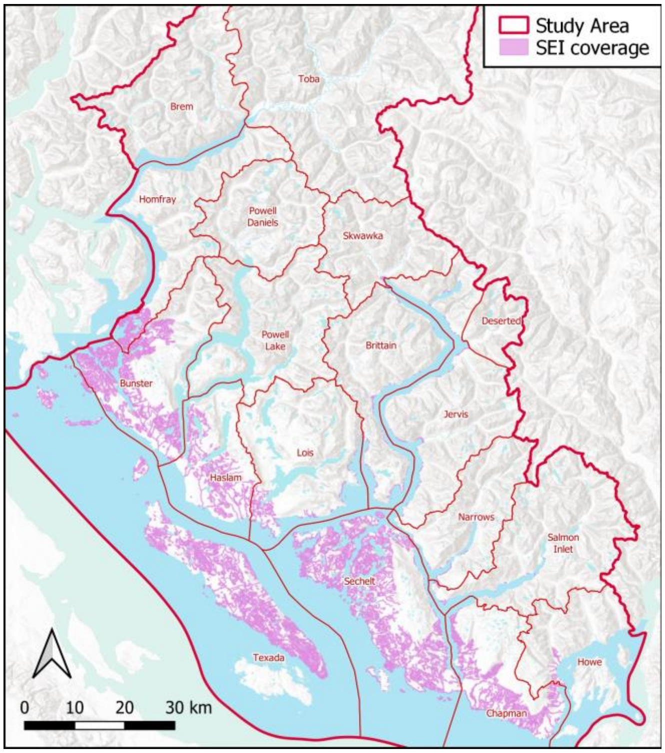
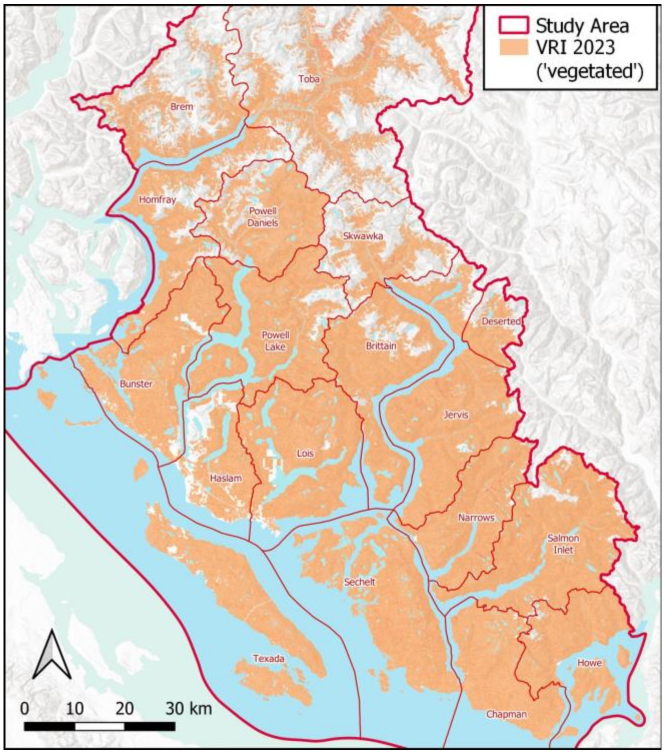


Figure 3. Sensitive Ecosystem Inventory (SEI) coverage in the study area.



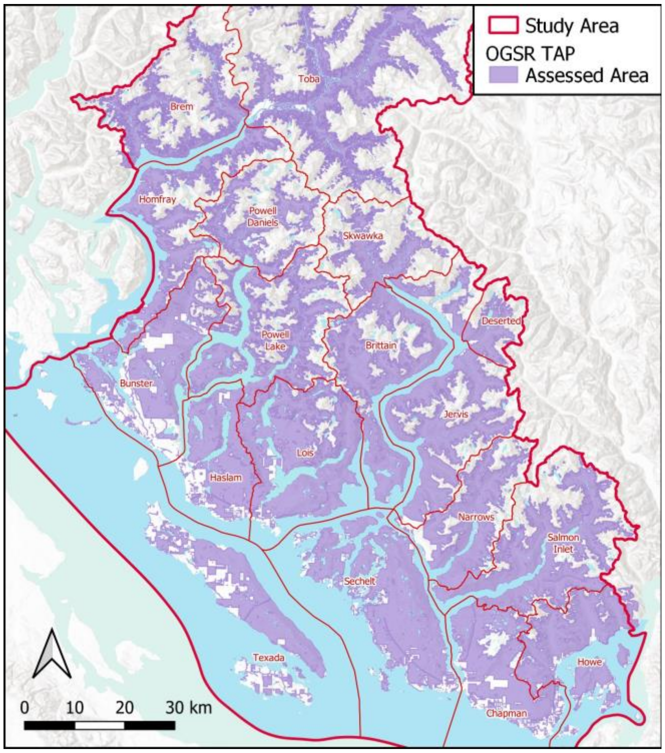


Figure 4. Vegetation Resource Inventory (VRI) coverage in the study area.

Figure 5. OGSR Technical Advisory Panel mapping (OGSR TAP) coverage in the study area.

Table 1. Primary spatial data sources and their coverage within the study area.

Source	Coverage	Vintage *(created or last modified)*
Terrestrial Ecosystem Mapping (TEM)	See **Figure 2**	2008-2022
Sensitive Ecosystem Mapping (Sunshine Coast SEI)	See **Figure 3**	2008
Vegetation Resource Inventory (VRI)	See **Figure 4**	2023
OGSR Technical Advisory Panel mapping (OGSR TAP)[3]	See **Figure 5**	2022
Freshwater Atlas layers (streams, lakes, wetlands, coastline)	Whole study area	2006
Topographical riparian mapping (TNT)	Whole study area	2021
CRIMS shell fish and herring spawn mapping	Whole study area	2004
Pacific Estuary Conservation Program (PECP) mapping	Whole study area	2007 (update 2019)
Terrain Inventory Mapping	Whole study area	1972-1987

Details about all of the input data can be found in **Appendix B**.

2.3 Mapping Themes & Layers

A number of publicly available data sources (see **Appendix B**) were assembled to depict and create a variety of mapping themes, which are outlined in **Table 2**.

New map layers had to be created to help depict the following themes, which are not currently mapped or only partially mapped for the study area:

- Potential Ecological Communities at Risk, based on TEM/SEI
    - All ecological communities (including forest communities, regardless of structural stage)
    - Forested communities (non-flood, non-wetland)
- Potential Sensitive Ecosystems
- Natural Range of Variability and Risk
- Climate Microrefugia

A combination of data was used to devise the above layers, including ‘crosswalking’ some sources together (e.g., correlating TEM ecosystems with Ecological Communities at Risk, Sensitive Ecosystems, and Climate Microrefugia), as per the methods detailed in **Appendix B**, and the crosswalk and ratings tables in **Appendix E.**

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[3] The forested assessment land base (FALB) used by the Old Growth Strategic Review (OGSR) Technical Advisory Panel (TAP) is a modified version of the provincial Vegetation Inventory (Vegetation Composite Polygons Rank 1 layer, aka VRI) forest management land base (FMLB). The modifications include such things as:
- Include areas with known forest harvesting history
- Exclude areas considered Vegetated but Non-Treed, where not otherwise considered forested
- Exclude natural disturbance type 5 (alpine tundra and subalpine parkland)

These spatial files are available from the CDFCP, and are organized in project folders that allow them to be loaded into a corresponding QGIS project file (e'g', Sunshine Coast Pilot project_3July2024.qgz) to be viewed, already formatted/styled, or used for further analyses.

Table 2. Map themes and layers included in the pilot project; *layers resulting from GIS geoprocessing are in bold italics*.

Theme	Layers
Tenure	• Forest Landscape Units • Regional Districts • Municipalities • Forest Harvest Restriction • Parcel Fabric
Landcover & Disturbance	• CEF Human Disturbance 2021 • Digital Road Atlas (DRA) • ESRI landcover • VRI 2023 AgeClass 1 & 2 • ***Disturbance Masks:*** o ***Cleared / cutblocks*** o ***Built / developed, including roads***
Ecological & Terrain Data	• TEM & SEI mapping • Vegetation Resource Inventory Mapping (VRI 2023) • Old Growth Strategic Review (OGSR) Technical Advisory Panel Old forest Mapping • Biogeoclimatic Ecosystem Classification (BEC 12)
At Risk and Other Sensitive Ecosystems	
Ecological Communities at Risk	• BC Conservation Data Centre (CDC) Element Occurrences • ***Potential ECAR (x-walked from TEM/SEI)*** • ***Potential Old & Mature Forested ECAR (from TEM/SEI & VRI, OGSR)***

Theme	Layers
Sensitive Ecosystems	• Sunshine Coast SEI • ***Potential Sensitive Ecosystems from TEM/SEI:*** ○ ***Wetlands*** ○ ***Riparian*** ○ ***Woodland*** ○ ***Estuaries*** ○ ***Herbaceous*** ○ ***Sparsely Vegetated*** (including Cliffs) ○ ***Old & Mature Forest*** (from TEM/SEI & VRI) • **OGSR TAP Old Forest mapping:** ○ Priority Deferral Areas (old forest) ○ Ancient forest ○ Big tree old forest ○ Priority recruitment forest ○ Intact forested watersheds • ***Riparian fringe*** (buffered FWA lakes, wetlands, streams) • **Karst potential** • **Sensitive Nearshore Marine Ecosystems (from CRIMS)** ○ Shellfish beaches (from CRIMS) ○ Herring spawn areas (from CRIMS)

Theme	Layers
NRV Risk	• ***Natural range of variability & risk levels*** (from BEC & VRI)
Hydroriparian	• ***Lakes, wetlands, streams*** (buffered from FWA) • Wetland ecosystems (from TEM/SEI) • Riparian Ecosystems (from TEM/SEI) • ***Fans & cones*** (from TEM/SEI modifiers)
Climate Microrefugia	• ***Hydroriparian layers***(listed above) • ***Coastal fringe*** (from FWA and CRIMS) • ***Moist/cool forest*** (from TEM/SEI) • ***Old forest*** (from TEM/SEI & VRI & OGSR) • ***Old & mature forest with big trees*** (from OGSR) • ***Ancient forest*** (from VRI) • ***Talus slopes*** (from TEM/SEI)

Because the ecosystem mapping is quite old for most of the study area, '***disturbance masks'*** were created to excise all or parts of polygons that have been developed and/or logged since the TEM was completed (methods and sources in **Appendix B**). Two disturbance masks were produced:

- permanently built areas, including roads;
- and cleared areas, including agriculture and cutblocks (including VRI polygons with age class 1 or 2).

The accuracy and precision of the input sources was variable, and despite efforts to revise and refine the masks based on aerial imagery, they are still very coarse.

The lack of accuracy and precision in the disturbance masks made them unsuitable to be used to permanently alter the TEI layers. Only the VRI layer (age class 1 & 2) was actually used as a "cookie-cutter" to remove disturbed areas, and only to change those TEI layers consisting of only forested polygons (i.e., TEM/SEI polygons containing forest in structural stage 5 to 7 were selected and saved as a separate layer). Recent VRI clearcuts (age class 1 and 2) were clipped out of the forested TEI polygons in the 'old & mature forest' layers.

3 PROJECTED CLIMATE IMPACTS

Climate change will have profound impacts on the BC's south coast ecosystems, fish and wildlife, and needs to be an overarching consideration when undertaking conservation and climate adaptation planning for the study area. **Figure 6** shows Climate BC's predicted changes in mean annual temperature in the study area by 2070. Biogeoclimatic projections, such as those used in the Climate BC model[4], can be used to approximate climate change impacts on a wide range of species, ecosystems, and ecosystem services (Mahoney 2019). The Climate BC model projects that by 2070 the CDFmm will completely disappear from the study area (and BC). In its place will be a new BEC zone that is completely novel to the province (**Figure 7**). By 2070 this novel BEC zone will have also displaced the drier CWH subzones (CWHxm and CWHdm) from where they are currently found in the study area, and by 2100 it will have also displaced most of the current CWHvm1 as well (**Figure 7**). This means all coastal areas, as well as valley bottoms, will be in a much warmer BEC zone, one with no current analog in the PNW and possibly North America (Mahoney et al. 2022; Mahoney 2019). For context, climate modeling by the Pacific Climate Impacts Consortium has projected that by the 2050s, Vancouver will be warmer than present day San Diego, 2000km to the south (Metro Vancouver 2016).

Within the study area, potential ranges/niches of many species and ecosystems will shift markedly. Pojar (2010) summarizes the consequences as follows:

> Species will be forced to migrate to stay within their range of temperature and moisture tolerance. However, slow moving species, such as trees, will need decades and probably centuries to catch up to their shifted climate niche. Species with poor dispersal capabilities (e.g. red-legged frogs or tailed frogs) could fail to move quickly enough to survive at the local level. Species whose potential geographic range shrinks or disappears (e.g. many species in the CDFmm, which is projected to disappear by 2070) could ultimately vanish in the event of disease or extreme events (e.g. fire, drought) and loss of suitable environmental conditions.

General predicted changes in the zonal climate envelopes include the following:

- A general shift of BEC zones from North to South – (the CDFmm is an exception: Climate BC modelling indicates this zone will be constrained be from moving both northerly and elevationally, and will therefore disappear completely);
- A major upslope expansion of dry coastal forest;
- Shrinking of alpine and subalpine ecosystems;
- Wide-ranging change in wetlands and aquatic ecosystems because of warmer water and changes in hydrology related to decreased snowpack and altered precipitation patterns;
- Large diebacks for trees due to drought and drought-facilitated insect, disease, and fire damage;
- Increased frequency and intensity of windstorms and blowdown damage (Pojar 2010).

Species that are already rare or at risk will be particularly vulnerable to climate shifts, especially those in smaller and more isolated populations and with poorer dispersal abilities (e.g. Red-legged Frogs, Coastal Tailed Frogs), and those which are already limited or stressed by lack or fragmentation of suitable habitat (e.g. Marbled Murrelets and other old growth obligates). Species and ecosystems that are currently at risk because they are at the northern limit of their range within the CDFmm or CWHxm subzones will be disproportionately affected, because there will be no suitable future biogeoclimatic

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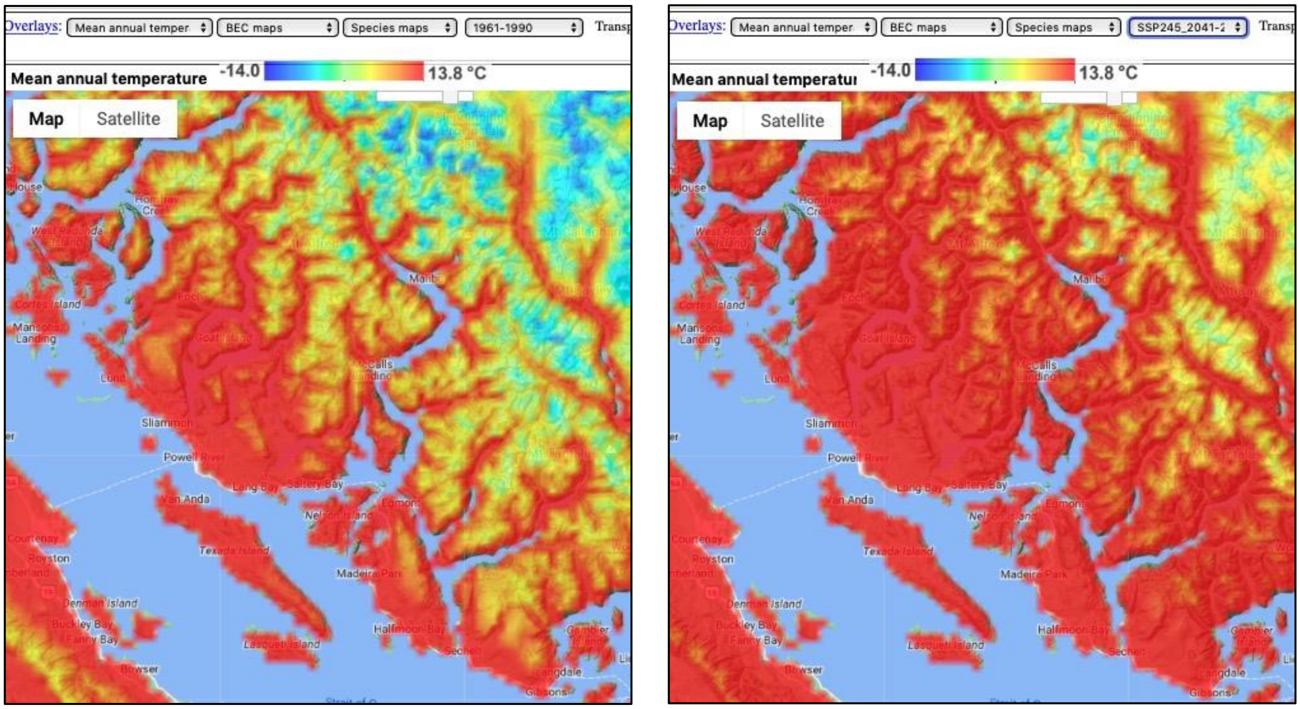
[4] See https://climatebc.ca (Mahoney et al. 2022).

conditions to which they can retreat. Species and ecosystems that are disturbed and fragmented beyond their ***natural range of variation*** (see **Section 6**) will be less resilient against wildfire, heat stress, drought, disease, and insects.



a) 1961 to 1996 **b) 2041 to 2070**

Figure 6. Projected changes in mean annual temperature for the study area by 2040-2070 (Source: Mahoney et al. 2022).

Climate-driven ecosystem shifts are already leading to extensive biological impacts across BC and Canada; ultimately, conserving species and ecosystems at risk will require more than just protecting remnants of suitable habitat[5] (Corristine & Kerr 2011). As such, conservation planning that aims to support the long term persistence of species and ecosystems at risk not only needs to capture remaining at risk ecosystems and habitats, it also needs to be future-oriented in terms of capturing adequate recruitment habitat, migration corridors, and ***climate microrefugia*** (see **Section 8**).

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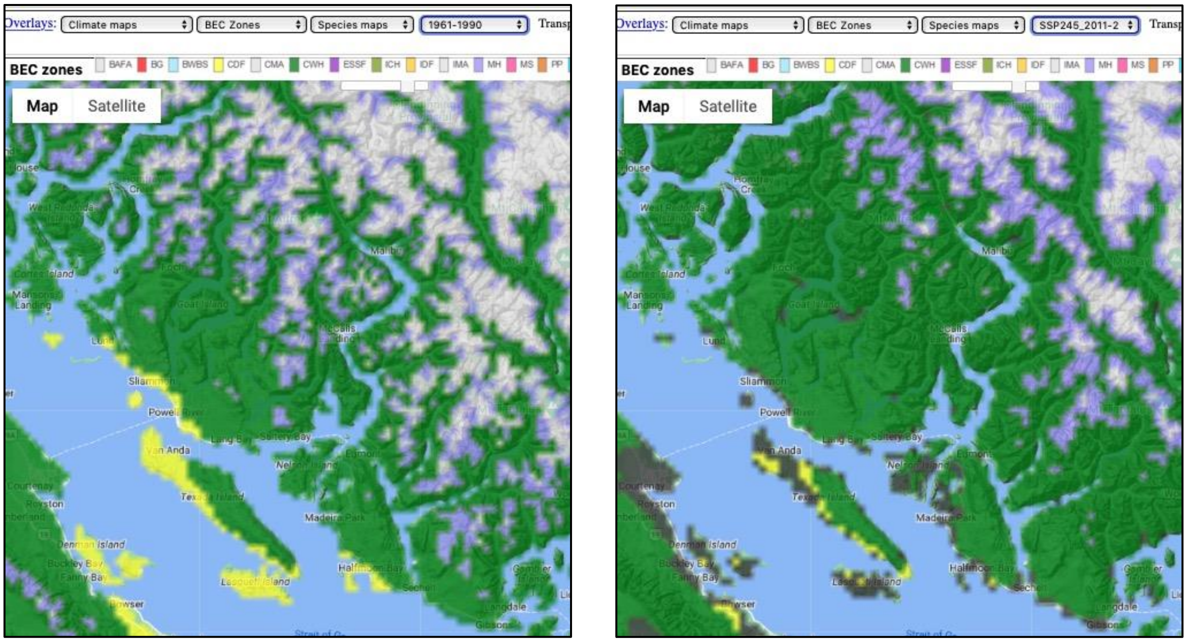
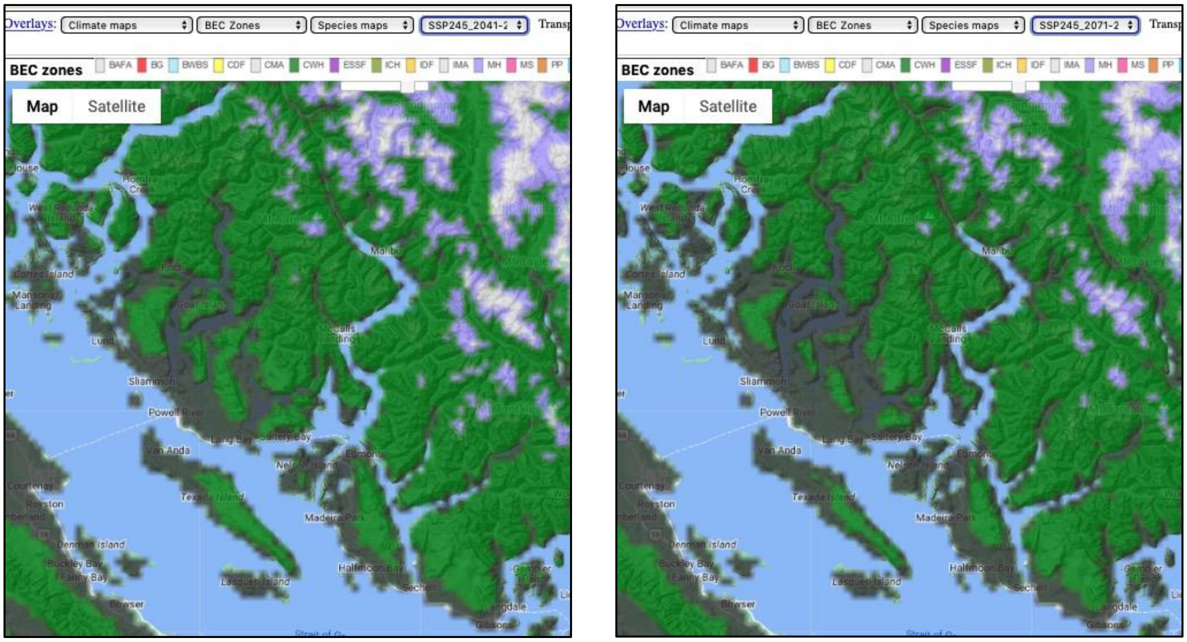
[5] BC has no dedicated species at risk legislation, and federal species at risk legislation (SARA) is plagued by ineffectiveness and lack of timeliness and limited application outside of federal lands (Westwood et al. 2019).



a) 1961-1990

b) 2011-2040



c) 2041-2070

d) 2071-2100

Figure 7. Projected shifts in the study area's biogeoclimatic zones, by 30 year periods.
The CDF is indicated in yellow, the CWH in shades of green, and the MH in purple. (Source: CCISS Tool, 2024- Climate Change Informed Species Selection Tool (thebeczone.ca)).

4 SENSITIVE & AT-RISK ECOSYSTEMS

Due to decades of intensive forest harvesting and development (especially in lower elevations along the coast and in valley bottoms; i.e. the CDFmm, CWHxm and CHWdm BEC units), many of the study area's ecological communities are at risk of being lost, particularly old forest ecosystems. Many of these ecosystems will be further imperilled by climate change (as described above in **Section 4**). Many other areas with sensitive ecosystems in the study area, including karst features, are also susceptible to climate change impacts.

Ecological Communities at Risk (ECAR) and other ***Sensitive Ecosystems*** are priorities for conservation and inclusion within conservation networks due to their Provincial and regional scarcity, fragility or vulnerability to disturbance, and value to biodiversity: sensitive ecosystems are important habitat for several at risk plant and animal species, especially:

- Old and mature forest, particularly with tall trees and in the drier and lower elevation BEC subzones (CDFmm, CWHxm, dm & vm1);
- Dry open woodland (especially within the CDFmm on Lasqueti and Texada Islands);
- Wetlands, floodplains and riparian areas;
- Shallow soiled, sparsely vegetated areas (e.g. rock outcrops, cliffs);
- Beach/dune areas (primarily on Savary, Hernando and Thormanby Islands, and Sargeant Bay, but there may be undocumented species at risk in similar habitats on Harwood Island and elsewhere).

4.1 Ecological Communities At Risk

The BC Conservation Data Centre (BC CDC) maintains lists of Ecological Communities at risk of being lost in BC (ECAR). The CDC's element occurrence mapping[6] for the study area includes occurrences of 14 red listed and five blue listed ecological communities (tabulated in **Appendix D, Table D-1**). CDC element occurrence mapping of ECAR is not, however, comprehensive, and is concentrated on the CDFmm. As a result, not all ECAR are represented / mapped. When used alone, the CDC element occurrence mapping can therefore be misinterpreted to suggest:

- Few ECAR are found outside the CDFmm,
- There are fewer types of ECAR in a given area than actually occur.

By contrast, the *BC Species and Ecosystems Explorer* database[7] (BCCDC 2024) indicates that 58 red listed and 37 blue listed ecological communities are potentially found in the study area (tabulated in **Appendix D, Table D-2**). Twenty-two of these communities are also globally imperilled (G2) or critically imperilled (G1), and 26 are known to be endemic. The global range of many of these ECAR is largely or almost entirely restricted to the CDFmm[8] and CWHxm subzones of southwest British Columbia, underscoring both their global uniqueness and BC's responsibility for their conservation.

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[6] CDC element occurrences (EOs) represent a stand or patch of an ecological community, or more commonly, a cluster of stands or patches of an ecological community (NatureServe 2002). EOs are given conservation rankings based on their condition, size and landscape context (MOE 2006).

[7] Based on a search conducted in February 2024, using the Sunshine Coast Natural Resource District as a boundary.

[8] The CDF zone is home to the highest number of species and ecosystems at risk in BC, many of which are ranked globally as imperilled or critically imperilled (see CDFCP.ca for more information).

To provide a more realistic representation of where ECAR are likely to occur on the Sunshine Coast, a list was generated of all TEM units/codes used by the 21 TEM projects in the study area. This was crosswalked with the list of ECAR in **Appendix D, Table D-2**, to identify all TEM polygons that potentially contain ECAR (see **Appendix E** for crosswalk table). Using the methods outlined in **Appendix B,** the crosswalk table was then used to generate ratings tables that were joined to the TEM spatial data to produce maps showing *potential* locations of ECAR in the study area, without considering age or condition.

Disturbance masks were created to excise all or parts of ECAR polygons that have been developed and/or logged since the TEM was completed (methods and sources in **Appendix B**). Two disturbance masks were produced: permanently built areas, and cleared areas (including VRI polygons with age class 1 or 2). The accuracy and precision of the input sources was variable, and despite efforts to revise and refine the masks based on aerial imagery, they were still very coarse and inconsistently accurate. Several important areas occur under the 'built' mask (**Figure 8**), which would remove them from the mapping, so it was considered too inaccurate to be used to alter the TEM polygons. The VRI layer was the only input used to revise the TEM, by adjusting forest age and cutting out recent cutblocks from the mature & old forest layers.

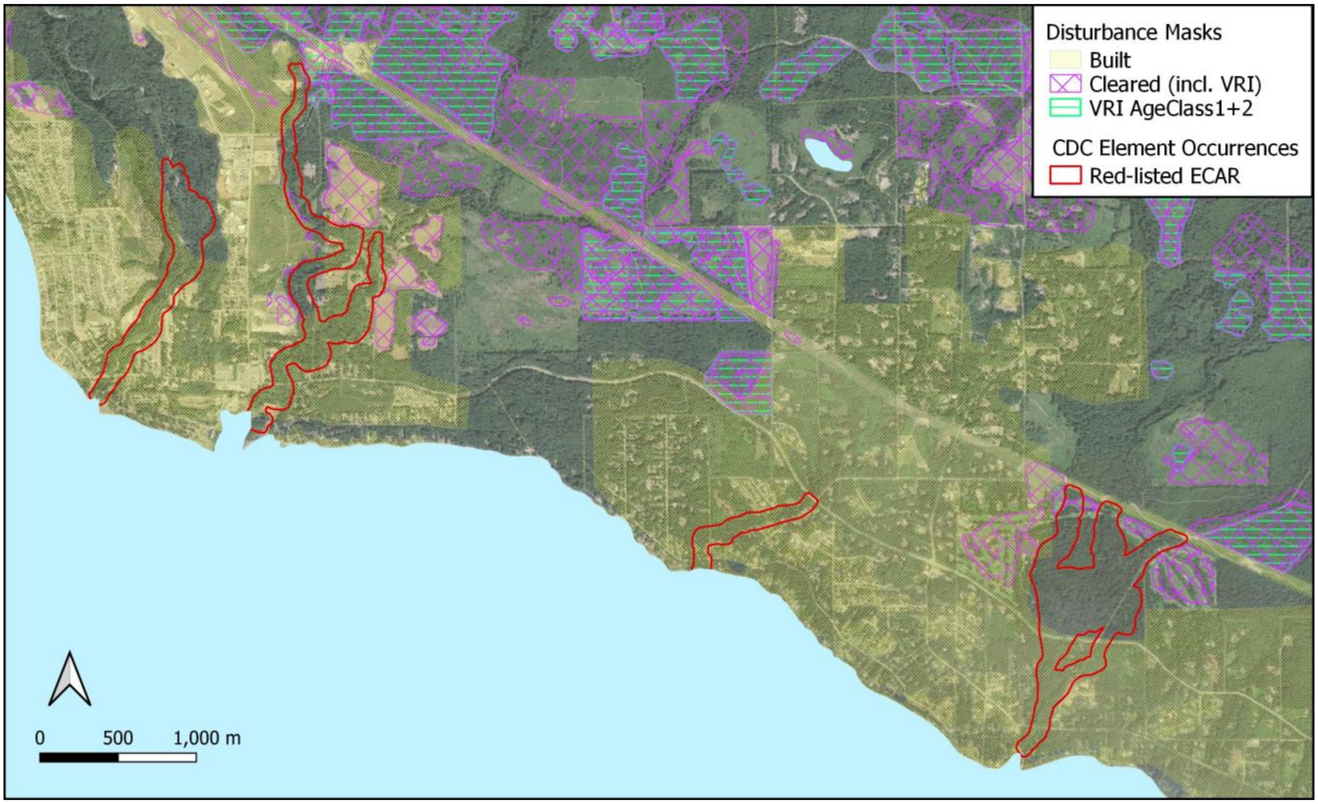


Figure 8. Example of the disturbance masks and CDC mapped EOs shown on aerial imagery; poor/inconsistent accuracy and low precision precluded all inputs except VRI from being used as a mask (for old & mature forest layers only).

Locations of CDC Element Occurrences for all ECAR in the study area are shown in **Figure 9**, as well as all TEI polygons where ECAR are *potentially* found, regardless of age.

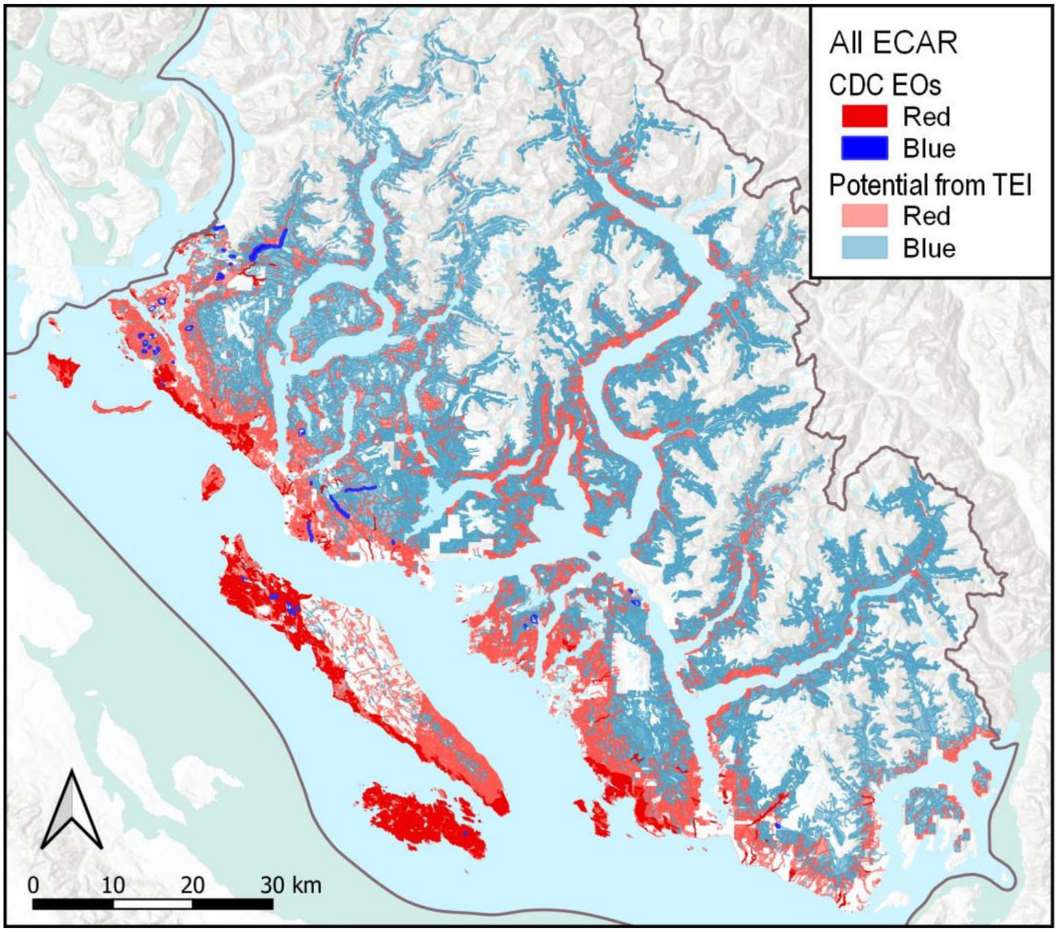


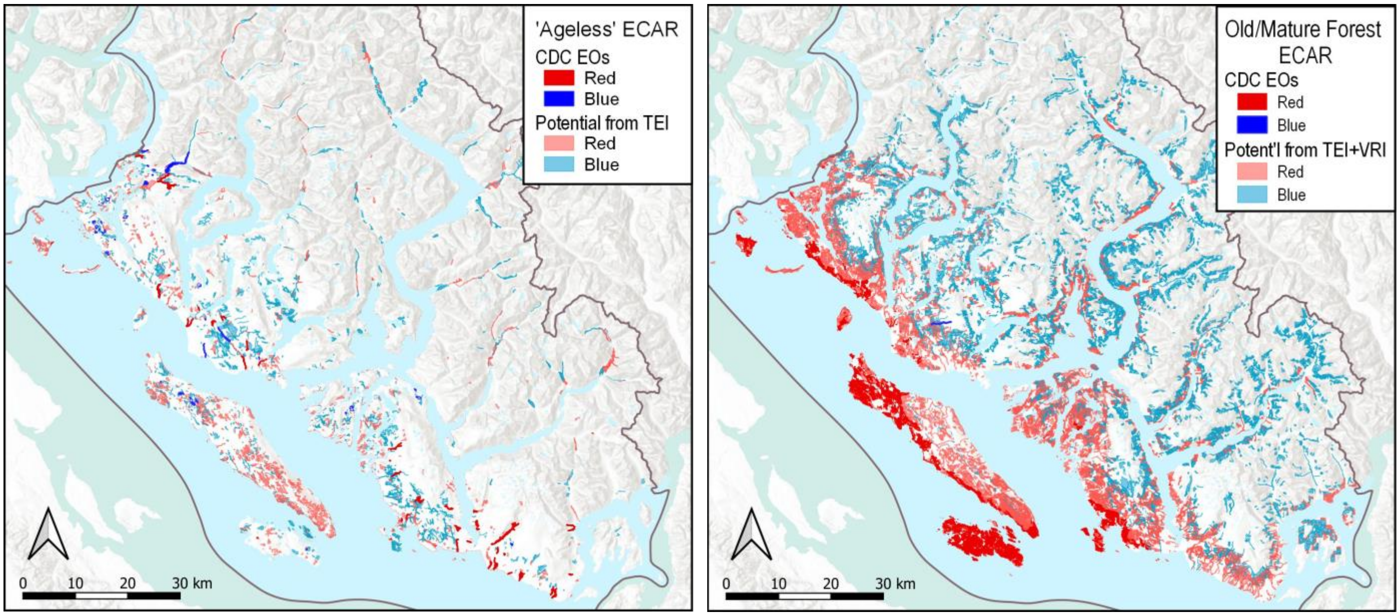
Figure 9. Locations of all CDC Element Occurrences for ECAR and all potential ECAR locations from TEM/SEI.

While the CDC element occurrence mapping only captures 19 of the 95 red and blue-listed ECAR that *Species and Ecosystems Explorer* identifies as potentially occurring in the study area, the potential ECAR mapping based on TEM captures 59 (**Appendix D**). The TEM-based ECAR mapping also shows that ECAR are much more widely distributed in the study area than is suggested by the CDC element occurrence mapping alone.

Note that the potential ECAR mapping has gaps where TEM coverage is lacking or incomplete (see the TEM coverage map in **Figure 2**). The CDC considers size, condition, viability, etc., of the ecological community during element occurrence mapping (NatureServe 2002); these assessments were beyond the scope of the potential ECAR mapping done for this pilot study, but some of these results may be of use as Source Features from which to create EOs.

Figure 10 shows locations of ecological communities that have been mapped by the CDC as Element Occurrences as well as potential ECAR based on TEI, but differentiated by habitat type. Ecosystems in **Figure 10a** are non-forested or high-value at any stand age (e.g., riparian, treed wetland). **Figure 10b**

shows the potential ECAR locations of forested ecosystems, with young forests that are unlikely to meet "sufficiently established criteria"[9] filtered out.



a) Ecological Communities that are at risk regardless of structural stage / age class.

b) Ecological Communities that are at risk once mature or old; "insufficiently established" forests are filtered out.

Figure 10. ECAR in the study area, including CDC element occurrences, and potential occurrences based on TEM/SEI (and VRI for b).

4.2 Sensitive Ecosystems

Sensitive ecosystems are those deemed ecologically sensitive/fragile, rare on the landscape, generally high biodiversity, and containing important habitats for many threatened and endangered plant and animal species (i.e. Species at Risk). Sensitive ecosystem categories mapped by the Sunshine Coast Sensitive Ecosystems Inventory (Cadrin et al. 2003) include: wetlands (bog, swamp, fen and shallow water), riparian areas, old forest, woodland, herbaceous (non-forested ecosystems), and cliffs. Mature forest and seasonally flooded fields were mapped as other important ecosystems (**Figure 11**).

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[9] As per guidelines used to identify listed plant communities for the Great Bear Rainforest Order (Banner et al.2019), criteria for '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.

Determining VOT density was beyond the scope of this pilot study. Hence all forests 80 yo and greater were considered to have potential for being "sufficiently established".

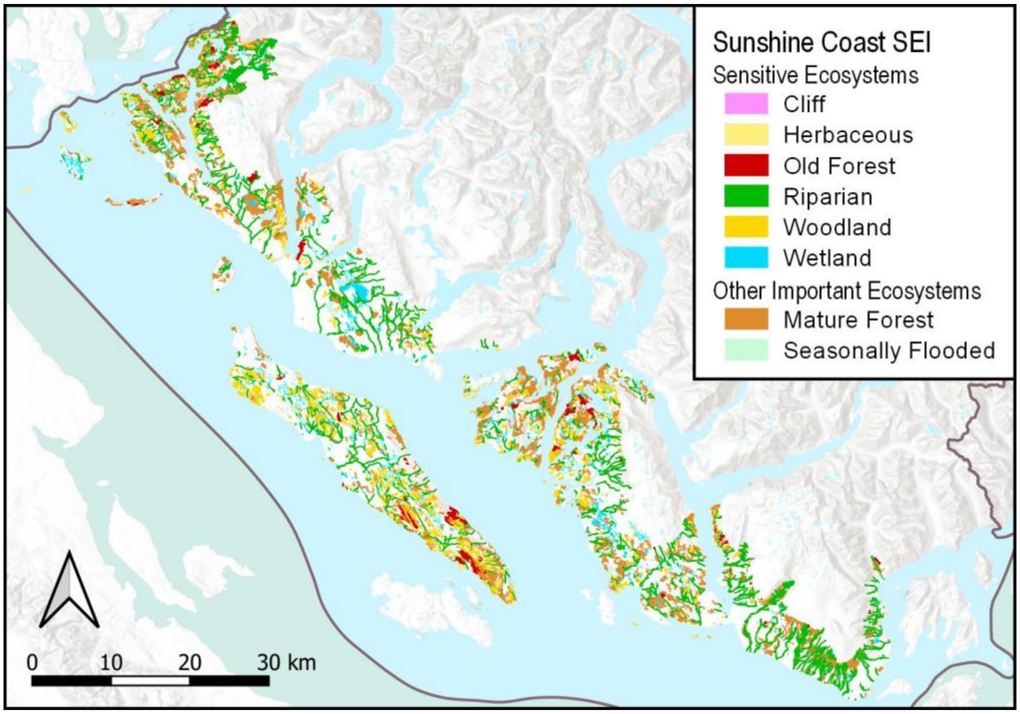

Figure 11. Sensitive Ecosystems Inventory of the Sunshine Coast (Cadrin et al. 2003).

The Sunshine Coast SEI mapping has a number of problems related to its scope and vintage:

- Mapping coverage is limited to lower elevation areas along the coast;
- Many forests mapped as old or mature at the time of mapping have since been logged or developed;
- Many forest stands that were "young" at the time of mapping are now "mature".

To address these issues, the data sources and methods outlined in **Table 2** and **Appendix B** were used to update and extend mapping of *potential* sensitive ecosystems in the study area (**Figure 12**). In summary, these methods included:

- A list of current Sensitive Ecosystem (SE) classes and subclasses applicable to the study area were generated (as per Terrestrial Ecosystem Information Unit 2023):
    - Wetland (WN:bg,ms,fn, sp etc.)
    - Riparian (RI:fh,fm,fl)
    - Woodland (WD)
    - Herbaceous (HB:du,cs,hb,vs)
    - Sparsely Vegetated (SV:ro,cl,ta)
    - Old / Mature Forest (coniferous forest with potential to be mature or old).
- The above SE classes and subclasses were crosswalked with the TEM map codes or Site Series used by the various TEM/SEI projects (21) with coverage in the study area (see crosswalk table in **Appendix E**).
- RI:ff (riparian 'flood fringe') cannot be derived directly from TEM (and coverage is incomplete), so a variety of data sources were used, including the Freshwater Atlas streams, lakes and wetlands (with 30 - 50 m buffers) and The Nature Trust of BC's topographical riparian mapping (TNT 2021). See the 'Riparian Sources' table in **Appendix E** for details.

- Old and mature forests were mapped using a combination of methods: Where there is no TEM coverage, VRI and/or TAP OGSR mapping was used (see **Appendix B**); Where there is TEM coverage, the age of forested TEM/SEI polygons was updated, if necessary, using corresponding/overlapping VRI polygons:
    - ➢ recent clearcuts (VRI polygons with age class 1 or 2) were clipped out of the TEI polygons in the forested layers;
    - ➢ ‘centroids’ were generated for each remaining polygon, or remaining portion(s) of TEI polygons;
    - ➢ each TEI centroid was assigned age class data from the VRI polygon that it fell within, and this data was joined back to the TEI polygon that the centroid originated from;
    - ➢ TEI polygons with structural stage 7 (old forest) were assigned age class of 9 (250+ yo) even if VRI identified them as younger (age classes 5-8).

Note that the potential sensitive ecosystems mapping (**Figure 12**) still has gaps where TEM, SEI and VRI coverages are lacking or incomplete (see **Figures 2** to **5**).

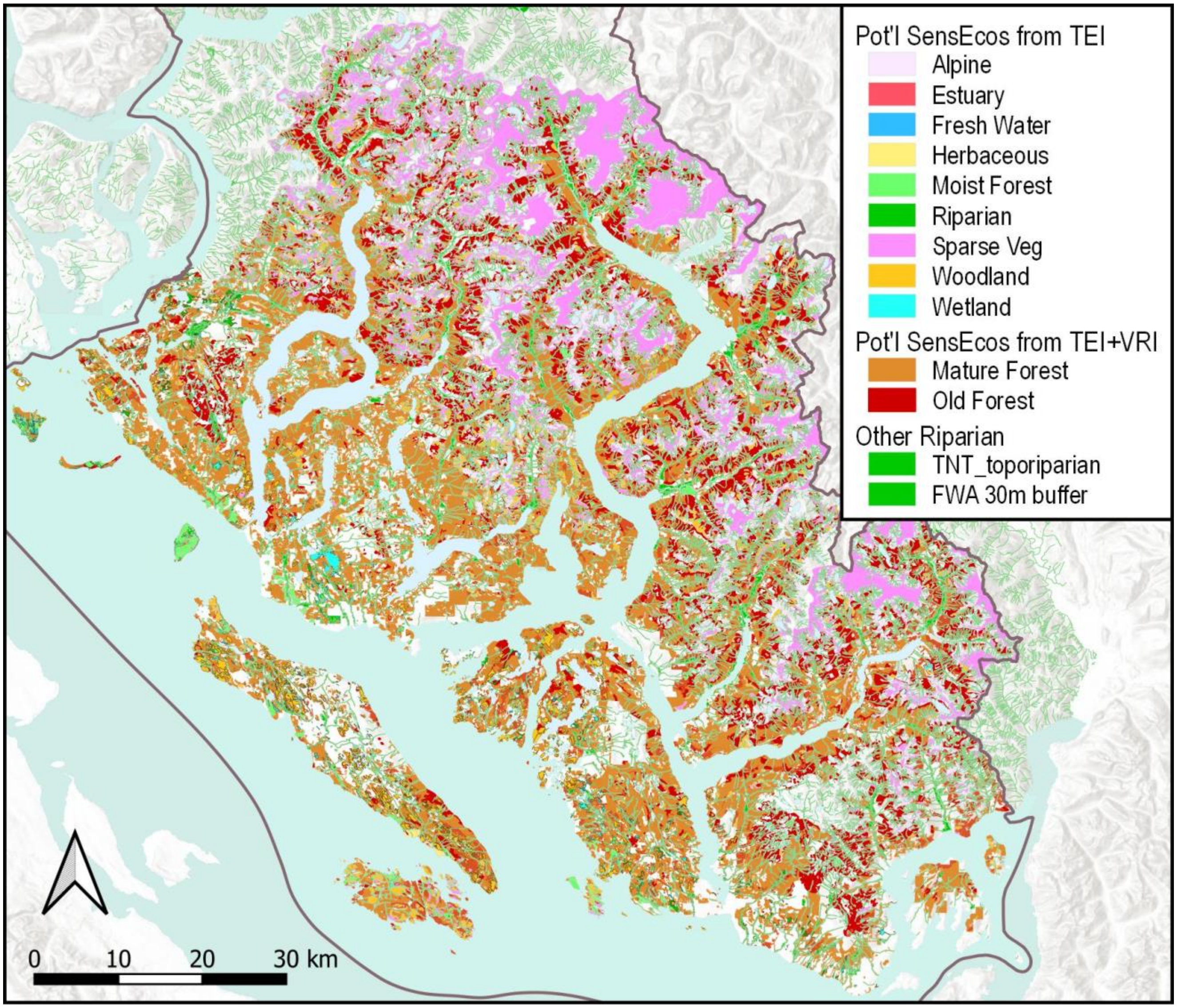

Figure 12. Potential sensitive ecosystems in the study area based on TEM and other data sources.

4.2.1 Old Growth Forest

The BC government formed the Old Growth Technical Advisory Panel (TAP) to implement the recommendations of its 2020 Old Growth Strategic Review (OGSR; Gorley & Merkel 2020). The OGSR states: "Forests with old and ancient trees contain unique combinations of attributes that grow from ecosystems that have formed over centuries or millennia. These attributes can rarely, if ever, be replicated in younger or compromised ecosystems, even if they contain old trees. Some of the many values found in forests with old and ancient trees are:

- Unique conditions and processes that are important to conservation of biodiversity;
- Unique species, many of which are still undiscovered;
- Banks of genetic material for future use or adaptation strategies;
- High value timber with qualities not found in younger forests;
- Resistance to fire;
- Interception and storage of water;
- High carbon storage and sequestration capacity;
- Botanical forest products, including medicinal, edible, decorative and ceremonial plants;
- Fish and wildlife habitats, including essential attributes for nesting or denning, thermal protection and hiding from predators;
- Spiritual and cultural uses, including carvings, canoes, and ceremonial poles;
- Aesthetics such as resident viewing and tourism;
- Commercial and non-commercial recreation; and
- Knowing they are there for their own sake – intrinsic value".

TAP was tasked with identifying old forest ecosystems that are at highest near-term risk of irreversible biodiversity loss, for harvest deferral until the Province devises a new Old Growth Strategy. Due to a century of intensive forest harvesting, many of the study area's forest ecosystems are at risk are old, particularly in the valley bottoms and the drier BEC subzones (i.e. CDFmm, CWHxm and CWHdm). **Figure 13** shows remaining patches old growth, with areas identified by TAP as priorities for deferral highlighted. (Note that this mapping is based on TAP data that does not extend to private and First Nations lands). The TAP deferral criteria (OG TAP 2021a) include:

1. Big-treed old growth (remaining old growth with big trees);
2. Remnant old ecosystems (remnant old growth in BEC variants with less than 10% old remaining, in total and within a landscape unit);
3. Ancient forest (forest over 400 years old in ecosystems with rare stand-replacing disturbance);
4. Intact watersheds (contiguous areas of forest ecosystems relatively unaltered by human activities).

Big-tree & Remnant Old Growth

Old forests meeting criteria 1 and 2 are rare in the study area (**Figure 13)**, and largely overlap with the red and blue listed forest communities shown in **Figure 10.** (Note that this mapping is based on TAP data that does not extend to private and First Nations lands).

Ancient Old Growth

With regard to ancient forest (criteria 3), inherent deficiencies in the Provincial Vegetation Resource Inventory (VRI) do not allow for ancient forests (>400 yo) to be distinguished from old forests (>250 yo) without field verification (Holt et al. 2008; Price et al. 2020). As a consequence, ancient forests are poorly represented in the TAP priority deferral mapping (OG TAP 2021b), which also doesn't cover private and First Nations lands.

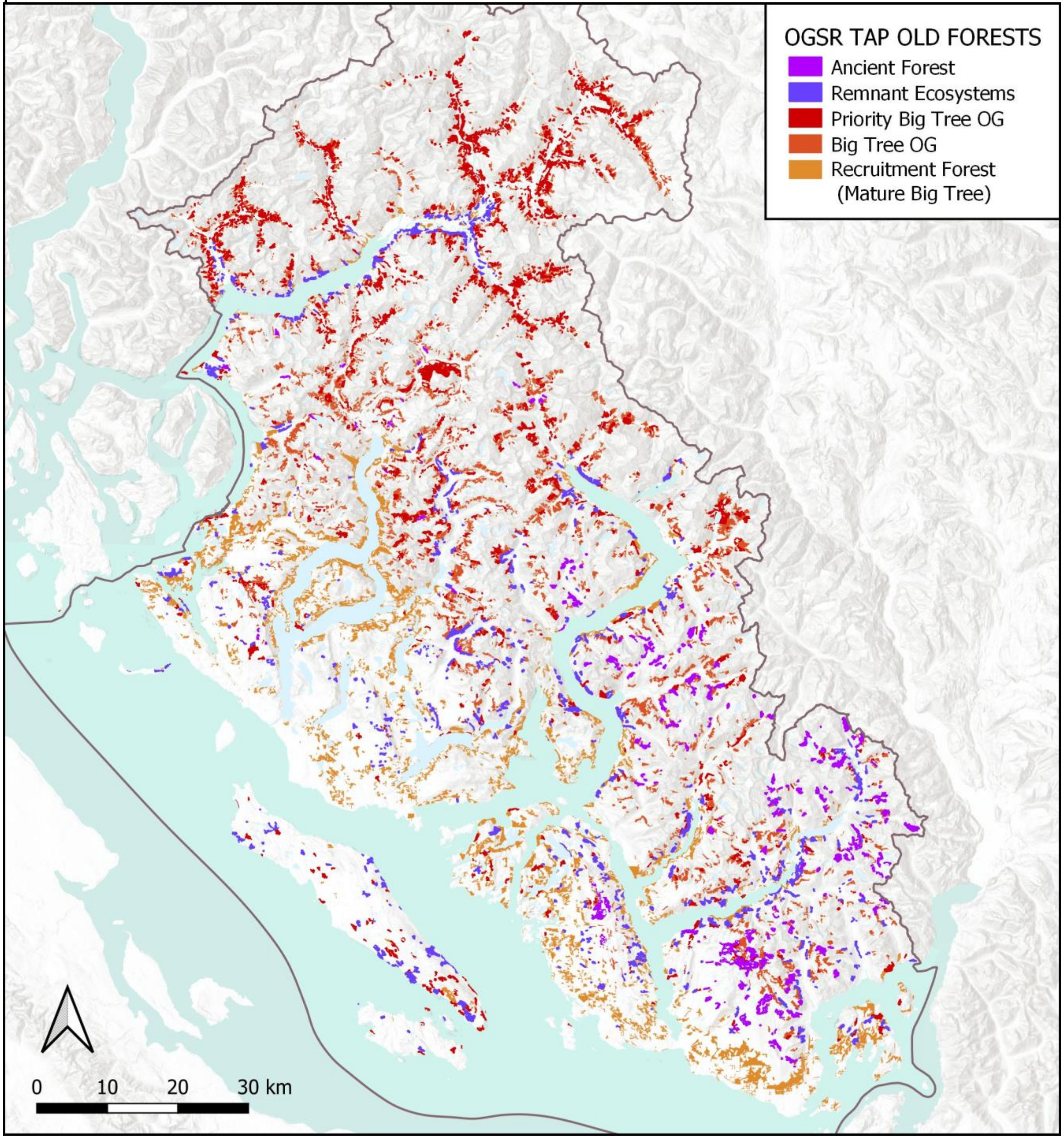

Figure 13. Old forest priorities mapped by the Old Growth Strategic Review Technical Advisory Panel.

To fill this gap, **Figure 13** also highlights additional old forest stands in the VRI with leading species aged 350 yo and up (as classed in the forest analysis completed by James Tricker, **Appendix C).** Because most of these forests are at higher elevations where there are infrequent natural disturbances, there is good probability that they are actually ancient (>400 yo), and therefore likely to meet **deferral criteria #3.** Specifically, this is because:

- Wetter and higher elevation coastal forests naturally experience only low levels of disturbance (i.e. fire): historically these forests would have been 85-95% old growth. Fire-return intervals in these types of forests have been estimated at between 700 and 6000 years, and as a result some forests are many thousands of years old (Price et al. 2020, Hebda 2007, Lertzman et al. 2002). For example, the Caren Range Forest of the lower Sunshine Coast is known to have 1250 year old Hemlock and 1824 year old Yellow Cedar, and may be the oldest known closed canopy forest in the world (Jones 2003).
- Consequently, within the study area, many remaining big tree old growth stands in the CWHvm2 and MHmm would be expected to be ancient (400+ years old), particularly those stands in the MHmm subzone, where trees are slow growing and small for their age (and hence are often many hundreds of years old before reaching a harvestable size).
- In comparison, the Technical Advisory Panel's mapping of ancient forest[10] shows only a handful of ancient forest stands in the study area, with none being labelled as greater than 557 years old.

According to the Old Growth Strategic Review (Gorley & Merkel 2020), and the Old Growth Technical Advisory Panel (OG TAP 2021), ancient forests are globally unique[11], rare, and contain species as yet undiscovered, and many of these ancient forests are non-renewable within any reasonable time frame. These forests have ancient genetic material and are repositories of biota and processes we may not even know or understand. They also store extremely high amounts of carbon, built up over millennia (OG TAP 2021; Gorley & Merkel 2020). This makes them an important buffer against species extinction, climate change, and lost future opportunities.

Klinka & Chourmouzis (2001, citing others) highlight the watershed importance of such forests, noting that their relatively open forest canopy is ideal for capturing and retaining snow: this prevents spring flooding and provides clean water even during dry summers[12]. Recent research shows that high elevation old and ancient forests play a critical role in providing climate change refuge (see **Section 8** for details), functioning as microrefugia for species populations at lower elevations as well as for high elevation species unable to move elsewhere as the climate shifts (Wolf et al. 2021, Morelli et al. 2016). These irreplaceable forests are sensitive to disturbance and are slow to recover (Parish & Antos 2006; Antos 2004; Voller & McKinnon 1999); they should not be in the timber harvest land base (Wolf et al. 2021).

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[10] Which was based on Province of BC 2010. BC Land Management Handbook #25. Structural stage 7b. NDT 1, 2 and 4 for less frequent disturbance.

[11] Some of BC's coastal rainforests are thousands of years old. These forests have completely different biodiversity values than forests defined by the Provincial old growth threshold of 250 years (Price et al. 2020).

[12] In addition, Klinka & Chourmouzis (2001) state that *any* form of clear-felling MH forests on sites where deeper snow is likely to accumulate (e.g. cooler, flatter sites) is inappropriate. This is because deep, lingering (e.g. into June) snow in the MH zone creates adverse conditions for the establishment, survival and growth of trees, and therefore preventing regeneration.

Intact Watersheds

Due to the extensive amount of harvesting that has taken place in the study area, few forests meet deferral criteria #4. **Figure 14** shows some of the remaining relatively intact watersheds in study area, as mapped by the Old Growth Technical Advisory Panel (OG TAP 2021). These are watersheds with relatively contiguous and intact old and mature forest, largely unfragmented by roads and human activity. They include areas of relatively undisturbed forest in the Toba, Brem, Homfray, western Powell Lake, upper Brittain, western Skwawka, and Deserted landscape units, as well as Desolation Sound Provincial Park and Lasqueti Island.

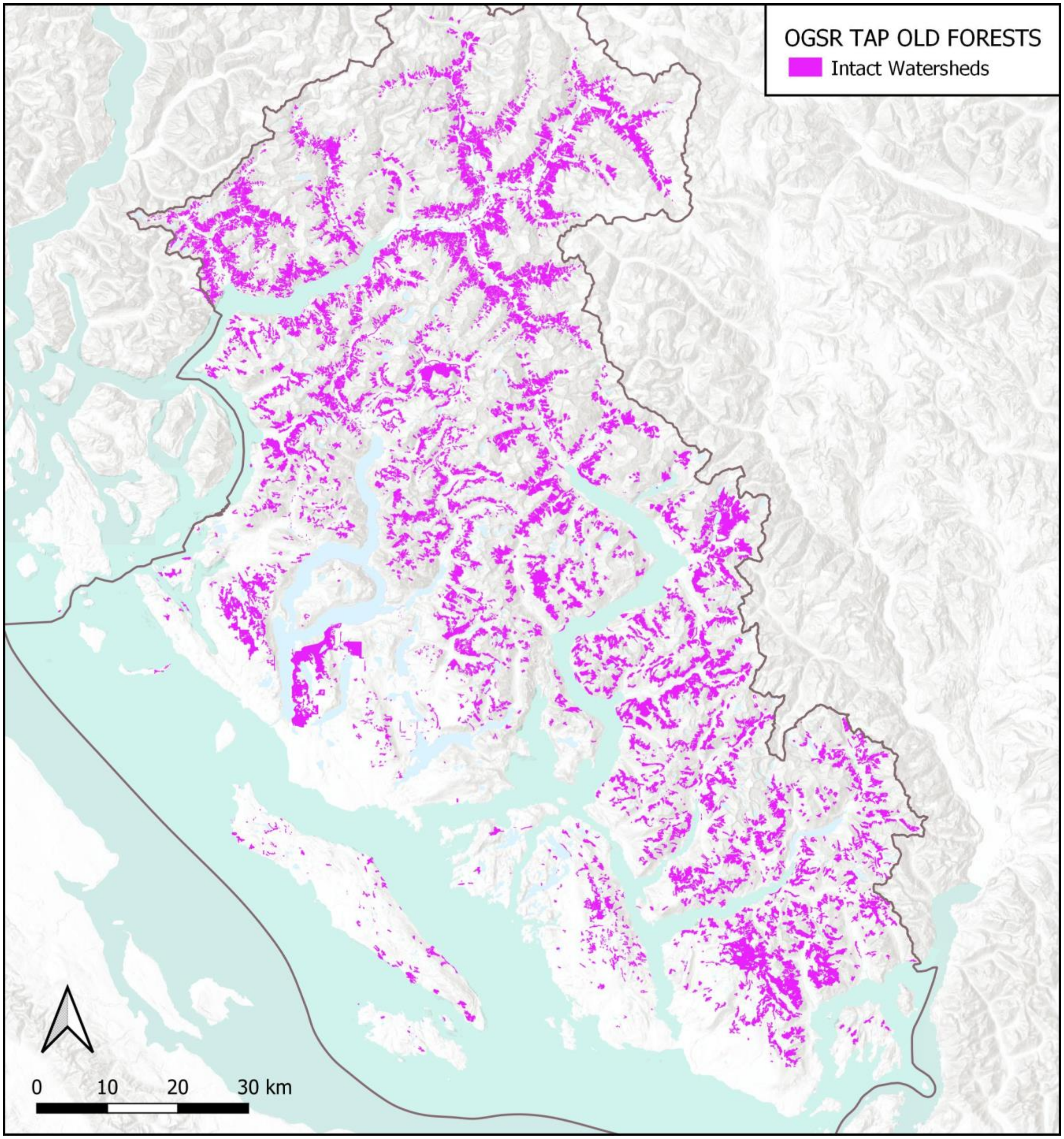

Figure 14. Relatively intact watersheds with high conservation value.

4.2.2 Karst

Karst is a unique, non-renewable resource with significant biological, hydrological, mineralogical, and scientific values. Karst ecosystems often support unusual or rare plant and animal species, both on the surface and underground (BC Ministry of Forests 2003). Karst ecosystems in B.C. are highly vulnerable to disturbance: road construction and forest harvesting can damage karst sinkholes, under-surface water systems, and potentially collapse entire karst cave systems (Holt 2007).

Figure 15 shows the general location of the Stromberg Karst area on Texada Island. Areas mapped by the Province as having karst potential are also shown. Consultation with local cavers would assist with identifying other important karst areas.

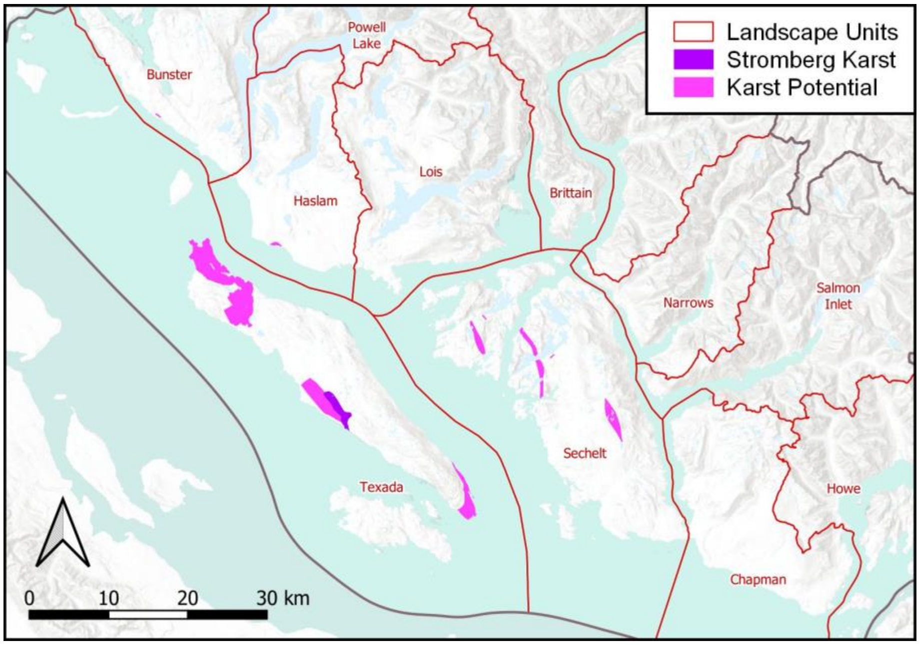

Figure 15. Stromberg Creek karst area and karst potential.

4.3 Summary of Conservation Considerations

- *Climate-driven ecosystem shifts are already leading to extensive biological impacts across BC and Canada; ultimately, conserving species and ecosystems at risk will require more than just protecting remnants of suitable habitat[13] (Corristine & Kerr 2011). A conservation network that aims to support the long term persistence of species and ecosystems at risk in the study area not only needs to capture remaining at risk ecosystems and habitats, it also needs to be future-oriented in terms of capturing adequate recruitment habitat, migration corridors, and climate microrefugia (see **Section 8**).*

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[13] BC has no dedicated species at risk legislation, and federal species at risk legislation (SARA) is plagued by ineffectiveness and lack of timeliness, and limited application outside of federal lands (Westwood et al. 2019).

- *Conservation planning should aim to capture at risk ecosystems highlighted in* ***Figure 8****, especially red-listed communities, and particularly in areas of the CDFmm and CWHxm1 that are hot-spots for at risk species and ecosystems, including: the northern end, southern tip and western side of Texada; all of Lasqueti; the Malaspina peninsula; and the area west of Inland Lake.*

- *CDFmm ecosystems were historically shaped by traditional indigenous resource management practices (e.g., using fire and thinning to maintain an open understory favorable to food and medicine plants). Conservation planners should make allowances for silvicultural practices that enhance old forest structure in red and blue listed CDFmm ecological communities, as per Negrave & Steward (2010), specifically those which:*
    - *maintain structural diversity in stands with high conservation value (e.g. old growth forest);*
    - *recruit structural diversity and old forest traits in structurally homogenous stands (e.g. second growth stands).*

- *It is recommended that conservation plans and networks include old and ancient forest ecosystems identified as being at risk, and the intact watersheds shown in* ***Figure 14*** *especially given their potential value to species at risk, watershed functioning, and as climate microrefugia (as discussed in* ***Section 8****).*

- *Conservation plans and networks should identify and prioritize karst features, in consultation with local cavers and naturalists.*

5 NATURAL RANGE OF VARIABILITY & RISK

An important consideration when planning for conservation and climate adaptation is how much a natural landscape can be altered before species are lost and desired ecosystem services are compromised; i.e. how much needs to be conserved for the long term viability of species and ecosystems? (Price et al. 2009). This is particularly important in context of the projected climate-driven shifts and impacts described in **Section 4**.

The Old Growth Strategic Review (OGSR; Gorley & Merkel 2020) states that a general risk rating based on an ecosystem's "***natural range of variability***"[14] (NRV) should serve as guidance. The NRV rule of thumb is that as long as ecosystems are not disrupted beyond 30% of their natural/historic abundance on the landscape, there is *low* risk of losing species and ecosystem functioning/services[15]. However, if the natural abundance of ecosystems is altered by 70% or more, the risk of losing species and ecosystem services across the landscape is *high* (see Gorley & Merkel 2020; Keane et al. 2009, Price et al. 2009, Price et al. 2007, CIT 2004b). The NRV of forested ecosystems on the coast reflects the amount of a forest that would naturally be old (CIT 2004b).
In BC, precautionary NRV targets for old growth retention have not historically been applied, due to impacts on timber supply[16]. Nonetheless, NRV risk thresholds are a useful yardstick for gauging relative risk of losing biodiversity and ecological functions/services in a particular watershed or landscape unit, and levels of risk posed or ameliorated by different conservation network configurations. **Table 3** shows the historic percentages of old forest that would be expected in each BEC unit found in the study area. These are: CDFmm 29%[17] CWHxm1,dm 70%, CWHvm 85-90%, and MHmm 90-95% (MOE 2020). It also shows the percentage of old growth forest in each BEC unit below which (<30% of the historic percentage of old forest) there is high risk of losing species and ecosystem services, and above which (>70% of the historic percentage of old forest) there is low risk.

Estimates of remaining old forest (age class 9) within each BEC-landscape unit combination in the study area, together with associated NRV risk levels, are shown in **Table 4** (based on 2023 VRI age class data, using methods outlined in **Appendix C**) and illustrated in **Figure 16**. Although the results of this analysis are indicative only, it suggests that percentages of old growth remaining in most of the study area's BEC-landscape unit combinations are well below the high risk thresholds shown in **Table 3**. This is especially so in the lower elevation areas and valley bottoms (i.e. CDF, CWHxm and CWHdm), where it appears that old growth percentages may not even meet the targets laid out in BC's *Order for Establishing Provincial Non-spatial Old Growth Objectives*. Similarly low percentages of old growth

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[14] This is typically based on a description of ecosystems as they existed before major changes brought about by extensive industrial or agricultural activity (Gorley & Merkel 2020), recognizing that the structure of some ecosystems (e.g. CDFmm ecosystems) was historically shaped by traditional indigenous resource management practices (e. g. using fire and thinning to maintain an open understory favorable to plant foods and medicine).

[15] According to the World Resources Institute: *"Natural ecosystems like forests and wetlands provide essential services to water utilities, businesses, and communities — from water flow regulation and flood control to water purification and water temperature regulation.* (cited in Gorley & Merkel 2021, p. 29).

[16] Interim 30% NRV targets (high risk) were adopted for The Great Bear Rainforest, a decision based on timber supply analysis rather than the precautionary 70% NRV targets recommended by the area's scientific advisory committee (Price et al. 2009).

[17] According to Negrave & Steward (2010) the structure of pre-contact CDF forests is not accurately known but evidence suggests that old, often widely-spaced, trees were a pivotal characteristic of the landscape.

remain in these BEC units province-wide (Price et al. 2020). The large number of species and ecosystems at risk in these BEC units, as discussed above, is a reflection of this.

Table 3. Historic percentages of old forest that would be expected in each BEC unit found in the study area, and percentage old forest cover associated with high versus low risk of losing ecosystem services for each (MOE 2020).

BEC UNIT (forest type)	Historically Expected % Old Forest	Risk Thresholds based on % Old Forest Remaining	
		LOW Risk: At least 70% of Historic Expected remains	HIGH Risk: Less than 30% of Historic Expected remains
CDF mm	29	>20	<9
CWH xm1	70	>49	<21
CWH dm1	70	>49	<21
CWH vm1, vm2	85-90	>61	<26
CWH ds1, ms1	60	>42	<18
MH mm1, mm2	90-95	>65	<28

When ecosystem services and resiliency of coastal forests are compromised by extensive loss of mature and old forest cover (relative to historic levels) the risk of drought, wildfire, floods (UBC Faculty of Forestry 2022), and species loss (Price et al. 2020) increases. These kinds of risks will be exacerbated by climate change, as discussed in **Section 4**.

For these reasons, at the very minimum, conservation planning should aim to retain and recruit sufficient old and mature forest within each BEC/landscape unit combo to exceed the high-risk threshold targets shown in **Tables 3** and **4**. For watersheds hosting important fish populations (especially salmonids), community water supplies (**Figure 17**), and species and ecosystems at risk, the percent old forest targets for each BEC-landscape unit combo should ideally align more closely with the low risk thresholds (e.g. >20% for CDF forests, 49-61% for CWH forests depending on variant, and >65% for MH forests). For BEC - landscape unit combos with less than 30% of the original old growth forest remaining due to past harvesting (**Figures 16** and **17**), sufficient mature forest should be reserved toward meeting and exceeding this target, with priority given to productive mature stands capable of producing 'big trees', given how rare big-tree old growth is and because forests on productive sites are likely to recover old growth attributes more quickly (Holt et al. 2008).

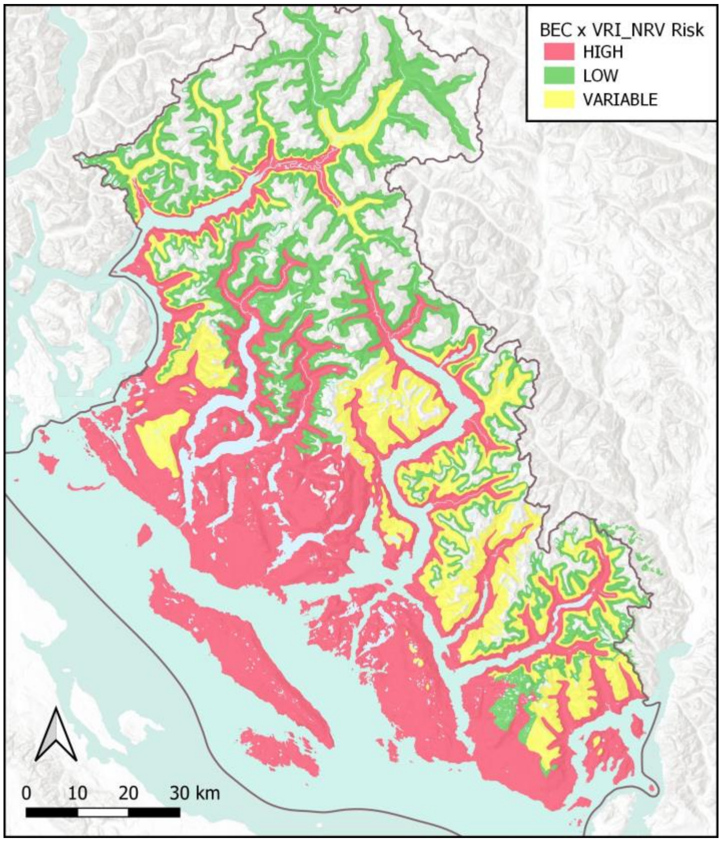

Figure 16. NRV Risk ratings for BEC Variant – Landscape Unit combinations in the study area.

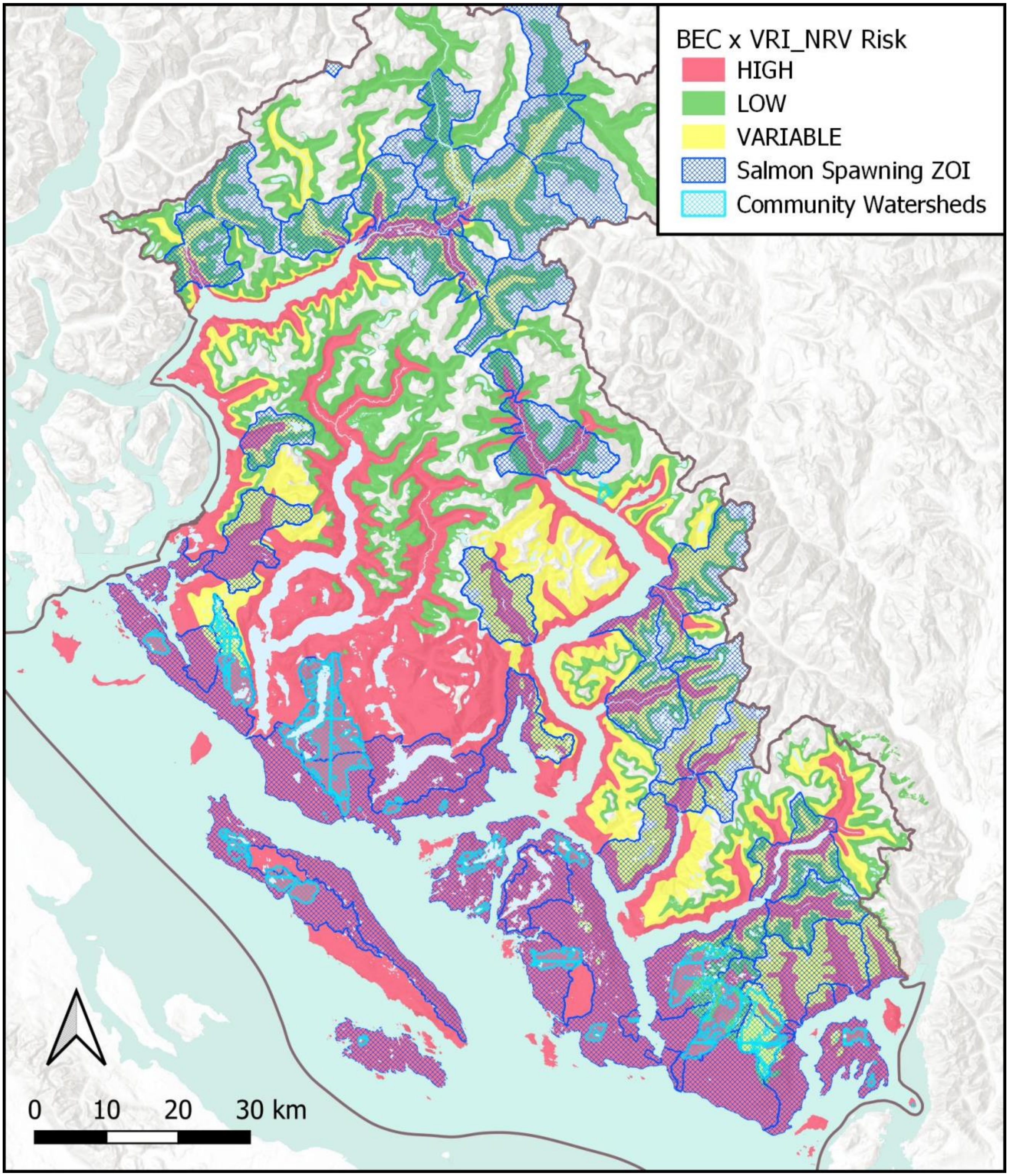

Figure 17. NRV Risk ratings for BEC Variant – Landscape Unit combinations in the study area, with drinking water and important salmon spawning watersheds overlaid.

Table 4. Estimates of old forest remaining in the study area, by BEC-Landscape Unit combination, and in comparison to the percent historically expected to occur and to high and low risk thresholds for natural range of variation (based on analysis by James Tricker 2024).

BEC – Landscape Unit Combinations	Percent Old Growth				NRV RISK
	Historically Expected	Low Risk Threshold (>70% of Historic)	High Risk Threshold (<30% of Historic)	Actual	
Brem				**60.8**	
CWH dm	70.0	49.0	21.0	**12.7**	HIGH
CWH ms 1	60.0	42.0	18.0	**94.4**	LOW
CWH vm 1	85-90	61.0	26.0	**42.8**	VARIABLE
CWH vm 2	85-90	61.0	26.0	**80.4**	LOW
MH mm 1	90-95	65.0	28.0	**83.8**	LOW
MH mm 2	90-95	65.0	28.0	**100.0**	LOW
Brittain				**19.5**	
CWH dm	70.0	49.0	21.0	**4.3**	HIGH
CWH vm 1	85-90	61.0	26.0	**6.3**	HIGH
CWH vm 2	85-90	61.0	26.0	**28.5**	VARIABLE
MH mm 1	90-95	65.0	28.0	**35.6**	VARIABLE
Bunster				**11.6**	
CDF mm	29.0	20.0	12.0	**0.0**	HIGH
CWH dm	70.0	49.0	21.0	**2.8**	HIGH
CWH vm 2	85-90	61.0	26.0	**29.6**	VARIABLE
CWH xm 1	70.0	49.0	21.0	**2.9**	HIGH
MH mm 1	90-95	65.0	28.0	**42.5**	VARIABLE
Chapman				**18.9**	
CDF mm	29.0	20.0	12.0	**0**	HIGH
CWH dm	70.0	49.0	21.0	**1.8**	HIGH
CWH vm 1	85-90	61.0	26.0	**4.1**	HIGH
CWH vm 2	85-90	61.0	26.0	**25.8**	HIGH
CWH xm 1	70.0	49.0	21.0	**0.0**	HIGH
MH mm 1	90-95	65.0	28.0	**71.8**	LOW
Deserted				**53.4**	
CWH dm	70.0	49.0	21.0	**2.9**	HIGH
CWH vm 1	85-90	61.0	26.0	**31.5**	VARIABLE
CWH vm 2	85-90	61.0	26.0	**57.1**	VARIABLE
MH mm 1	90-95	65.0	28.0	**77.6**	LOW
Haslam				**1.2**	
CDF mm	29.0	20.0	12.0	**0.0**	HIGH
CWH dm	70.0	49.0	21.0	**1.0**	HIGH
CWH vm 2	85-90	61.0	26.0	**3.4**	HIGH

BEC – Landscape Unit Combinations	Percent Old Growth				NRV RISK
	Historically Expected	Low Risk Threshold (>70% of Historic)	High Risk Threshold (<30% of Historic)	Actual	
CWH xm 1	70.0	49.0	21.0	**0.0**	HIGH
MH mm 1	90-95	65.0	28.0	**9.1**	HIGH
Homfray				**37.3**	
CWH dm	70.0	49.0	21.0	**7.8**	HIGH
CWH vm 1	85-90	61.0	26.0	**18.2**	HIGH
CWH vm 2	85-90	61.0	26.0	**45.1**	VARIABLE
CWH xm 1	70.0	49.0	21.0	**0.9**	HIGH
MH mm 1	90-95	65.0	28.0	**75.1**	LOW
Howe				**22.3**	
CDF mm	29.0	20.0	12.0	**0**	HIGH
CWH dm	70.0	49.0	21.0	**3.5**	HIGH
CWH vm 1	85-90	61.0	26.0	**5.6**	HIGH
CWH vm 2	85-90	61.0	26.0	**36.8**	VARIABLE
CWH xm 1	70.0	49.0	21.0	**0.4**	HIGH
MH mm 1	90-95	65.0	28.0	**56.1**	VARIABLE
Jervis				**47.3**	
CWH dm	70.0	49.0	21.0	**13.0**	HIGH
CWH vm 1	85-90	61.0	26.0	**15.9**	HIGH
CWH vm 2	85-90	61.0	26.0	**46.6**	VARIABLE
MH mm 1	90-95	65.0	28.0	**71.3**	LOW
Lois				**6.5**	
CWH dm	70.0	49.0	21.0	**1.0**	HIGH
CWH vm 2	85-90	61.0	26.0	**5.9**	HIGH
CWH xm 1	70.0	49.0	21.0	**0.6**	HIGH
MH mm 1	90-95	65.0	28.0	**26.2**	HIGH
Narrows				**36.1**	
CWH dm	70.0	49.0	21.0	**4.6**	HIGH
CWH vm 1	85-90	61.0	26.0	**14.2**	HIGH
CWH vm 2	85-90	61.0	26.0	**29.7**	VARIABLE
MH mm 1	90-95	65.0	28.0	**61.2**	VARIABLE
Powell Daniels				**45.1**	
CWH dm	70.0	49.0	21.0	**4.8**	HIGH
CWH vm 1	85-90	61.0	26.0	**25.1**	HIGH
CWH vm 2	85-90	61.0	26.0	**62.3**	LOW
MH mm 1	90-95	65.0	28.0	**89.5**	LOW
Powell Lake				**21.6**	
CWH dm	70.0	49.0	21.0	**0.2**	HIGH
CWH vm 1	85-90	61.0	26.0	**7.3**	HIGH

BEC – Landscape Unit Combinations	Percent Old Growth				NRV RISK
	Historically Expected	Low Risk Threshold (>70% of Historic)	High Risk Threshold (<30% of Historic)	Actual	
CWH vm 2	85-90	61.0	26.0	**23.8**	HIGH
MH mm 1	90-95	65.0	28.0	**70.2**	LOW
Salmon Inlet				**41.3**	
CWH dm	70.0	49.0	21.0	**10.8**	HIGH
CWH vm 1	85-90	61.0	26.0	**10.2**	HIGH
CWH vm 2	85-90	61.0	26.0	**34.2**	VARIABLE
MH mm 1	90-95	65.0	28.0	**68.7**	LOW
MH mm 2	90-95	65.0	28.0	**88.9**	LOW
Sechelt				**4.3**	
CDF mm	29.0	20.0	12.0	**0.0**	HIGH
CWH dm	70.0	49.0	21.0	**4.1**	HIGH
CWH vm 2	85-90	61.0	26.0	**18.6**	HIGH
CWH xm 1	70.0	49.0	21.0	**0.6**	HIGH
MH mm 1	90-95	65.0	28.0	**34.4**	VARIABLE
Skwawka				**49.4**	
CWH dm	70.0	49.0	21.0	**4.6**	HIGH
CWH vm 1	85-90	61.0	26.0	**25.0**	HIGH
CWH vm 2	85-90	61.0	26.0	**63.5**	LOW
MH mm 1	90-95	65.0	28.0	**81.3**	LOW
Texada				**4.5**	
CDF mm	29.0	20.0	12.0	**5.7**	HIGH
CWH dm	70.0	49.0	21.0	**1.2**	HIGH
CWH xm 1	70.0	49.0	21.0	**3.4**	HIGH
Toba				**56.8**	
CWH dm	70.0	49.0	21.0	**18.2**	HIGH
CWH ds 1	60.0	42.0	18.0	**26.2**	VARIABLE
CWH ms 1	60.0	42.0	18.0	**60.4**	LOW
CWH vm 1	85-90	61.0	26.0	**43.5**	VARIABLE
CWH vm 2	85-90	61.0	26.0	**73.5**	LOW
MH mm 1	90-95	65.0	28.0	**85.9**	LOW
MH mm 2	90-95	65.0	28.0	**74.4**	LOW

5.1 Summary of Conservation Considerations

- *Old growth percentages in most of the study area's BEC-landscape unit combos are far below the NRV thresholds indicating high risk of losing ecosystems services and resulting loss of species (**Figures 16** and **17**), as outlined in the OGSR. At a minimum, conservation plans and networks should be designed to retain and recruit sufficient old and mature forest within each BEC - landscape unit combo to more than exceed the high-risk threshold targets shown in **Tables 3** and **4**.*

- *For watersheds hosting important fish populations (especially salmonids), species and ecosystems at risk, and community water supplies, the percent old forest targets for each BEC-landscape unit combo should ideally align more closely with the low risk thresholds (e.g. >28% for CDF forests, 49-61% for CWH forests depending on variant, and >65% for MH forests). For BEC - landscape unit combos with less than 30% of the original old growth forest remaining due to past harvesting, sufficient mature forest should be reserved toward meeting and exceeding this target, with priority given to productive mature stands capable of producing 'big trees'.*

6 HYDRORIPARIAN & AQUATIC ECOSYSTEMS

6.1 Climate Impacts on Aquatic Ecosystems

Climate change will also profoundly impact aquatic species and ecosystems. On the south coast, summers are becoming dryer and hotter with more frequent heat waves and increased year-to-year variability compared to historical levels. Winters will likely become increasingly warmer and wetter. Large and frequent winter rainstorms and large decreases in snowfall are expected (Little 2012). These changes in precipitation and temperature will have significant implications for hydrology and aquatic ecosystems (see **Appendices F & G** for details) and for fish, as summarized in **Table 5.** Whether today's riparian and retention standards will be adequate for safeguarding aquatic ecosystems and fish into the future is an important consideration when planning for conservation networks and climate adaptation. Aquatic habitats and species most vulnerable to climate change (as per Pojar 2010) include:

- cold-water habitats;
- cold-water species (e.g. Cutthroat Trout and Dolly Varden);
- flow sensitive species, such as cutthroat trout (Price & Daust 2016);
- high altitude systems (e.g. small cirques and wetlands in the Mountain Hemlock BEC zone);
- small shallow lakes;
- small connecting streams.

Table 5. Summary of projected climate change impacts on fish and fish habitat in the study area (adapted from: Little 2012 and Klassen & Hopkins 2016).

Climate change impact	Biophysical impacts on fish
Increased frequency / magnitude of winter floods	• Increased stream sedimentation – increased egg scour and burial and reduced egg survival. • Increased stream channel migration, degradation and aggradation (i.e. channel instability). • Lack of habitat during peak flows.
Change in peak flow timing	• Mismatch between hydrological regime and migration and spawning. • Fewer migrating smolts, decreased speed of migration or increased predation.
Lower low flows in summer/early fall	• Reduced spawning habitat – lower successful spawning and fry-to-smolt survival. • Exacerbation of naturally low flows in many small coho and trout-rearing streams.
Increased water temperature	• Thermal stress – lower fry-to-smolt survival and increased movement to higher elevations and deeper waters to remain within suitable stream temperatures. • Decreased critical nearshore lake habitat and feeding opportunities. • Altered growth and development. • Increased incidence and severity of disease. • Decreased dissolved oxygen - decreased carrying capacity for fish. • Thermal barriers to migration - altered species distribution.
Change in timing of seaward migration	• Change in food availability. • Mismatch in predator/prey interaction.
Increased risks to peripheral fish habitats	• Increasing isolation of peripheral fish populations – loss of headwater stocks of cutthroat trout and Dolly Varden. • Increased wildfire and landslides – habitat damaged, fish killed, with potentially high impacts in isolated populations.

Climate change poses heightened risks to isolated peripheral fish populations (e.g. headwater stocks of Cutthroat Trout and Dolly Varden). For example, the growing intensity and extent of wildfire will damage riparian/aquatic habitat and kill fish more often, putting isolated fish populations at increased risk of being wiped out (Klassen & Hopkins 2016).

6.2 Fish-bearing Streams

The fish-bearing status of a stream is important because it often dictates whether or not riparian reserves will be applied to it, as per Forest Practices Code (FPC) standards. **Figure 18** shows the FWA stream network overlain with FISS fish observation data[18]. This data, however, is not sufficient for establishing the presence of fish in a particular stream reach, as observations are not complete. Nor does the presence of an obstacle establish the absence of fish in the reaches above it, as resident fish populations often exist beyond such barriers, particularly when perennial lakes, wetlands or large streams lie above (Nordin et al. 2023). **Figure 18** shows the locations of major salmon spawning lines and watersheds in the study area (note however, there are numerous smaller salmon spawning channels that are not shown). Other third order watersheds that feature salmonid spawning zones of influence (as per PSF 2021) are also highlighted.

In accordance with the Forest Practices Code's *Fish-stream Identification Guidebook* (Province of BC 1998), any stream channels with less than 20% mean gradient are by default considered to be fish-bearing[19]. In their guidance for avoiding misclassification of fish streams in BC, Nordin et al. (2023) note that in many cases it is more cost effective to default upstream reaches above obstacles to fish-bearing status, given the time, effort, and cost involved in completing a reliable survey to confirm the absence of fish at all times of the year (and given that there is a good chance fish will be discovered). Although BC regulation recognizes the 20% gradient threshold as limiting upstream passage for most fish species (especially in smaller streams), this does not capture all fish-bearing stream reaches, as Cutthroat Trout, Bull Trout, Dolly Varden char and sometimes Rainbow Trout can be found in very steep streams, well in excess of 20% slope (Province of BC 1998).

A detailed classification of non-fish-bearing stream reaches in the study area was beyond the scope of this analysis. However, to get a rough indication of which streams in the study area could have fish-bearing potential, as per the 20% gradient default standard, a 'quick and dirty' gradient analysis of the FWA stream network was conducted, using the QGIS Roadslope plug in[20][21]. Streamlines shown to have

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[18] FISS observations are not comprehensively representative of fish distributions in an area. Proper identification of fish bearing streams is important, because small, non-fish-bearing streams are not currently afforded protection with riparian reserves under current regulation.

[19] Unless there is a permanent obstacle, above which "there are no connected lakes or wetlands, and all reaches upstream of the permanent barrier exceed 20% gradient and/or are confirmed to be simultaneously dry or completely frozen at any time of the year, precluding the survival of a local population." (Nordin et al. 2023).

[20] Applied over 250m long stream segments, using ESRI's World Hill Shade layer as the digital elevation model. This analysis is only meant to be generally indicative only, and is not a substitute for a rigorous gradient analysis. https://plugins.qgis.org/plugins/road_slope_calculator/

[21] It appears that <20% gradient streams have been mapped for the Sunshine Coast Forest District, however this data is not publicly available so was not included in this analysis https://catalogue.data.gov.bc.ca/dataset/fish-habitat-potential-based-on-stream-gradient-dsc/

a gradient less than 20% are highlighted in purple on **Figure 18**[22]**.** Note that this is likely an underestimate of the potential fish-bearing streams in the study area, as the FWA has been found to grossly underestimate small stream habitat in coastal watersheds (Rosenfeld 2002). It should also be noted that although small streams (<1.5m wide) are not protected, they are critically important rearing habitat for Cutthroat Trout (Rosenfeld et al. 2002) and other species.

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[22] Note that further analysis is required to filter out <20% gradient stream segments that are unlikely to be reasonably accessed by fish, based on steepness of downstream reaches.

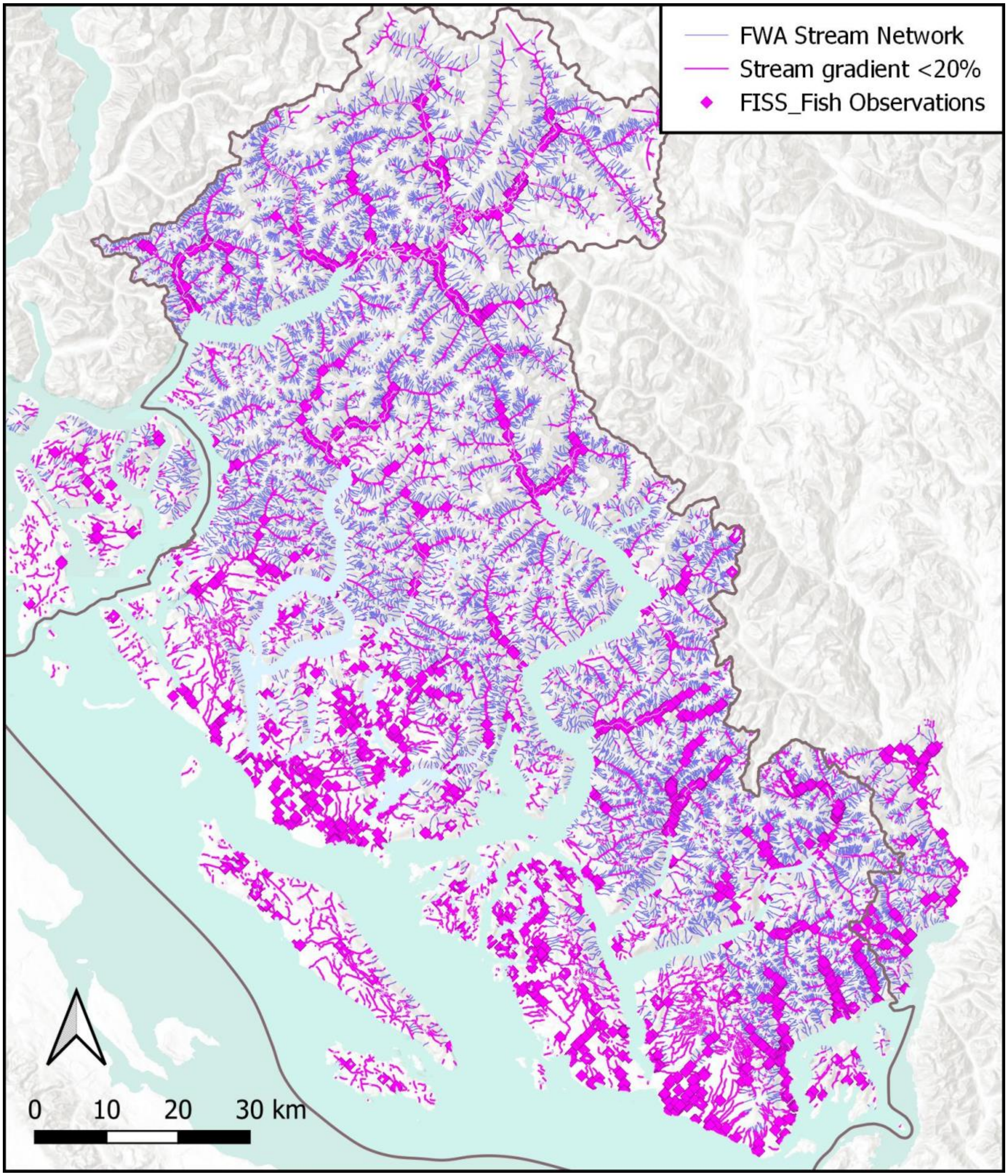

Figure 18. Potential Fish-bearing streams and FISS observations in the study area.

For reasons discussed in the next section, conservation planning should, at minimum, include all potentially fish-bearing streams (as per the 20% default criteria outlined in the *Fish-stream Identification Guidebook* and more recent guidance on obstacles provided by Nordin et al. 2023) along with riparian buffers (see **Table 6**), unless defensible surveys[23] have confirmed fish absence during all times of the year.

6.3 Stream Buffers

The role of riparian stream buffers in the protection of fish habitat and overall watershed health is well established (FPB 2020). In BC, forest managers typically default to the fixed width riparian buffers prescribed under the Forest Practices Code (FPC) (von Loessel 2016), which range from 0-50m in reserve width (depending on the size of the stream and whether it is fish-bearing), with no riparian reserves required for non-fish-bearing streams (S5 & S6), or small fish-bearing (S4) streams less than 1.5m wide. This is in contrast to the more conservative Forest Stewardship Council standards (FSC 2005), which include a similar range of minimum default buffer widths, but with 30m reserves for *all* fish-bearing streams (including small S4 streams) and 20m buffers for some small (S5 & S6) non-fish-bearing streams.

There are a number of problems with the current FPC stream buffer standards. Costello (2008) states that lack of protections for small streams is one of the largest impediments to coastal Cutthroat Trout (a blue listed species) conservation in BC. Small streams make a disproportionately large contribution as potential rearing habitat for Cutthroat Trout in coastal watersheds (Rosenfeld 2002). Wet floodplains, flood channels and off channel pools and wetlands provide additional important winter habitat and flood refuge for fish (CIT 2004a). These refuges also serve as source areas for natural recolonization of stream reaches depopulated by disturbance (such as wildfire, landslides or large floods; CIT 2004a).

There is also growing acknowledgement of the importance of small non-fish-bearing streams to the health of downstream aquatic ecosystems and fish populations (Cunningham et al. 2023, Barnowe-Meyer 2021, FPB 2018, Tripp et al. 2017, Sweeney & Newbold 2014). Small headwater streams account for 70%–80% of the total river network, and exert a critical downstream influence by:

- retaining or transmitting sediment and nutrients;
- providing habitat and refuge for diverse aquatic and riparian organisms (e.g. Coastal Tailed Frogs);
- creating migration corridors; and
- governing connectivity at the watershed-scale (Wohl 2017).

Their protection is especially important in the face of mounting climate related stressors, such as increasing magnitude and frequency of flooding flows, higher summer/fall stream temperatures, and more blow down (e.g. Stackhouse et al. 2023, Johnson & Alila 2023, FPB 2018).

Lack of protections for small streams is particularly concerning with respect to stream temperature and climate change. Small and medium sized streams are most vulnerable to temperature fluctuations, and keeping them shaded is an important means of regulating downstream water temperatures (Kubo et al. 2019). In a recent UBC study by Stackhouse et al. (2023), clearcutting to stream edge (as is common in small S4 fish-bearing streams, which are the most common streams on the coast) was found to increase

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[23] FPB (1998) found that a major reason for forestry related damage to small streams on the south coast was: 1) failure to identify small streams; 2) failure to properly classify fish-bearing streams (particularly S3 streams), to which buffers were consequently not applied, and 3) inadequate inventories that failed to identify fish bearing streams (due to lack of survey intensity, and failure to conduct inventories at all times of the year).

maximum fall stream temperatures (September is a key time for salmon migration and spawning) by as much as 5.8 °C, with the streams predicted to reach over 18°C. At these temperatures, cold-water specialists such as Dolly Varden will experience high mortality (Stackhouse et al. 2023). From a temperature perspective, Kubo et al. (2019) also note that on east-west oriented watercourses narrower-dense riparian buffers can be effective, but for north-south oriented watercourses, wider-taller buffers are needed for shading.

Headwater amphibians, such as Coastal Tailed Frogs, which rely on mature and old forest stream-side cover to create suitable microclimate conditions, are also expected to suffer negative impacts from rising stream temperatures and more severe drought and heatwaves (Thurman et al. 2022). Cunningham et al. (2023) suggest that requiring riparian buffers on headwater streams (given they comprise 70-80% of coastal stream networks) would lend much-needed climate resilience to BC's salmon streams, by mitigating forest harvesting impacts on stream temperature, and leading to downstream cooling.

Where the FPC reserve buffers do apply, the default widths may be inadequate for protecting valued species and ecological functions. Research suggests that 15-30m reserve buffers don't always protect streams from harvesting impacts, and buffers 10m or less offer little to no protection in many cases, largely because of blowdown (Sweeney & Newbold, 2014). Maintaining a healthy stream diversity of amphibians and macroinvertebrates often requires buffers greater than 30m (Olson et al. 2014, Sweeney & Newbold 2014, BC MoE 2004, Kiffney et al. 2003). In addition, riparian ecosystems themselves will become increasingly vulnerable to stress and alteration as they are more frequently disrupted by extreme events such as large floods (Fink & Scheidegger 2021, citing others). Stackhouse et al. (2023) also showed that even with a 30m no harvest buffer in place, any amount of clearing cutting up to a riparian management zone (RMZ) causes stream temperatures rise to rise in late September, and further temperature rises with intensity of thinning inside the RMZ.

Table 6 provides a summary of recommended minimum default buffers for streams (including small and non-fish-bearing streams), based on a review of recent literature and best practices. In addition to reserve widths, the table also makes recommendations for riparian management zones (RMZs) around the reserves. It should be reiterated, however, that thinning in RMZs has been shown to increase stream temperatures, even when 30m no-touch reserves are in place (Stackhouse et al. 2023, Olson et al 2014). Where RMZs consist of young, dense, second growth forests, thinning that promotes canopy gaps, understory growth and growth of tall windfirm trees should be prioritized (as per Nordin and Malkinson 2021).

Given the importance of small streams to biodiversity, fish winter habitat and refuge, watershed functioning and climate resilience, it is recommended that they are also captured during conservation planning, with minimum default buffers as outlined in **Table 6.**

6.4 Sensitive Marine Habitats

Streams carrying high sediment loads due to forestry and associated road-building activities can increase sediment loading in the near shore areas of the marine waters they discharge into. Coastal log handling and upland forest harvest operations can also discharge sediment and debris into marine foreshore areas (Province of BC 1995). As suspension feeders, shellfish are particularly susceptible to increased sediment, which can obstruct feeding (Holden et al. 2019). In high concentrations, woody forestry debris can cause significant oxygen depletion and smother clam beds and eelgrass beds. Leachates from woody debris deposits can also be toxic to fish and other aquatic organisms (Holden et al. 2019). The FPC Riparian Area Management Guidebook (Province of BC 1995) identifies herring spawning areas, shellfish beds, marsh areas, existing aquaculture sites, juvenile salmonid rearing areas, and adult salmon holding areas as marine sensitive zones (MSZ), as well as the seaward portions of estuaries (the upward estuarine portions being classified the same as the stream/river reach that feeds them) (Province of BC 1998). **Figure 19** shows some of the sensitive nearshore marine habitats that occur in the study area, namely herring spawn areas, estuaries and shellfish beaches.

Under current BC regulation there is no requirement for reserves or buffers in MSZs. In recognition of the important role coastal riparian ecosystems play in protecting nearshore marine habitats, Forest Stewardship Council Certification (FSC 2005) does, however, require protections for MSZs, and prescribes minimum reserve and management buffers that vary depending on the sensitivity of the marine shoreline. These minimum default buffers are outlined in **Table 6**. Coastal buffers should be applied throughout the study area, particularly in upland areas bordering the features shown in **Figure 19.** Coastal buffers also serve as climate micro-refugia, as discussed in **Section 8.**

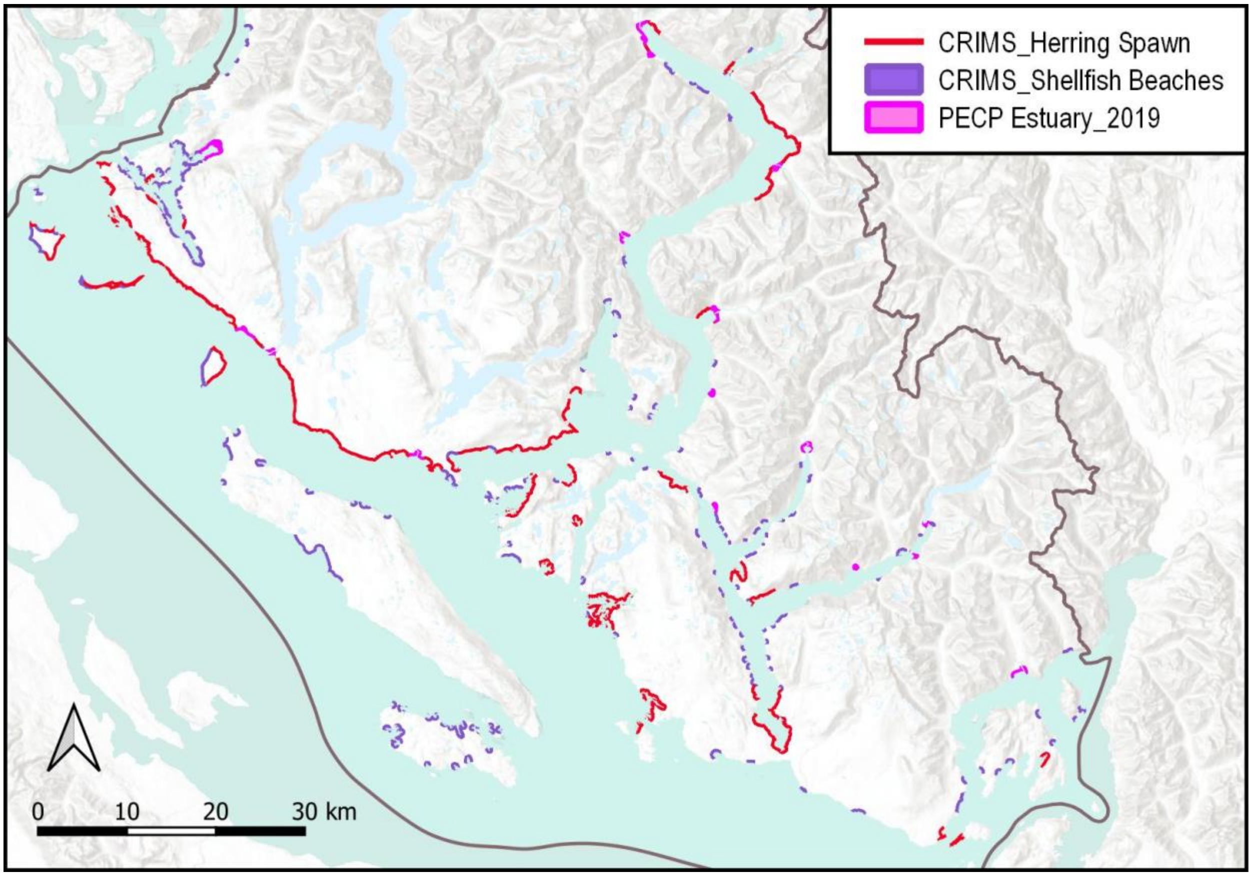

Figure 19. Sensitive marine habitats in the study area.

6.5 Hydroriparian Ecosystems

One way of addressing the challenges and shortfalls of conventionally applied riparian buffers and protections for fish-bearing vs. non-fish-bearing streams and fish refugia, is to expand riparian protections to include a wider range of "hydroriparian" functions. The *Hydroriparian Handbook* (CIT 2004a) uses the term "hydroriparian" to describe aquatic ecosystems plus the adjacent terrestrial ecosystems that are influenced by, and influence, the aquatic system (Price et al. 2009). They include river floodplains and extend around lakes and wetlands, and along estuarine and ocean shores. The distinction between upland and stream or wetland is often unclear, and riparian ecosystems can extend considerably beyond channels and wetlands (CIT 2004a).

Hydroriparian ecosystems merit important consideration when planning for conservation, because the sustained health of aquatic ecosystems and fish habitat requires that all hydroriparian ecosystem functions be maintained during forest development (CIT 2004a). Specifically, they are important for:

- Fish and fish habitat (sustaining water flow and quality, large woody debris, spawning habitat, leaf litter, macroinvertebrates, and cobble recruitment);
- Regulating stream flows, and moderating impact of floods and drought;
- Maintaining water quality, including sediment/turbidity and water temperature;
- Creating and sustaining critical habitat for wildlife and many species at risk, including bats, raptors, amphibians (CIT 2004a).

Additionally, hydroriparian ecosystems are important because they:

- Often host ecological communities at risk (see **Figure 10**),
- Support productive and diverse environments that support many wildlife species,
- Serve as corridors for wildlife movement,
- Create cool microclimates and climate refuges (CIT 2004a),

Figure 20 shows a selection of sensitive hydroriparian ecosystems found in the study area, derived from provincial TEM and TIM, the Freshwater Atlas, and TNT toporiparian mapping (as per **Table 2**, and **Appendix B**). These include:

- Lakes and wetlands (including bogs, fens, and swamps),
- Streams and rivers and their associated riparian areas[24],
- Floodplains,
- Fans, cones & gullies[25].

Hydroriparian planning (e.g. as was done for the Great Bear Rain Forest) involves protection of unstable terrain, reserves around a portion of small streams, and reserves, including buffers, of all areas where vegetation is influenced by water (Price et al. 2009), whether fish are present or not. For example, the unconfined nature of stream channels on floodplains and fans means that the entire floodplain and fan must be considered; buffering the stream channel alone is not sufficiently precautionary (CIT 2004a). Wetlands and small headwater streams are also given buffers and protections, in recognition of their important role in watershed functioning, and as habitat and climate refugia for wildlife and species at risk. These protections are especially important for climate resilience, as ecological communities around

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[24] Riparian areas being defined by Green & Klinka (1994; LMH28) as: "adjacent to and influenced by lakes, rivers, streams, and wetlands. These sites vary from narrow bands along wetlands and lakes and small streams to large floodplains, and are important or critical habitat for many species."

[25] Alluvial fans and gullies have important influences on water and sediment flow through watersheds (CIT 2004a). See Wilford et al. (2009).

small springs, wetlands and ephemeral streams will be among the first areas affected by altered hydrology caused by changing rainfall patterns and reduced snowpack (Dwire et al. 2018).

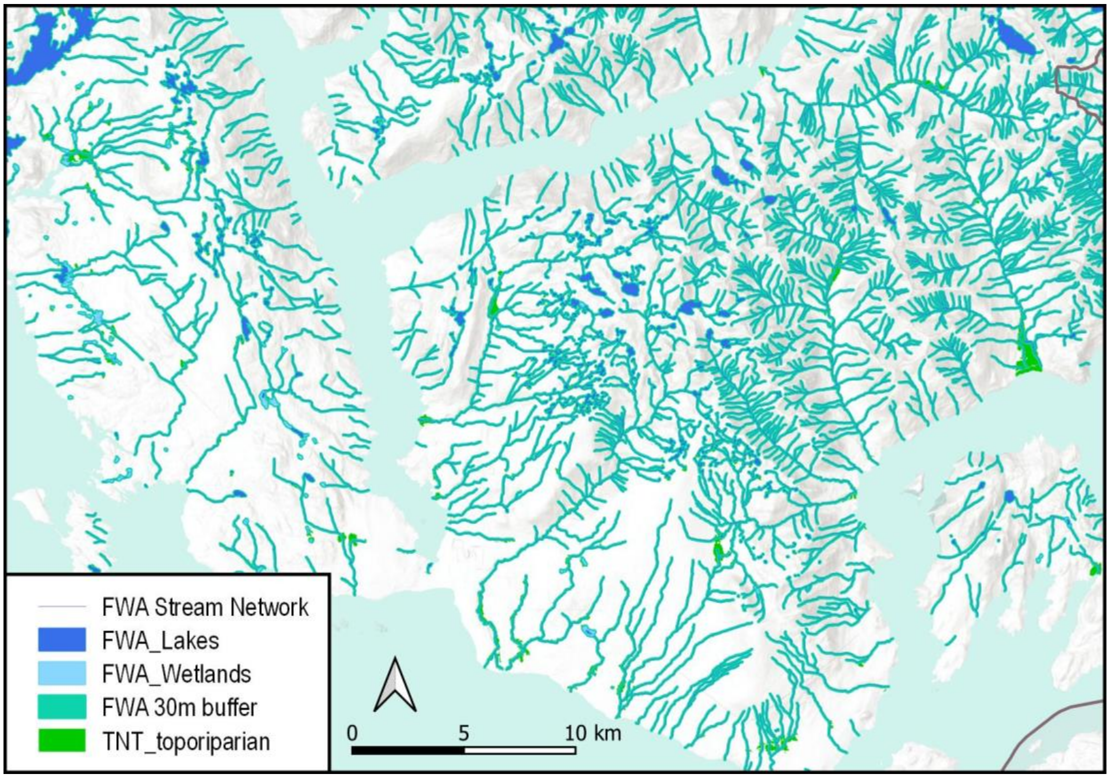

Figure 20. Hydroriparian ecosystems shown for a small portion of the study area.

Table 6 includes a summary of recommended default buffers for hydroriparian features. These buffers should be considered as alternatives or additions to the FPC defaults (except where variable buffers provide greater protection), particularly in watersheds that support important fish habitat and salmon spawning. Higher and well thought out forest retention targets should also be considered in these watersheds, for reasons detailed below.

6.6 Hydrological Risk

The risk posed to important ecological processes, such as watershed hydrology, when an area's forest composition is altered beyond its NRV (as per **Section 6**), also needs to be considered for conservation and climate adaptation planning. Climate change and forest harvesting have complex and compounding impacts on watershed hydrology and aquatic ecosystems. In the last 15 years, probabilistic frequency pairing approaches comparing the effect of forest harvesting on stream flows have shown that the flood regimes of BC's forested watersheds are much more sensitive to clear cut logging than previously thought[26] (e.g. Alila et al. 2009, Green & Alila 2012, Johnson & Alila 2023). UBC research has shown

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[26] Forest cover was often thought to have little effect on larger floods (Bathurst et al. 2020), and since the 1990s (when forest harvesting was generally limited to 25% of a watershed) equivalent clearcut areas (ECAs) in BC have commonly increased to 40% or more.

that harvesting can increase frequency of floods of all sizes (including extreme floods) with as little as 20% of watershed harvesting - causing 20, 50 and 100 year flood events to become 4 to 10 times more frequent (Johnson & Alila 2023; see **Appendix G** for more details).

Forest harvesting in Pacific Northwest watersheds has also been shown to exacerbate summer low flows in the long term (while increasing low flows in the short term), with recent long-term studies indicating that stream flows in plantation forests do not return to original levels seen under mature/old growth forest cover, *even when riparian buffers are in place* (Perry & Jones 2017, Segura et al. 2020).

The above work suggests that previous estimations of forest harvesting related effects on high flows, low flows, landslides, water quality, etc. have been underestimated. These effects will be compounded by climate change as it increases the frequency and magnitude of storms and rain-on-snow events on BC's south coast (see **Appendices F & G** for more details).

6.6.1 Buffers vs. Retention

Buffering aquatic features, and assigning management prescriptions on the basis of the presence or absence of designated fish has been the standard approach to protecting aquatic ecosystems from forest harvesting in British Columbia (Price et al. 2009; as discussed in **Section 3.1**). However, as the magnitude and frequency of flood and drought events mount (whether due to climate change or forest harvesting) the recovery time for ecosystems between these events will be increasingly inadequate. Over time, this will erode the integrity of riparian systems and reduce their capacity to stabilize stream channels and temperatures, and provide other important ecosystem services that support fish and healthy aquatic ecosystems (Johnson & Alila 2023, Talbot 2018, Schmidt and Potyondy, 2004). While bolstering no-harvest buffers and other protective measures for riparian ecosystems (e.g. as per recommendations above and in **Table 6**) is a logical first line of defense against climate change, in the long run, riparian buffers and current equivalent clearcut area (ECA) standards are unlikely to be adequate for safeguarding biodiversity, fish and aquatic ecosystems against the combined impacts of climate change and forest harvesting[27].

Increased retention and recruitment of old and mature forest, as per the NRV targets outlined in **Section 6**, will help reduce risk of extreme high/flooding flows and low summer/fall flows within watersheds (see **Figures 16** & **17**). The degree to which forest harvesting and climate change will impact streams flows in a given watershed is further affected by a complex interplay of individual watershed characteristics, such size, shape, aspect, slope, vegetation composition, storage (wetlands, lakes, reservoirs, etc.), susceptibility to rain-on-snow events, and drainage density (density of the road and stream network) (Johnson & Alila 2023). These characteristics should also be considered (with assistance of a qualified hydrologist and ideally as part of a frequency paired modeling exercise[28]) when deciding on how much harvesting should be permitted in a watershed, and where cut blocks vs. retention areas should be distributed. This is particularly so for watersheds with important salmon fisheries, and in watersheds which lack natural storage capacity and therefore respond to precipitation events in 'fast and flashy' ways (Little 2012).

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[27] E.g. recent work by Wilson et al. (2021) found intensified watershed logging over the last 40 years to be associated with >97% declines in productivity for Steelhead, Cutthroat and Coho.

[28] Frequency paired hydrological modelling can be used to model the risk of harvesting/not harvesting in different parts of the watershed.

6.7 Summary of Conservation Considerations

- *Climate change will profoundly impact aquatic species and ecosystems. On the south coast, summers are becoming dryer and hotter with more frequent heat waves and increased year-to-year variability compared to historical levels. Winters will likely become increasingly warmer and wetter. Large and frequent winter rainstorms and large decreases in snowfall are expected (Little 2012). These changes in precipitation and temperature will have significant implications for hydrology and aquatic ecosystems (see* ***Appendices F*** *and* ***G*** *for details) and for fish, as summarized in* ***Table 5.*** *Weighing whether today's riparian and retention standards will be adequate for safeguarding aquatic ecosystems and fish into the future is an important consideration for conservation planning.*

- *Given the importance of small streams to biodiversity, fish winter habitat and refuge, watershed functioning and climate resilience, it is recommended that they are captured in a conservation network, with minimum default buffers as outlined in* ***Table 6.***

- *Under current BC regulation there is no requirement for reserves or buffers in marine sensitive zones (MSZs). In recognition of the important role coastal riparian ecosystems play in protecting nearshore marine habitats, Forest Stewardship Council Certification (FSC 2005) does, however, require protections for MSZs, and prescribes minimum reserve and management buffers that vary depending on the sensitivity of the marine shoreline. These minimum default buffers are outlined in* ***Table 6.*** *Coastal buffers should be applied throughout the study area.*

- *In the long run, riparian buffers and current Equivalent Clear cut Area (ECA) standards are unlikely to be adequate for safeguarding biodiversity, fish, and aquatic ecosystems against the combined impacts of climate change and forest harvesting[29]. Increased retention and recruitment of old and mature forest is recommended, as per the NRV targets outlined* ***Section 6,*** *to help reduce risk of extreme high/flooding flows and low summer/fall flows within watersheds.*

- *The degree to which forest harvesting and climate change will impact streams flows in a given watershed is further affected by a complex interplay of individual watershed characteristics, such size, shape, aspect, slope, vegetation composition, storage (wetlands, lakes, reservoirs, etc.), susceptibility to rain-on-snow events, and drainage density (density of the road and stream network) (Johnson & Alila 2023). These characteristics should also be considered (with assistance of a qualified hydrologist and ideally as part of a frequency paired modeling exercise[30]) when deciding on how much harvesting should be permitted in a watershed, and where cut blocks vs. retention areas should be distributed. This is particularly so for watersheds with important salmon fisheries.*

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[29] E.g. recent work by Wilson et al. (2021) found intensified watershed logging over the last 40 years to be associated with >97% declines in productivity for Steelhead, Cutthroat and Coho.

[30] Frequency paired hydrological modelling can be used to model the risk of harvesting/not harvesting in different parts of the watershed.

7 CLIMATE MICROREFUGIA & CORRIDORS

7.1 Microrefugia & Corridors

With climate change, the long-term survival of species in the study area will be dependent on the availability of suitable microclimatic refugia (as per Kim et al. 2022, Suggitt et al. 2018, Betts et al. 2018, Ashcroft 2010, Noss 2001, etc.). Microrefugia are areas that will remain cooler and moister relative to surrounding areas, and are therefore more likely to persist as the climate warms (Morelli 2018). In these patches plant and animal species have a chance to endure as the climate becomes unsuitable; this may dampen population declines (Kim et al. 2022) and allow for future species re-expansion from these refugia (Meineri & Hylander 2017).

Recent research shows that tall, old and structurally complex forests have a strong insulating effect (on the order of 2.5 to 5 degrees C cooler than plantation forests in summer months; Wolf et al. 2021, Frey et al. 2016), and are therefore important microrefuge (Ashcroft 2010, Wolf et al. 2021). Conservation and restoration of old-growth forests (with tall trees and complex structure) is needed to maintain favorable microclimates and to reduce climate change impacts on temperature-sensitive species (Frey et al. 2016, citing others).

Retaining old forests on high elevations relative to their surroundings has been shown to be particularly important (Wolf et al. 2021). This is because they function as microrefugia for species populations at lower elevations as well as for high elevation species unable to move elsewhere as the climate shifts (Wolf et al. 2021, Morelli et al. 2016). Old-growth in high elevation and high topographic position index areas should be conserved when possible (Wolf et al. 2021, Morelli et al. 2016). Within the study area, this correlates with old forests in the MHmm subzone, which are also likely to be ancient. Ancient forest in the MHmm subzone (which have remained undisturbed for centuries) are also potential fire refugia – defined as “places that are disturbed less frequently or less severely by wildfire” (Krawchuk et al. 2016) - which can play an important role in ecosystem persistence (Stralberg et al. 2020; Meddens *et al*. 2018).

Because old growth forests are cooler, moister, and less subject to desiccation, they are also less likely to burn than plantation forests[31] (Gavin 2020); young plantations in particular have high wildfire severity risk (Zald & Dunn 2018). During wildfires (which are projected to increase in frequency and intensity with climate change) old forest stands can serve as firebreaks and islands of safety for wildlife, and support reservoirs of plants and animals for repopulating burned areas. Fire refugia are also more likely to occur in valley bottoms, gullies, and local concavities, potentially due to cold-air pooling and soil moisture (Meddens et al., 2018; Wilkin et al., 2016).

Maintaining riparian and wetland habitats is also a priority for maximizing climate resilience. Being relatively moist and cool, wetlands serve as important heat refuges as well as stepping-stones for climate driven species movement. Riparian ecosystems span climatic gradients and have cool, moist

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[31] Gavin (2020) notes that “the available fuel is small in diameter and easily dried by winds and preheated by approaching fire. Plantations are loaded with such fuel of small wind- and sun-exposed trees. This results in fire spread rates on the order of three feet per second, precluding firefighting. While loggers reduce flammable debris after harvest, there is no avoiding the flammability of young trees in a strong wind. This was seen in some long runs in managed land on the second day of the fires.”

microclimates relative to surrounding areas. As such they serve as heat refuges and important dispersal corridors for climate-driven movement of species (Krosby et al. 2018). Features that enhance this capacity include:

- large temperature gradients (e.g. span BEC units),
- high canopy cover (e.g. old or mature forest with tall trees),
- large relative width,
- low exposure to solar radiation (e.g. shaded or north aspects),
- low levels of human modification (Krosby et al. 2018).

Although having corridors between watersheds is important, riparian corridors are the most important element of a corridor network, because they link valley bottoms with the steep upland parts of watersheds (CIT 2004a, Fink & Scheidegger 2021). Under climate change, riparian/floodplain areas will function as both climate refugia and critical movement corridors, and old forests with big trees will provide important thermal refuge for many species. However, due to historic forest harvesting and the preponderance of plantation forests, there is limited microrefuge remaining in much of the study area (as per the NRV table results in **Section 2**).

Other types of microrefugia in the study area include: fringing areas along the shores of coastlines and deep lakes (cooler than surrounding areas), deep gorges, talus slopes (particularly important for salamanders and reptiles), downslope parts of valleys and basins where cool air pools, and evergreen-deciduous forest mosaics (Wolf et al. 2021, Morelli et al. 2016, Frey et al. 2016, Ashcroft 2010). Because karst landscapes are among the most topographically complex systems with various microhabitats, they are also microrefugia where species can persist despite unfavourable climate change (Batori et al 2020).

Fish have particular microrefuge requirements, including areas where they can escape the scouring and sedimentation caused by high/flooding winter flows (winter storms are projected to increase in intensity and frequency under climate change) (as discussed in **Section 7**). These include small streams and side channels extending off mainstream channels, as well as off-channel habitats such as flood channels, wetlands and pools (CIT 2004a, Province of BC 1998). These refugia also serve as source areas for recolonizing other stream reaches after a disturbance (e.g. flood, landslide, heat dome) (CIT 2004).

Fish will also increasingly require refuge from high temperatures and low flows during summer and fall. Cold water thermal refuges include stream reaches fed by deep cold-water aquifers[32] (Morelli et al 2016, citing others), as well as stream segments shaded by canyons and riparian gallery forests (Torgersen 2012). At a smaller scale, side channels, springbrooks and tributary junctions are also important cold-water refuge, as they often have cooler temperatures than mainstream channels (Torgersen 2012).

In sum, the long-term persistence of fish, wildlife, and species and ecosystems at risk in the study area will require retention and maintenance of climate microrefugia and movement corridors, such as:

- Riparian corridors,

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[32] E.g. in alluvial valley segments with high groundwater/surface-water exchange (see Torgersen 2012).

- Floodplains[33],
- Small and headwater streams,
- Wetlands,
- Old forest (especially with big trees),
- Ancient high elevation forest,
- Mature big tree forest,
- Moist forest[34] (typically characterized by western red cedar),
- Lakeshore and coastal fringing vegetation,
- Talus slopes & karst systems,
- Intact watersheds/areas that span multiple BEC units.

At present, however, there appears to be no Provincial mapping that specifically identifies climate microrefugia, and sensitive ecosystem classes/mapping are not designed to explicitly capture these features. To help address this gap, data sources and methods outlined in **Table 2** and **Appendix B** were used to map the locations of selected climate microrefugia in the study area (**Figure 21**). In summary:

- Wetland, riparian:flood, moist forest and talus microrefugia types were mapped by crosswalking them with TEM map codes/units used by TEM projects (21) with coverage in the study area (see crosswalk table in **Appendix E**).
- Riparian fringe cannot be derived directly from TEM so a variety of data sources were used, including the Freshwater Atlas streams, lakes, and wetlands (with 30 – 50 m buffers) and TNT's topographical riparian mapping (TNT 2021) (see riparian crosswalk table in **Appendix E** for details).
- Old and mature forests were mapped by selecting forested TEM polygons and updating them using VRI; where there was no TEM coverage, VRI was used (**Appendix B).**
- 'Big tree' old and mature forests were selected from the OGSR TAP mapping (selecting VRI polygons with site index >20 could be used to help fill gaps in the TAP mapping, but was beyond scope of this study).
- OGSR TAP mapping was used to identify known ancient forest, and potentially ancient forests were mapped by selecting VRI polygons with leading species aged 350 yo and up (as classed in the old forest analysis completed by James Tricker, **Appendix C).**
- Coastal fringe was mapped using the Freshwater Atlas Coastline layer, and adding a 50m buffer where adjacent to important marine resources (as per **Figure 19**), and 30m on all other coastline.

A number of limitations associated with the climate microrefugia mapping (**Figure 21**) should be noted:

- The mapping has gaps where TEM and VRI coverages are lacking or incomplete (see the TEM & VRI coverage maps in **Figures 2** & **4**).
- No criteria for ecosystem condition, fragmentation or viability were applied.
- Microrefugia specific to fish (such as tributary junctions, side channels, shaded stream segments, and stream reaches fed by coldwater aquifers) were not mapped (beyond project scope)
- Relatively intact watersheds/areas that span multiple BEC units were not mapped (beyond project scope)
- Mapping of moist forest microrefugia was limited to areas with TEM coverage (exploring options for using VRI and other data sources to identify these types of ecosystems was also beyond project scope).

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[33] Typical dominant tree species include: cottonwood, sitka spruce and red alder, as well as western cedar in drier BEC variants.

[34] Western cedar is often a dominant tree species; also amabilis fir and sitka spruce in wetter BEC variants.

As much as possible, climate microrefugia shown in **Figure 21** should be considered for incorporation into climate adaptation and conservation network planning, especially those that do double duty as:

- ecosystems at risk (**Figure 10**),
- sensitive ecosystems (as per **Figure 12**),
- habitat for species at risk, and
- important fish habitat (**Figure 18**).

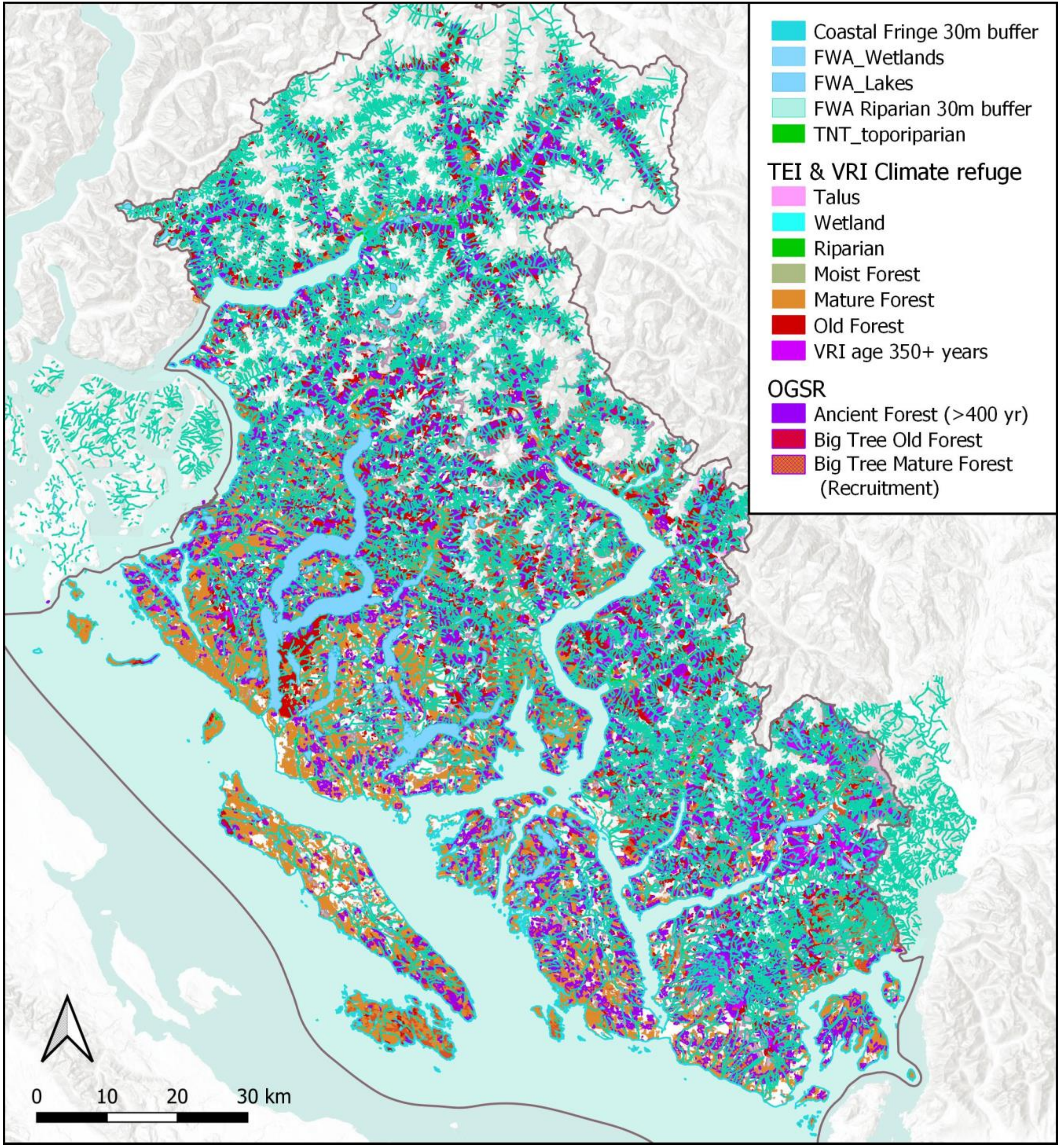

Figure 21. Potential climate microrefugia and corridor opportunities in the study area.

Most of the moist forest in the study area has been logged, however any remaining old forest stands in these areas should be prioritized for retention as microrefugia (**Figure 21**). These forests are often red or blue listed communities and usually big tree old growth as well. Mature stands of moist and floodplain forest should also be prioritized for recruitment. In watersheds that support valued fish populations, consideration should be given to selecting sub-basins to be retained as undisturbed refugia for fish stocks (CIT 2004a).

7.2 Amphibians & Other Wetland Obligates

Amphibians, turtles and other wetland dependent species with poor dispersal abilities are likely to be disproportionately affected by climate change. Lower elevation wetland species which are found in the drier BEC units, particularly the CDFmm and CWHxm, will likely be most affected because: 1) the climate envelopes for these BEC units are likely to disappear entirely from the study area (and BC, as per discussion in **Section 4**), and 2) they face many migration barriers due to widespread fragmentation and degradation of suitable habitat within their current ranges.

Models have shown that amphibians require large areas of relatively undisturbed uplands for long term population persistence, and that current regulations protecting 30m or less of surrounding terrestrial habitat are inadequate to support viable populations of pool-breeding amphibians (Hruby 2013, Harper et al. 2008), especially with anticipated increases in pool drying under climate change (Cartwright 2021). As such, conservation planning should include a network of core areas and movement corridors for these species, which incorporates:

- Large clusters of wetlands and associated upland habitat (core areas) known to support at risk wetland species;
- Movement corridors between core cluster areas;
- Climate corridors to higher elevation refuge habitat;
- Appropriate buffers, as per **Table 6.**

Of particular importance are areas with high concentrations of wetlands within the CDFmm, CWHxm1 and CWHdm, and potential corridors between them. Wetland clusters at higher elevations are also important (e.g. in the CWHvm and MH on the mainland), as they can potentially serve as future climate refuge for wetland species as they attempt to move upwards to escape heat and drought stress. Priorities should include areas that:

- Contain core clusters of wetlands, ~1-5km apart or less, at elevations mostly under 600m, as per Red-legged frog habitat requirements (except for future refuge locations, which are located higher up, or in higher areas with known or nearby Red-legged Frog occurrences).
- Are known to support at risk amphibians or turtles.
- Include surrounding upland habitat a minimum of 1000m from suitable wetland habitat.
- Include migration corridors between wetland clusters that:
  - are aligned through relatively flat terrain, and
  - follow ‘stepping stones’ of suitable habitat (not more than 5km apart), including wetlands, streams and riparian areas, moist forest (where ephemeral pools can occur) and lakeshores.
- Incorporate Critical Habitat for Pacific Painted Turtles, where defined.

7.3 Summary of Conservation Considerations

- *For a conservation network to support the long term persistence of fish, wildlife, and species and ecosystems at risk in the study area, it needs to incorporate climate microrefugia (**Figure 21**) and movement corridors, such as:*
    - *Riparian corridors,*
    - *Floodplains,*
    - *Small and headwater streams,*
    - *Wetlands,*
    - *Old forest (especially with big trees),*
    - *Ancient high elevation forest,*
    - *Mature big tree forest,*
    - *Moist forest,*
    - *Lakeshore and coastal fringing vegetation,*
    - *Talus slopes and karst systems,*
    - *Intact watersheds/areas that span multiple BEC units (see **Table 2** and **Figure 14**).*

- *As much as possible, the above features should be incorporated into conservation plans and networks, especially those that do double duty as ecosystems at risk (as per **Figure 10**), habitat for species at risk, or as important fish habitat (**Figure 18**).*

- *Most of the moist forest areas shown in **Figure 21** have been logged, however any remaining old forest stands in these areas should be prioritized for retention as microrefugia (they are also red or blue listed communities; they are usually big tree old growth as well). Mature stands of moist forest should also be prioritized for recruitment.*

- *In watersheds that support valued fish populations, consideration should also be given to selecting sub-basins to be retained as undisturbed refugia for fish stocks (CIT 2004a).*

- *Amphibians, turtles and other wetland dependent species with poor dispersal abilities are likely to be disproportionately affected by climate change. Conservation plans/networks should include a network of core areas and movement corridors for these species, which incorporates:*
    - *Large core clusters of wetlands (1-5km apart or less) with 1000m+ of surrounding upland habitat, in areas known to support at risk wetland species;*
    - *Movement corridors between core cluster areas, aligned through relatively flat, low elevation (600m or less) terrain and along 'stepping stones' of suitable habitat;*
    - *Climate corridors to higher elevation refuge habitat;*
    - *Critical Habitat for Pacific Painted Turtles, where defined.*

- *To improve the long-term viability of amphibian diversity in the study area, a conservation network should incorporate buffers and retention areas that maintain or improve amphibian habitat quality and connectivity within and between the areas with known amphibian breeding habitat (especially for red-legged frogs and Western Toads), such as the Inland Lake area near Powell River.*

Table 6. Summary of priority features for consideration when undertaking conservation planning, with recommended default buffer widths where applicable.

Feature	**Primary Purpose**	**Minimum Default Buffers**		**Additional Comments** *Thinning within RMZ should be to accelerate growth of tall trees for shade because of warming effect thinning in the RMZ has on stream temperatures (Stackhouse et al. 2023, Olson et al 2014). Minimum basal area retention in MZ as per FSC (2005) in most cases.*	**Sources**
		Reserve Zone Width (m)	**Management Zone width (m)**		
Fish-bearing Streams [35]					
S1a large rivers • >100m wide	Aquatic health	30*	40*	Min 65% basal area retention in MZ	FSC (2005)
S1b • >20m wide	Aquatic health	50*[36]	20*	Min 65% basal area retention in MZ	FRPA, FSC (2005)
S2 • >5–20m wide	Aquatic health	30*	40*	Min 65% basal area retention in MZ	FSC (2005)
S3 • 1.5-5m wide	Aquatic health	30*	20*	Min 65% basal area retention in MZ	FSC (2005)
S4 • <1.5m wide	Aquatic health	30*	20*	Min 65% basal area retention in MZ	FSC (2005)
Non-fish-bearing Streams					
S5a & S6a (FSC 2005) • >10m wide • >3m wide & <=500m from fish-bearing stream • 1-3m wide & <=250m from fish-bearing stream	Minimum for aquatic health	20	20	MZ as needed to prevent blow down, min 65% basal area retention	FSC (2005)
	Amphibians	15-30+	15-20	MZ as needed to prevent blow down, min 65% basal area retention	Olson et al. (2014), BC MoE (2004), USDA (2016)
	Shade/temperature, microrefugia	20-30+[37,38]	25	MZ as needed to prevent blow down, min 65% basal area retention	Barnowe-Meyer (2021), Stackhouse et al. (2023), Sweeney & Newbold (2014)
	Macroinvertebrates	30	25	MZ as needed to prevent blow down, min 65% basal area retention	Kiffney et al. (2003); Sweeney & Newbold, (2014)

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[35] Stream reaches with < 20% gradient and >20% gradient stream reaches with known fish occurrences.

[36] Shading and temperature regulation on larger streams and rivers require tall, dense, and wide riparian buffers (Kubo et al. 2019).

[37] Stackhouse et al. (2023) showed that even with a 30m no harvest buffer in place, any amount of clearing cutting up to a riparian management zone (RMZ) causes stream temperatures rise to rise in late September, and further temperature rises with intensity of thinning inside the RMZ. September is a key time for salmon migration and spawning.

[38] Small and medium sized streams are most vulnerable to temperature fluctuations; on east-west oriented watercourses narrower-dense riparian buffers can be effective, but for north-south oriented watercourses, wider-taller buffers are needed for shading (Kubo et al. 2019).

Feature	**Primary Purpose**	**Minimum Default Buffers**		**Additional Comments** *Thinning within RMZ should be to accelerate growth of tall trees for shade because of warming effect thinning in the RMZ has on stream temperatures (Stackhouse et al. 2023, Olson et al 2014). Minimum basal area retention in MZ as per FSC (2005) in most cases.*	**Sources**
		Reserve Zone Width (m)	**Management Zone width (m)**		
	Wildlife Corridor	30 +	25	MZ as needed to prevent blow down, min 65% basal area retention	USDA (2016)
S5b & S6b2 (FSC 2005) • 3-10m wide & >500m from fish-bearing stream • 0.5 – 3m wide & >250m from fish-bearing stream • <0.5m wide	Minimum for aquatic health	10+	10 –25	MZ as needed to prevent blow down, min 30% basal area retention	FLNRO (2017)
	Amphibians	15-30+	15-20	Min 50% basal area retention in MZ	Olson et al. (2014), BC MoE (2004a, 2004b)
	Shade/temperature, microrefugia	20-30+[12]	10 –25	MZ as needed to prevent blow down, min 65% basal area retention	Barnowe-Meyer (2021), Stackhouse et al. (2023), Sweeney & Newbold (2014)
	Macroinvertebrate	30+	10 –25	MZ as needed to prevent blow down, min 30% basal area retention	Kiffney et al. (2003); Sweeney & Newbold, (2014)
	Wildlife Corridor	30+	10 –25	MZ as needed to prevent blow down, min 30% basal area retention	USDA (2016)
Very small, steep headwater streams	Biodiversity, aquatic health, microrefugia			70% retention of watershed area occupied by upland streams as riparian forest [39]	CIT (2004a)
Hydroriparian Ecosystems					
Wetlands	Minimum for biodiversity, aquatic health, microrefugia	30 (or 1.5 tree ht)	15-30	MZ as needed to prevent blow down, min 30% basal area retention	CIT (2004a), FRPA, FSC (2005)
	Fish	30	30	MZ as needed to prevent blow down, min 30% basal area retention	Collison & Gromack (2022)
	Amphibians	40-1000	10 –25	MZ as needed to prevent blow down, min 30% basal area retention	Olson et al. (2014), BC MoE (2004a, 2004b), Hruby (2013)
	Plant biodiversity	60	10 –25	MZ as needed to prevent blow down, min 30% basal area retention	Hruby (2013)
Lakes	Biodiversity, fish, aquatic health[40], microrefugia,	30 (or 1.5 tree ht)	15-30	MZ as needed to prevent blow down, min 30% basal area retention	CIT (2004a) Collison & Gromack (2022), FSC (2005)

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[39] Particularly for watersheds with important fish habitat (e.g. salmon spawning areas, climate refugia, etc.).

[40] Research in BC's Interior is showing that even large lakes can be vulnerable to eutrophication related to extensive logging of upland areas (FPB 2018).

Feature	**Primary Purpose**	**Minimum Default Buffers**		**Additional Comments** *Thinning within RMZ should be to accelerate growth of tall trees for shade because of warming effect thinning in the RMZ has on stream temperatures (Stackhouse et al. 2023, Olson et al 2014). Minimum basal area retention in MZ as per FSC (2005) in most cases.*	**Sources**
		Reserve Zone Width (m)	**Management Zone width (m)**		
Active flood plains[5][6]	Aquatic health, fish, biodiversity, microrefugia	1.5 tree heights[41]*	As needed for windfirm reserve*	* or as per relevant stream buffer above, which ever is greater	CIT (2004a)
Riparian zones	Aquatic health, fish, biodiversity, microrefugia	1.5 tree height*	As needed for windfirm reserve*	* or as per relevant stream buffer above, which ever is greater	CIT (2004a)
Fans[23]	Aquatic health, fish, biodiversity, microrefugia	1.5 tree heights*	As needed for windfirm reserve*	* or as per relevant stream buffer, which ever is greater	CIT (2004a)
Torrented gullies	Aquatic health, biodiversity, microrefugia	1.5 tree heights*	As needed for windfirm reserve*	* or as per relevant stream buffer, which ever is greater	CIT (2004a)
Unstable /erodible terrain	Aquatic health, fish			not assessed	
Karst landscapes	Biodiversity, microrefugia, hydrology	1.5 tree heights	As needed for windfirm reserve*		CIT (2004a)
Marine Shoreline					
High value marine habitat[42]	Biodiversity, microrefugia, fish/shellfish	50	30	Min 50% basal area retention in MZ	FSC (2005)
Estuaries, marine lagoons	Biodiversity, microrefugia, fish/shellfish	40	15	Min 50% basal area retention in MZ	FSC (2005)
All other coastline	Biodiversity, microrefugia, fish/shellfish	20	15	Min 50% basal area retention in MZ	FSC (2005)
Species & Ecosystems @ Risk					
Ecological communities at risk	Biodiversity			Buffers as for relevant features above	
SAR occurrences	Biodiversity			For recommended buffers refer to *Accounts and Measures for Managing Identified Wildlife* and relevant recovery plans	
SAR habitat	Biodiversity	**	**	For recommended buffers refer to *Accounts and Measures for Managing Identified Wildlife* and relevant recovery plans	

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[41] The first tree height is to capture the influence of the terrestrial system on the aquatic system; the additional half tree height is to protect conditions within the buffer (CIT 2004a, Price et al. 2009).

[42] High value marine habitats include shallow intertidal areas, kelp beds, herring spawn areas, and other nearshore habitats used by marine invertebrates for reproduction and rearing (CIT 2004).

Feature	**Primary Purpose**	**Minimum Default Buffers**		**Additional Comments** *Thinning within RMZ should be to accelerate growth of tall trees for shade because of warming effect thinning in the RMZ has on stream temperatures (Stackhouse et al. 2023, Olson et al 2014). Minimum basal area retention in MZ as per FSC (2005) in most cases.*	**Sources**
		Reserve Zone Width (m)	**Management Zone width (m)**		
TAP priority old forest	Biodiversity			Including potentially ancient forest[43], as per **Figure 9**	
TAP priority recruitment forest	Biodiversity				
Relatively intact watersheds/areas	Biodiversity, microrefugia				
Climate/Hydrological Resilience					
Hydroriparian ecosystems	Biodiversity, aquatic health, fish, microrefugia, climate corridor	As for relevant features above		As per discussion in **Section 7**	Stackhouse et al. (2023); Fink & Scheidegger (2021), Krosby et al. (2018), Morelli et al. (2016), CIT (2004a),
Lakeshore & coastal fringing vegetation	Biodiversity, microrefugia			As per discussion in **Section 7**	Morelli et al (2016), Ashcroft (2010)
High elevation ancient forest	Biodiversity, hydrology, microrefugia			As per discussion in **Section 8**	Wolf et al. (2021), Morelli et al. (2016)
Old Forest (all)	Biodiversity, hydrology, microrefugia			As per discussion in **Section 8**	Wolf et al. (2021), Gavin (2020); Frey et al.(2016),
Mature forest*	Biodiversity, hydrology, microrefugia			*As needed to bring old forest percentages up to NRV thresholds for each BEC – Landscape combo in **Table 4**	Wolf et al. (2021), Gavin (2020); Frey et al. (2016)
Moist, low lying forest	Biodiversity, hydrology, microrefugia		As needed for windfirmness	* Conserve these often small patch ecosystems where possible, to serve as thermal refugia and as stepping stones between larger conserved areas.	Wolf et al. (2021), (Gavin 2020); Frey et al. (2016)
Talus	Biodiversity, microrefugia			Particularly relevant for amphibians and other wildlife	Morelli et al. (2016)

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[43] Ancient forests are poorly identified by the VRI (OG TAP 2021b), therefore potentially ancient stands (>300 or 350 years) need to be field checked.

8 CONSERVATION CONSIDERATIONS & APPLICATIONS

8.1 Conservation Planning

The pilot maps generated for this project highlight important features that should be considered when undertaking conservation and/or climate adaptation planning on the Sunshine Coast. Specifically, these are features to be considered as priorities for planners and resource managers when:

- Identifying priority areas for conservation and/or retention;
- Planning climate resilient green infrastructure or conservation networks;
- Selecting areas for ecological recruitment, restoration and/or enhancement;
- Conducting Municipal Natural Assets Inventories;
- Responding to referrals;
- Promoting action, stewardship and/or awareness for climate adaptation.

A larger list some of the key policy arenas and tools that affect biodiversity and climate resilience in the study area, and where the pilot mapping layers could be used to support decision-making is located in **Appendix H.**

8.2 Climate Resilience: Connectivity & Corridors:

Climate shifting raises significant concerns about whether existing reserves and corridors will remain suitable for the species and ecosystems they're meant to protect[44] (Mahoney 2019). Locations with disappearing climates/BEC zones, such as the CDFmm, are at elevated risk of habitat loss (Mahoney 2019). Projected climate impacts on stream flows and water temperatures also raise concerns as to whether current standards for ECAs and riparian buffers will be adequate for future safeguarding of fish and aquatic ecosystems against the combined impacts of climate change and forest harvesting. As such, ensuring climate resilience for the study area requires consideration of the following key factors:

- Retaining and recruiting sufficient old forest (as per NRV thresholds in **Tables 3 & 4**) to reduce risk of losing species and ecosystem services, and to reduce flood risk (especially during extreme weather events).

- Capturing both large and small patches of remnant at risk ecosystems and habitat for species at risk:
  - large patches (less edge effect, more robust populations, etc.)
  - small patches (last strongholds for many rare and at risk plants and animals, stepping stones between larger patches) (Wintle et al. 2019).

- Ensuring redundancy and separation between retained at risk ecosystems & wildlife habitat, to guard against total loss during extreme events, such as wildfire.

- Incorporating terrestrial thermal refuges wherever possible, including:
  - Old forest patches (especially those with big trees),
  - Ancient forest at high elevations,
  - 'Big tree' mature forest,

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[44] For example, recent modeling has shown that by 2050, none of BC's parks will be in their historic climate zones (Mahoney 2019).

  - Wetlands, streams and their surrounding riparian areas (as per minimum buffer recommendations in **Table 6**),
  - Moist forest (old and mature stands),
  - Fringing vegetation along lakeshores and coastlines,
  - Talus slopes and karst systems.

- Incorporating a network of climate corridors and stepping stones between at risk ecosystems, higher and lower elevations, and wetter and drier areas, via:
  - Longitudinal corridors (riparian, floodplain and moist forest) up valley bottoms (which in the study area are also typically north-south corridors);
  - Riparian corridors along small streams (as per minimum buffer recommendations in **Table 6**);
  - Elevational corridors up hill/mountain sides that cross multiple ecotones/BEC units;
  - Islands of microrefugia that will remain cooler and wetter than surrounding areas, and connections between them (e.g. wetlands, ponds, riparian areas, old forest, moist forest);
  - Maintaining vegetation and shade around small and headwater streams (to help cool stream network), as per buffer recommendations in **Table 6**.

- Capturing thermal and flood refuge habitats for fish wherever possible, and applying buffer recommendations in **Table 6**:
  - small streams and side channels,
  - flood channels and springbrooks,
  - off-channel wetlands and ponds,
  - shaded stream sections,
  - stream segments fed by cool deep-water aquifers,
  - tributary junctions.

- Reserving forest on unstable terrain, such as alluvial fans and steep gullies.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Benefits of the Approach

- **Potential ECAR mapping:** Helps create **better picture** of *potential* **variety and distribution** of at-risk and sensitive ecosystems in a given area.
- **Potential Sensitive Ecosystem Mapping:** Helps create **better picture** of *potential* **distribution** of sensitive ecosystems in a given area; maps important sensitive features in areas without SEI coverage;
- **Hydroriparian mapping:** Helps address water and aquatic health related concerns, which are often priorities for local governments and First Nations; uses data sources that extend beyond areas of TEM coverage.
- **NRV Risk mapping**: Helps create a picture of the overall risk to species, ecosystems and ecosystem services (including hydrological functioning) posed by loss of old forest cover, within given landscape units. Can be used to help decide on old forest retention and recruitment targets.
- **Climate Microrefugia:** Provides starting/discussion point for designing climate resilient conservation networks (also consolidates many of the values in the above mapping).
- **Disturbance Masks:** Useful as a ‘quick & dirty’ way to update TEM/SEI mapping by removing parts of polygons that have been logged since mapping was completed, to remove cut blocks from layers used to depict old and mature forest.
- **‘Quick & dirty’:** Comparatively easy and low cost, using existing publicly available spatial data, rather than requiring new mapping.

9.2 Limitations

9.2.1 General

- TEI data distribution packages include multiple overlapping TEM projects, with different dates, different polygons, and sometimes different mapcodes and site series descriptions.
- TEM mapping does not cover the entirety of the study area – there are a number of gaps (mainly parks, private lands, and the Toba, Brem, Homfray and Texada landscape units).
- TEM coverage in much of the Bunster, Haslam, Texada, Howe and lower Chapman landscape units does not include structural stage information.
- VRI mapping covers most of the study area and fills many of the gaps in TEM mapping. However, it is not wall-to-wall, with notable gaps in some areas of private and protected land, and especially in the Haslam, Powell Lake, Lois, and Bunster landscape units.
- OGSR TAP coverage does not include private or First Nations lands, or higher elevation low productivity forest. In some areas (e.g. the Inland Lake area) the polygons were out of alignment with shorelines (thereby depicting forested polygons in the water, etc.).
- See **Table 2** in **Section 3.3** and **Table B-1** in **Appendix B** for additional comments about data sources and limitations.

9.2.2 Accuracy

- TEM polygons are comprised of three deciles – the ecosystem of interest might be a very small component of the larger polygon, especially for natural small patch ecosystems, or remnant fragments of ecosystems in a converted landscape. E.g. first decile might be rural, but ECAR, sensitive ecosystem or climate microrefugia is in second or third decile. Conversely, the first decile may be equal in size to the second decile, or to the second and third deciles combined, and may even be smaller than the second and third

deciles together. Any polygon that contained a target ecosystem (ECAR, SE, climate refuge) was selected and included in a separate shapefile to represent that target group.
- 1:20:000 scale: not ideal for local government planning (their preference is 1:5,000 or less).
- The 'built' disturbance layer was too inaccurate to be used to alter the ECAR, SE, and climate microrefugia layers due to issues in each of the input layers (e.g., rock outcrops and coastal log piles were interpreted as urban; smaller/recent developments/landscape conversions not picked up).

9.2.3 Disturbance Masks

- No single disturbance or landcover layer did a good job of capturing built up areas and permanent land clearing (e.g., agriculture and rights-of-way). Different attributes from different data sources were selected, and rigorous 'eyeballing' was required to try and filter out natural ecosystems (e.g. rock outcrops, wetlands, etc.) erroneously captured in these layers. Editing of inaccurate linework to match aerial imagery was required as well. Due to time constraints, this was not done in an exhaustive and comprehensive enough way to make the layer serviceable.

9.2.4 Old and Mature Forests

- Using the TEM to identify old and mature forests for ECAR, sensitive ecosystem, and climate microrefugia mapping was challenging because the TEM is largely out of date and much of it lacks structural stage information (vs. the VRI, which is regularly updated). A combination of layers was required to more accurately depict old and mature forest, using both the TEM and VRI:
  - ➢ A 'disturbance mask' of recent cut blocks from VRI was used to remove parts of forested TEM polygons that have been logged since the TEI was completed;
  - ➢ VRI data was then overlaid and used to assign age class to the remainder of forested TEM polygons; some TEM polygons that were mapped as 'young' are now considered mature (see **Appendix B** for details).

  The accuracy of these methods is untested and requires validation (field, peer, etc.). Further discussion is needed as to whether TEM updated using these methods is a reasonable method for identifying old and mature forests, or whether it would be better to use just the VRI or a different combination of the two.

- OGSR TAP data was used to map big tree old and mature forests. However, this data does not extend to private and First Nations lands.

9.2.5 Ecological Communities at Risk

- The potential ECAR mapping is a *possible* precursor to source features used for ECAR *Element Occurrence* mapping (NatureServe 2002). However, our potential ECAR mapping is limited in that:
  - It does not consider size, fragmentation, context, or condition of ecosystems.
  - It is subject to the scale and accuracy issues inherent in using 1:20,000 TEI & VRI data for local level planning.

9.2.6 Sensitive & Hydroriparian Ecosystems

- The Ri:fringe subclass cannot be adequately distinguished using existing 1:20,000 TEM alone (see methodology used by Metro Vancouver in their SEI mapping; Meidinger et al. 2014, pp.50-52). To help identify flood fringe ecosystems, TEM units that we categorized as 'moist forest' type, and known to have linear spatial patterns, were crosswalked with the Riparian flood fringe SE subclass. However, these moist forest units are sometimes small patch, not linear/riparian, so eyeballing or some other method of distinguishing them will be needed to filter these out. (See the Riparian Crosswalk table in **Appendix F for** additional comments about mapping riparian ecosystems).

- A combination of methods was used to map Ri:fringe in areas with TEM coverage, and RI generally in areas without TEM (as per the Riparian Crosswalk table in **Appendix F**). However, no in-depth comparisons were done to see if this approach is a reasonable alternative to interpretation of aerial imagery.

9.2.7 NRV Risk

- With respect to hydrological risk, the method used only looks at old forest (age class 9; >250yo) and does not account for mature forests (especially those with big trees) that are nearing equivalency to old growth in terms of hydrological functioning.
- Landscape units were used because they are an administrative unit used for forestry planning. The method would ideally by applied to smaller watershed units (e.g. third order watersheds) that make more sense ecologically.
- The method used did not look at other hydrological risk factors, such as watershed size, shape, aspect, slope, vegetation composition, storage (wetlands, lakes, reservoirs, etc.), susceptibility to rain-on-snow events, and drainage density (density of the road and stream network).

9.3 Recommendations

9.3.1 Accuracy

- Explore ways of using remote sensing or manual imagery interpretation to improve accuracy of a ‘permanent disturbance mask’ (to remove portions of TEM polygons that have been developed).
- Explore ways of using remote sensing to pick up and better delineate small patch and linear ecosystems (e.g. wetlands - especially forested wetlands - and riparian areas)
- Consider using LiDAR derived DEMs (where available) to correct and improve accuracy of FWA streamlines and TNT toporiparian mapping.
- Explore ways of using LiDAR to identify cleared/built up areas, and to better map forest cover and canopy height.

9.3.1.1 Crosswalk Table

- Organize a wider peer review of the crosswalk Table by CDC ecologists, the TEI team, and other Provincial ecologists to confirm site-series/map code correlations with:
    - Listed plant communities (and to help fill in the few remaining plant communities with mapcode blanks),
    - Sensitive ecosystem classes and subclasses,
    - Climate microrefugia.

9.3.2 ECAR, Sensitive & Hydroriparian Ecosystems

- Organize further peer review/discussion around the approach and methods used to derive potential ECAR and sensitive ecosystem maps, and whether they would do a ‘good enough’ job of identifying potential ECAR and SE for some applications (e.g. flagging potential presence and distribution of ECAR in a given area for further assessment).
- Host further discussion with CDC and TEI unit to discuss how the crosswalk table could be used as an initial step in developing EOs, or to flag areas for local government ESA mapping.

- Fine tune the mapping of riparian ecosystems (particularly Riparian: fringe) (also see Meidinger et al. 2014 and McTavish 2022) and explore ways of using LiDAR derived DEMs to improve accuracy of stream networks and toporiparian mapping.
- Host discussions with CDC and TEI unit about adding new sensitive ecosystem subclasses for:
    - 'Big tree' old forest (given its rarity and importance to biodiversity and as climate refuge),
    - 'Big tree' mature forest (given its importance as recruitment forest, and to hydrological resilience),
    - Ancient forest (using 350+yo as the age threshold in the VRI, rather than 400, given the VRI's deficiencies in identifying 400+ yo forest),
    - Fans & cones (given relevance to aquatic health),
    - Coastal fringe (given importance for near shore marine habitats and climate refuge).
- Explore alternatives for more accurately mapping 'big tree' mature and old forest using LiDAR derived tree canopy/height models, and for extending 'big tree' old and mature forest mapping to include private and First Nations lands (e.g. by using site index in the VRI, or other methods, as per Price et al. 2023).

9.3.3 NRV Risk

- Connect with Dave Daust and James Tricker to discuss options for incorporating 'big trees' into NRV risk analysis and mapping.
- Explore ways of running the analysis that also incorporate mature stands approaching hydrological equivalency to old forests, to provide a potentially higher resolution/more accurate indication of hydrological risks (consult with Younes Alila).
- Explore other ways of improving the resolution of the analysis; e.g. by using third order watersheds instead of landscape units, and/or using more graduated measures of risk (rather than just high, low and variable).

9.3.4 Climate Microrefugia

- Arrange additional peer review of crosswalk Table by CDC, TEI Unit and other vegetation ecologists, to discuss/confirm/ improve the site-series – climate microrefugia correlations. (e.g. by incorporating north aspect features, or other refuge related elements captured in TEI data).
- Explore ways of using remote sensing to better delineate microclimate ecosystems (those sites which are moister and cooler relative to surrounding areas)
- Explore ways of better capturing fringing vegetation along coastlines as a variable width buffer, by also incorporating topography, using a similar methodology to that used for TNT's topographical riparian mapping (TNT 2021).
- Explore ways of identifying potential microrefugia for fish/aquatic ecosystems (not addressed in this mapping); discuss with provincial ecologists/terrain mappers.
- Identify and map relatively intact areas/watersheds than span multiple BEC subzones (expand on OGSR TAP mapping of relatively intact watersheds).

9.4

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APPENDIX A: REGIONAL DESCRIPTION & HYDROLOGY [45]

(The following information is sourced from Chapman & Patrick 2021)

Physiographic History

BC's Coast Mountains are primarily formed from the Coast Plutonic Complex, a huge mass of intrusive igneous rocks[46] (also known as *plutonic rocks*, formed from magma that intruded into the Earth's crust and cooled), uplifted by tectonic forces. In southwestern BC these rocks have been dated to 145-66 million years (Blank 2013). Because of their durability and resistance to weathering, plutonic rocks support the steep slopes and rugged topography that typify the Coast Mountains (Church & Ryder 2007).

Hydrology

Watersheds in the study area fall into two types of coastal streamflow regimes: rain dominated regimes and hybrid rain-snowmelt regimes. On the south coast, the snowpack zone starts from about 800m elevation (Hudson & Horel 2007). Streams with higher elevation watersheds (typically above 1000m) with winter snowpack have snowmelt dominated flow regimes, and typically reach highest flows during the spring snowmelt (Hudson & Horel 2007). Mixed or hybrid rain-snowmelt stream regimes, occur in watersheds having both low elevation, rain dominated reaches, as well as higher elevation snow pack dominated reaches. These streams have characteristics of both rain- and melt-dominated streamflow regimes, and are common in coastal BC (Eaton & Moore 2010). Hybrid streams in coastal BC typically have two periods of peak flow: rain-dominated high flows in the fall (October to January), and similar magnitude melt-dominated flows in the spring (April to June). In these systems, the relative importance rainfall decreases with elevation (particularly >1000masl) and with distance from the Coast, where winter precipitation is more likely to fall as snow than rain (Eaton & Moore 2010). Significant flooding can occur in hybrid watersheds as a result of midwinter rain-on-snow (ROS) events, with snowmelt plus rainfall causing stream flows to spike. ROS events are particularly intense in open sites (such as clearcuts) with shallow, transient snowpacks, which quickly melt during rainfall (Winkler et al. 2010). Wind accelerates snowmelt, so large open areas exposed to the wind have increased snowmelt and run-off. On the coast the elevations at which shallow snowpacks form vary year to year, but typically occur between 300-800m asl (where shallow snowpacks can melt and reform more than once in a winter) (Hudson & Horel 2007). 'Pineapple Express' rainstorms that last for several days can also melt out deeper snowpacks and cause significant flooding (Winkler et al. 2010).

Heterogeneous forest cover, such as that of old growth forest, leads to a more heterogeneous snowpack, because some stands receive more direct solar radiation than others. This spreads snowmelt out over a longer time period (Perry et al. 2016, citing others). Forest harvesting reduces snowpack heterogeneity, leading to greater snowmelt synchrony (the snowpack melting all at once) and higher peak/flooding

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[45] This summary is adapted from the Tla'amin Nation Watershed Protection Plan (2021). https://www.tlaaminnation.com/tlaamin-watershed-protection-plan/

[46] Which on the southwest Coast Mountains, range in age from 167 to 91 million years old (Bustin et al. 2013).

flows, with increases up to 50% reported in the literature (Perry et al. 2016, citing others). Harvesting in Douglas-fir/Western hemlock watersheds in the Pacific Northwest has been shown to exacerbate summer low flows in the long term (while increasing low flows in the short term), with recent long-term studies indicating that stream flows in plantation forests do not return to original levels seen under mature/old growth forest cover, even when riparian buffers are in place (Perry & Jones 2017, Segura et al. 2020).

In all cases, the presence of storage in the watershed can attenuate flows, decreasing high flows as water goes into storage and augmenting low flows through storage depletion (Eaton & Moore 2010). Storage has the general effect of reducing variation in stream flow over time – less flow in during high precipitation/melt periods, and more flow during dry periods. Lakes, ponds and wetlands in a watershed all serve as water storage, capturing water during peak flows, and slowly releasing it during drier periods (Eaton & Moore 2010). Riparian groundwater is particularly important for augmenting streams during periods of low flow. Aquifers are also a source of water storage and discharge (Eaton & Moore 2010). Groundwater storage capacity is a function of geology (see **Section 4.3** above for details); for example, a watershed underlain by highly permeable/fractured bedrock will have more groundwater recharge during rain and melt events, thereby decreasing storm runoff and augmenting flows during dry weather. However, as is the case in the study area, watersheds underlain by relatively impermeable granitic bedrock will have less groundwater storage, with lower moderating effects on streamflow[47].

The granitic bedrock geology of the study area is largely overlain by veneers of glacial till, which is also relatively impermeable (Eaton and Moore 2010, citing others therein). This impermeable layer is overlain with soils from the forest floor, which in undisturbed coastal forests, have *high* water infiltration capacity, largely due to root channels and organic material (which is very porous; Winkler et al. 2010). As a consequence, in coastal watersheds (where shallow soils typically overlie bedrock or glacial till), water primarily moves in shallow subsurface flows through forest soils. Because of the high infiltration capacity of coastal forest soils, overland flows of water are rare (Winkler et al. 2010). However, when these soils become saturated during spring melt (meaning they have no additional storage capacity), even moderate rain-on-snow events can generate significant peak/flooding stream flows (Winkler et al. 2010).

Climate & Biogeoclimatic Zones

The steep Coast Mountains are typically moist with saturated air masses from the Pacific west coast and Strait of Georgia depositing high levels of precipitation over the fall, winter and spring months (Little 2012). Coastal influence on lower elevation areas near the sea moderates year round temperatures. Summers are typically quite dry along the coastal shoreline areas and in the upper elevations. Higher elevation areas have colder winter temperatures and much higher snowfall accumulations. The shoreline areas receive very little snow in winter.

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[47] In smaller headwater streams, however, groundwater flow through fractures in otherwise impermeable bedrock can play an important role in moderating streamflows (Eaton and Moore 2010, citing others).

The study area spans four different biogeoclimatic (BEC) zones, and five subzones (**Figure 1**). Starting from sea level and working upwards in elevation, these include:

- **Coastal Douglas-fir Zone (CDF)**
  - Moist Maritime Subzone (CDFmm)
- **Coastal Western Hemlock Zone (CWH)**
  - Eastern Very Dry Maritime Subzone/Variant(CWHxm1)
  - Dry Maritime Subzone (CWHdm),
  - Very Wet Maritime Subzone (CWHvm)
    - submontane variant(vm1)
    - montane variant (vm2)
  - Southern Dry Submaritime Subzone/Variant (CWHds1[48])
  - Southern Moist Submaritime Subzone/Variant (CWHms1[49])
- **Mountain Hemlock Zone (MH)**
  - Windward Moist Maritime Subzone/Variant (MHmm1)
  - Leeward Moist Maritime Subzone/Variant (MHmm2)
  - Moist Maritime Parkland Subzone/Variant (MHmmp)
- **Coast Mountain Heather Alpine Zone (CMA)**

Descriptions of climatic conditions and vegetation cover in each of these zones are summarized below.

Coastal Douglas-Fir (CDF) BEC Zone:

The lowest elevation coastal areas (below <150m elevation) south of Lund fall within the Coastal Douglas-fir (CDF) zone. Due to the rainshadow created by Vancouver Island mountains, the CDF is much drier than other coastal zones, with dry summers, mild, wet winters. Its Mediterranean-like climate allows a rich and unique set of flora and fauna to thrive in this zone, unlike that found anywhere else[50] (CDFCP 2021). The CDF zone has a long growing season, but is also subject to drought. It is typically dominated by coastal Douglas-fir forests, with Arbutus and Shore pine on drier, rocky sites. The understory is commonly comprised of salal and Oregon grape (Meidinger & Pojar 1991). Studies have show that CDF forests historically have higher fire return intervals than other coastal forests (on average every 188 years), likely the combined result of a drier climate and human activity (Murphy et al. 2019).

Historically, First Nations played an important role in shaping and maintaining CDF ecosystems. Controlled burns, tilling, pruning and weeding were used to clear the understory and create openings in the forest canopy, to enhance growth of root vegetables, and promote new shoots to attract game. This cleared the understory of less fire-resistant species, and favoured the dominance of large, thick-barked Douglas-fir and Maple (Islands Trust 2018). Active pruning, tending, selective harvesting and transplanting of other food plants (e.g. berries, crab apples, etc.) would also have further shaped this ecosystem (Haggan 2006). Many CDF ecosystems are now threatened in part because these activities were disrupted by colonization**.** Replacing open stands largely comprised of relatively fire-proof veteran trees with denser stands of smaller, younger trees, in combination with the cessation of First Nations

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[48] Within the study area, CWHds1 is only found in upper valleys of the Toba Landscape Unit.

[49] Within the study area, CWHms1 is only found in upper valleys of the Toba Landscape Unit.

[50] With the exception some ecosystems which also occur in the San Juan Islands and/or parts of the Washington State's Puget Basin; however, largely intact examples of CDF ecosystems are almost exclusively found within BC.

activities that kept the understory cleared, has increased the susceptibly of CDF forests to catastrophic wildfire (Islands Trust 2018).

CDF zone is the smallest BEC zone in BC. Because this highly restricted zone is home to 75% of BC's population and has undergone extensive development, is it is also home to the highest number of species and ecosystems at risk[51] in BC, many of which are globally imperilled. 80% of land in the CDF is privately owned, less than 1% of old growth forests remain, and only 11% is protected (CDFCP 2018). The core distribution of most CDF ecosystems is within BC, underscoring both the global uniqueness of these ecosystems, and BC's responsibility for their conservation (CDFCP 2018).

Coastal Western Hemlock (CWH) BEC Zone

The CWH zone is the wettest biogeoclimatic zone in BC. It spans low to mid elevations along much of the BC Coast, ranging from sea level up to around 800 to 900m (asl). In the CWH summers are cool and winters are mild (Meidinger & Pojar 1991). Within the study area there are three CWH subzones, which vary in dryness, the driest being the CWHxm, and the wettest being the CHWvm. CWH ecosystems typically consist of western hemlock mixed with Douglas-fir, cedars and amabilis fir. In the drier subzone (CWHxm), Douglas-fir, salal and Oregon grape dominate, with arbutus and shore pine sometimes occurring on dry rocky sites. Due to its dryness and restricted range in the province, the CWHxm – like the CDF zone – contains many rare ecosystems and species at risk (CDFCP 2018). As sites become wetter with elevation and aspect (CWHdm and vm), western hemlock becomes more dominant, and more western red cedar and yellow cedar increasingly appear, as do deer ferns and sword ferns (Meidinger & Pojar 1991).

Mountain Hemlock (MH) BEC Zone

Above the CWH is the Mountain Hemlock zone (MH), which spans elevations between ~900m and 1300m asl. This subalpine zone is typified by short cool summers, and long cool, wet winters, with heavy snow cover for many months (Meidinger & Pojar 1991). Wet cold conditions tend to inhibit burning. Deep, poorly drained organic soils are often present (due to slow decomposition), as are bogs, fens, wetlands and tarns (lakes). Forests in this zone have two modes, 1) parkland, restricted to 'tree islands' where snowmelt is earliest and dominated by mountain hemlock on drier sites, and 2) yellow cedar and amabilis fir on wetter sites (Klinka & Chourmouzis 2001). As elevation increases, tree growth thins out with elevation (Meidinger & Pojar 1991) and meadows of blueberries, crowberries and mountain heather become more dominant. Modern fire history has shown that fires are rare in MH forests (most often occurring as small spot fires), with mean fire return intervals of 600 to 1500+ years (Hallett et al. 2003, citing others); however recent studies have shown found shorter intervals in drier, more southern MH locations (Hallett et al. 2003).

Because of the short growing season, poor soils, and low fire frequency in the MH zone, trees grow very slowly and are often very ancient for their size. MH forests in the lower Sunshine Coast's Caren Range

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[51] Including: 224 Red & Blue listed species and 35 Red listed ecological communities, of which 23 of which are Globally Imperiled.

are the oldest forests known in Canada[52], and 1200 year old yellow cedar and 800 year old Mountain Hemlock have been found in a recent cutblock on Mount Freda. The Mountain Hemlock zone is important from a watershed perspective. Its forest canopy captures and retains snow, which helps prevent spring flooding. Its deep organic soils and abundant tarns, lakes and wetlands filter and store rain and meltwater. The slow release of this stored water from the MH zone plays a critical role in augmenting low stream flows during dry summer months, helping maintain a continuous supply of water to the watershed's lower reaches (Klinka & Chourmouzis 2001).

Coast Mountain Heather Alpine (CMA) BEC Zone

Above ~1300m asl is the Coast Mountain Heather Alpine Zone (CMA). This zone occurs along the windward spine of the Coast Mountains. Summers are cool, and winters are mild compared to other alpine zones in the province (due to maritime influence). The area sees a large amount of precipitation, much of which is snow, and the snowpack is deep. Within the study area, most of the CMA zone is occupied by exposed bedrock. In areas with sufficient soil for vegetation, alpine meadows dominate, comprised of white and pink mountain heathers and low growing evergreen dwarf shrubs. At tree line, patches of stunted mountain hemlock, yellow-cedar, and subalpine fir occur (McKenzie 2006).

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[52] 1200+ yo Hemlock and 1800+ yo Yellow Cedar have been found in the Caren Forest, world age records for these species. Some MH ecosystems have likely remained undisturbed for up 10,000 years (Jones 2003). See Caren Range Ancient Forest for details

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APPENDIX B: METHODS AND INPUT DATA USED TO DERIVE NEW MAP LAYERS

Using a combination of data sources and methodologies (detailed below), new map layers were created to help depict the following themes for the study area:

- **Potential Ecological Communities at Risk (ECAR**), including:
    - All ecological communities (including forest communities regardless of structural stage);
    - 'Ageless' ecological communities - those that may be an at-risk community regardless of age or structural stage (including flood, wetland, and non-forest);
    - Old and mature forest communities (non-flood, non-wetland);
- **Potential Sensitive Ecosystems**
- **Climate Micro-refugia**
- **Disturbance Masks:**
    - Built / permanently cleared areas – for visualization only (kept as separate layer due to lack of precision and accuracy);
    - **Recent cutblocks** – used to clip these areas out of the forested layers from TEM, to exclude them from ECAR, Sensitive Ecosystems, and Climate Micro-refugia polygons.
- **NRV Risk** (see **Appendix C**).

The first three themes (ECAR, Sens Ecos, and ClimateRefuge) were derived by cross-walking information from various databases to the various TEI project databases (**Appendix E**), and then linking the cross-walked data to the TEI polygons.

Crosswalk Table Inputs (Non-spatial data)

The following non-spatial inputs were used to develop the crosswalk table:

- **List of Ecological communities at risk** – BC Species & Ecosystems Explorer (BCSEE) search results of red and blue listed ecological communities using the Sunshine Coast Forest District as a boundary (BCCDC 2024).
- **TEI Map Codes and site series descriptions**
    - **TEI ecosystem map codes**– current ecosystem map codes (SiteMC), downloaded from the TEI website and filtered for those occurring on the South Coast (Terrestrial Ecosystem Information Unit 2023).
    - **TEI Coding Updates for Non- Vegetated, Sparsely Vegetated, and Anthropogenic Units**. (Terrestrial Ecosystem Information Unit 2020)
    - **TEM & SEI map legends** – map legends and reports, where available from EcoCat, associated with TEI projects that cover the study area, as per **Table B-1.** Reports and legends that could **not** be found on EcoCat or elsewhere include:
        - Powell River Block 1 TEM
        - Weyerhauser TEM
        - Lois Lake East TEM
        - Lois Lake West TEM
        - Narrows Landscape Unit TEM
        - SEI of the Sunshine Coast (legend available, but no finalized report)
    - **TEI Master_Ecosystem_Codes_List_20200708** – for Historic and Retired mapcodes (used where individual project legends and reports were not available).

- **Non-forested ecosystem classification and codes:**
    - *Biogeoclimatic Ecosystem classification of Non-forested Ecosystems in British Columbia (McKenzie 2012)*
    - *Field Manual for Describing Terrestrial Ecosystems (BC MOE 2010).*
- **Wetland classification:** *Wetlands of British Columbia: A Guide to Identification (McKenzie & Moran 2004)*
- **SEI classes and descriptions**:
    - *Standard for Mapping Ecosystems at Risk in British Columbia (MOE 2006)*
    - TEI Contractor Package – Domains (TEI Unit 2023).

Spatial Data

- **Terrestrial Ecosystem Inventory (TEI)**
    - The terrestrial ecosystem mapping projects used to develop these layers are listed in **Table B-1**, and their coverage in the study area is shown in **Figure 2** of the main report.
    - "NonPEM_Coast" TEI data distribution package (20231011) was downloaded from BC Data Catalogue.
    - TEM, SEI, and NEMSS (no structural stage) project types were included.
    - Polygons with no ecological data (BEC, Site Series, MapCode) were omitted.
    - Weyerhaeuser TEM was omitted since it has complete overlap with other project(s) and the polygon boundaries appear the same (i.e., used the same linework), and there is no report available for the Weyerhaeuser TEM.
    - Resulting shapefiles were cleaned of any invalid geometries (e.g., 'self-intersection') and cropped (not clipped) to the study area by selecting polygons within or overlapping the study area boundary.
    - For each of the three ecosystem components (deciles) that TEI polygons may contain, a field was created with a concatenate function of BGC label and Site MapCode label (distribution package) or BGC label and SiteSeries label (swiya package) for that decile:
        - Concat_1 = BGC + SiteMC_1 or BGC + SiteS_1;
        - Concat_2 = BGC + SiteMC_2 or BGC + SiteS_2;
        - Concat_3 = BGC + SiteMC_3 or BGC + SiteS_3.
    - A unique list was created of all 'Concat' units occurring in the TEI databases, in all three deciles / components.

- **Vegetation Resources Inventory (VRI)**
    - "VRI Forest Vegetation Composite R1 Layer (2023)" was downloaded from BC Data Catalogue.
    - Polygons were selected where Projected Age Class 1 had a value of 5 to 9 (81 – 250+ years old).
    - Several filters were used to remove VRI polygons that are not forested, including removing those in the CMA zone.
    - Resulting shapefile was cleaned of any invalid geometries that were preventing geoprocessing, and then cropped to the study area by selecting VRI polygons within or overlapping the boundary.

- **Old Growth Strategic Review (OGSR) Technical Advisory Panel (TAP)**
    - Old growth layer was used where neither VRI nor TEM cover the area and provide information on structural stage or age class (I.e., Inland Lake area).
    - Several layers were included in the climate micro-refugia theme, including: Ancient forest; Big Tree Old Forest; Big Tree Mature Forest.

Ecological Correlations

- The BCSEE search results of **ecological communities at risk** (**Appendix D**), and a unique list created from the TEI data of all the mapped site units (**Concat = BGC_MapCode** or **BGC_SiteSeries**) in the study area, were used to develop a table that cross-walks the ECAR with the mapped TEI site units.
- All ECAR from the BCSEE search were included in the table, even those that we could not correlate to a MapCode or SiteSeries in the TEI mapping for the study area.
  - Where BCSEE specified a site series number for a plant community, the correlation was clear;
  - Where site series number was 00, the site series name or site description (if detailed enough) or map legend was used to make the correlations.
- Additional columns in the Xwalk table contain various non-spatial input data:
  - BC Listing (red or blue) – from BCSEE.
  - Site Series and Site Series Name – from individual map legends and/or 2003 (or later) TEM MapCodes spreadsheet.
  - Assumed (typic) situation (legacy projects) – from individual map legends and/or 2003 TEM MapCodes spreadsheet.
  - SMR – soil moisture regime, from individual map legends and/or 2003 TEM MapCodes spreadsheet.
  - nBEC – New BEC code, from current TEI approved ecosystem mapcodes spreadsheet, or deduced to a general level by the description (e.g., Em, Ws, Fl with no numbers).
  - REALM, GROUP & CLASS – from current TEI approved ecosystem mapcodes spreadsheet, or deduced based on description.

- Columns created for these analyses include:

Type – as a step towards determining the potential Sensitive Ecosystem and & Climate refuge type, a column was created to summarize the information from the 'Realm', 'Group', and 'Class' columns into one column, often using the information in the 'Ecosystem Type' or 'Ecosystem Subtype' columns in TEI Ecosystems Codes (v2.2). Each site series/plant community was assigned one of the following categories:

- **Alpine/Subalpine**) – as per TEI Group (vegetated non-forest ecosystems in the MH and CMA zones, e.g., fellfield, heath, meadow).
- **Anthropogenic** – as per TEI Ecosystem Type.
- **Avalanche** – as per TEI Ecosystem Subtype or deduced from site series description.
- **Estuary** – as per TEI Ecosystem Subtype or deduced from site series description.
- **Flood** (**fringe**, **active**, or **high**, **low** or **mid** bench) - as per TEI Ecosystem Subtype.
- **Forest** – as per TEI Ecosystem Subtype.
- **Herb** (coastal dune, grassland, shrub) – as per SEI Subclass, with: cs and: vs combined into a single Herb-Coastal category, or deduced from site series description (*Biogeoclimatic ecosystem classification of non-forested ecosystems in British Columbia 2012)*.
- **Moist Forest** – TEI Ecosystem Subtype of 'Forest' **and** soil moisture regime (SMR) of subhygric to hydric.
- **Rock** (**cliff**, **outcrop**, **talus**) – as per TEI Ecosystem Subtype.
- **Snow/Glacier** – based on SiteSeries name or MapCode (covered by permanent snow or ice).
- **Water** – as per TEI Ecosystem Subtype.
- **Wetland** – as per TEI Ecosystem Type.

- **Woodland** – based on site name (Arbutus and Garry Oak dominated site series).

ECAR Potential - site series that potentially support listed plant/ecological communities were assigned one of the following categories based on BC status as well as 'type' (see above), as per guidelines used to identify listed plant communities for the Great Bear Rainforest Order *:

- **Red** - Herb, Wetland, or Flood 'types' that could be associated with a red listed plant community, irrespective of stand age. Note that wetland and flood ecosystems may be forested, but early seral stages are still wetland or riparian and retain much of their ecosystem function, and tend to recovery quickly;
- **Blue** - Herb, Wetland, or Flood 'types' that could be associated with a blue listed plant community, irrespective of stand age. Note that wetland and flood ecosystems may be forested, but early seral stages are still wetland or riparian and retain much of their ecosystem function, and tend to recovery quickly;
- **Red if mature/old** - Forest and Moist Forest 'types' that could be associated with a red listed plant community, once the forest is sufficiently established *****;
- **Blue if mature/old** - Forest and Moist Forest 'types' that could be associated with a blue listed plant community, once the forest is sufficiently established *****.

* These site series have *potential* to meet "**sufficiently established criteria**", as per guidelines used to identify listed plant communities for the Great Bear Rainforest Order (Banner et al. 2019), specifically:

- All **floodplain systems regardless of age** (high, medium and low bench ecosystems are considered sufficiently established by default);
- **Forested systems in old and mature** "seral stages" (i.e. 80+yo), using VRI (2023) age classes 5-9.

SE Potential – site series that potentially contain sensitive ecosystems were assigned the following sensitive ecosystem classes [and subclasses if there was enough detail] based on the assigned value in 'Type' (described above) and site description, as per Appendix D of Standards for Mapping Ecosystems at Risk in BC (RISC 2006):

- Alpine [AP:av :hb :kr :pf :sh]
- Broadleaf Woodland [BW]
- Estuary [ES:md :ms: tf]
- Fresh Water [FW:la :pd] – ***This class is not consistently applied and may not be appropriate***
- Herbaceous [HB:cs :du :hb :sh :vs]
- Riparian [RI:ff :fh :fl :fm :gu :ri]
- Sparsely Vegetated [SV:cl :ro :ta] **–** ***Most is high elevation and may not be sensitive ?***
- Woodland [WD:co :bd] – ***:bd subclass should be BW? (arbutus)***
- Wetland [WN:bg :fn :ms :sp :sw]
- Old & Mature Forest – forest or moist forest 'type' were selected and treated separately (exported to a new shapefile and modified using VRI – see Disturbance Masks section).

Climate Refuge Type - site series containing potential climate microrefugia (as described in Appendix A) were assigned one of the following climate refuge types based on the assigned value in 'Type' (described above):

- Wetland
- Flood

  - Moist Forest
  - Talus

Note that there are additional important microrefugia types not captured by TEM.

Ratings Tables

- The ratings tables, or GIS lookup tables, consist of a unique list of the all the units mapped by TEI in the study area, along with corresponding data from the crosswalk table to be added to the spatial file database.
- Two separate ratings tables were created, one for each format of TEI provided: Distribution package using MapCode, and Swiya package using SiteSeries. Each ratings table has a unique list of the TEM units, with a **concatenated label** of Biogeoclimatic Zone, subzone, variant, and either SiteSeries or MapCode (e.g., ‘CWHdm Wm05’, or ‘CWHdm CT’).
- The following columns from the crosswalk table were included in the ratings tables:
  - Concat (BGC and MC/SS)
  - Listed Plant Community – English Name
  - ECAR Potential
  - Type
  - Climate Refuge Type
  - Sensitive Ecosystem Class
  - Sensitive Ecosystem Subclass (SE:sc)

Applying Ratings to TEI Spatial Layer

- Concat fields were created in each of the TEI layers’ (distribution package, swiya, SEI) attribute tables, for each of the deciles (Concat_1, Concat_2, Concat_3).
- The ratings tables were loaded into QGIS and **joined** to the appropriate TEI shapefile’s attribute table using the ‘Concat’ fields, for each decile.
- A set of new fields was added to each TEI attribute table, and the corresponding info was transferred from the ratings table while it was joined to the applicable Concat field:
  - **PCOM_1**, **PCOM_2**, **PCOM_3** – from “**Listed Plant Community** – English Name” column in the ratings table.
  - **ECAR_POT_1**, **ECAR_POT_2**, **ECAR_POT_3** – from “**ECAR Potential**” column in the ratings table.
  - **TYPE_1**, **TYPE_2**, **TYPE_3** – from “**Type**” column in the ratings table.
  - **CLIMREF_1**, **CLIMREF_2**, **CLIMREF_3** – from “**Climate Refuge Type**” column in the ratings table.
  - **SECL_POT_1, SECL_POT_2, SECL_POT_3** – from “**SE Class (Pot)**” column in the ratings table.
  - **SECL_SC_1, SECL_SC_2, SECL_SC_3** – from “**SE CL:SC (Pot)”** column in the ratings table.
- Additional fields in the shapefile attribute tables were added in an attempt to summarize or highlight info from all three eco deciles:
  - **ECAR_Potn_H** is the “Highest Value” that occurs in the polygon, of four categories (in descending order): Red, Red if mature/old, Blue, Blue if mature/old.

  - **ECAR_Ptn_RB** is the higher value of the two categories that apply ***regardless of forest age***: Red, Blue (mature & old forest have been treated separately, but this column may indicate recruitment for currently early seral forested ECAR.

Old & Mature Forest Layers

- TEI polygons that contain a forest or moist forest 'type' community were selected and exported to a new shapefile (for each package), to update forest age using VRI.
- VRI (2023) polygons with a forest age class of 1 or 2 (recent clearcuts) were selected and saved as a new shapefile.
- The VRI clearcut layer was overlaid on the TEI forest layers and used to remove those portions that have been recently logged from the TEI forest polygons in a 'cookie-cutter' manner (GIS geoprocessing = difference). Note that the remaining portions of TEI polygons that have been modified no longer have the same area, and ***may not have the same ecosystem proportions***.
- The modified TEI forest layers were then updated for forest age:
  - A **centroid** was generated for each polygon that represents the center of the polygon, but ensuring it is within the polygon boundary (geographic center may fall outside, e.g. crescent shape).
  - The centroids were overlaid on the VRI forest layer, and 'received' data from the underlying polygons (GIS = Join attributes by location).
  - The centroids, now containing VRI age class data, were joined back to the TEI forest polygons, and the age class was transferred to the TEI database. The entire TEI polygon was assigned VRI age class based on the centroid, although it ***may not accurately represent*** complex polygons (more than one ecosystem component), or polygons where the linework is very different from VRI (overlap is split).
- TEI forest polygons that VRI age class indicates are **currently mature or old** were selected and exported to a new shapefile to represent Old & Mature Forest **sensitive ecosystem** categories.
- TEI forest polygons that VRI age class indicates it **is currently mature or old** AND potentially contain a red or blue forest community '**if mature/old**' were selected and exported to a new shapefile to represent old or mature listed **forest communities (ECAR).**
  - **ECAR_Legend** contains the resulting status: from 'Red if mature/old' to 'Red', and from 'Blue if mature/old' to 'Blue'.

Table B-1. Mapping themes and layers used or created for the study, including sources of the spatial data.

THEME	SPATIAL DATA SOURCE	LINK	COMMENTS
Tenure			
• Regional Districts • Municipalities • Forest Landscape Units • Forest Harvest Restriction • Parcel Fabric	Landscape Units of British Columbia - Current Generalized Forest Harvesting Restrictions ParcelMap BC – Parcel Fabric	https://catalogue.data.gov.bc.ca	
Disturbance Masks			
• Roads	Digital Road Atlas (DRA)	https://catalogue.data.gov.bc.ca	• Buffered road network to include in disturbance mask
• Built up / Developed / Cleared areas	CEF Human Disturbance 2021 ESRI Sentinel-2 10m landcover	https://catalogue.data.gov.bc.ca https://www.arcgis.com/home/item.html?id=cfcb7609de5f478eb7666240902d4d3d	• Selected features to include in disturbance mask
• Cutblocks	VRI Forest Vegetation Composite R1 Layer (2023)	https://catalogue.data.gov.bc.ca	• Selected features to include in disturbance mask for updating TEM data
Ecological Data & Coverage			
• TEM & SEI mapping	TEI _Non-PEM South Coast 202311 Distribution package (include Sunshine Coast SEI) TEI _ SWIYA package *(Note: SWIYA data distribution package not publicly available)*	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/ https://catalogue.data.gov.bc.ca	• See **Table B-2** for the list of TEM projects used in the study, with data and coverage limitations noted. • TEM & SEI map units were crosswalked with other data sources (**Appendix E**) with added columns predicting the potential for: ○ Ecological communities at risk (ECAR) ○ Sensitive Ecosystems (SE) ○ Climate Microrefugia
• Vegetation Resource Inventory Mapping (VRI)	VRI Forest Vegetation Composite R1 Layer (2023)	https://catalogue.data.gov.bc.ca	• VRI covers most of the study area and fills many of the gaps in TEM mapping. However, it is not wall-to-wall, with notable gaps in some areas of private and protected land, and in the Inland Lake - Powell River area. • For the lower Sunshine Coast, many high alpine areas consisting almost entirely of rock and snow appear to be erroneously mapped as old forest by the VRI. To resolve this issue, VRI polygons assigned a BEC subzone of CMA were removed from the VRI forest layer

THEME	SPATIAL DATA SOURCE	LINK	COMMENTS
			• Other non-forest polygons were removed from the VRI forest layer
• OGSR Technical Advisory Panel Old forest Mapping	OGSR_TAP Old Forest Mapping	https://catalogue.data.gov.bc.ca	• Coverage does not include private or First Nations lands, or higher elevation low productivity forest. • Coverage includes the Inland Lake - Powell River area (which is not covered by VRI). • Inland lake polygons were adjusted to bring them into alignment with shoreline.
Ecological Communities at Risk			
• CDC Element Occurrences	Species and Ecosystems at Risk – Publicly Available Occurrences – CDC	https://catalogue.data.gov.bc.ca	• Representative for CDF and some CWHxm, but lacking coverage in CWHdm, vm & MH
• Potential ECAR	TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/	• TEM data crosswalked with ecological communities at risk (**Appendix E**)
• Old & Mature Forested ECAR	TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package VRI Forest Vegetation Composite R1 Layer (2023) OGSR_TAP Old Forest Mapping – Seral Stage	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/ https://catalogue.data.gov.bc.ca	• Forested (non-flood or wetland) ECAR were selected from the crosswalked TEM data (**Appendix E**) and age class was updated using (VRI 2023) • Gaps in the VRI (Inland Lake area) were filled with OGSR Old forest mapping
Sensitive Ecosystems			
• Sunshine Coast SEI	Sunshine Coast SEI	https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=3758	Coverage limited to lower elevations; 20+ years out of date.
• Potential SE ○ Alpine/Subalpine ○ Wetlands ○ Riparian ○ Old & Mature Forest ○ Woodland ○ Estuaries ○ Herbaceous ○ Sparsely Vegetated	TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package Freshwater Atlas (Stream network, major rivers, lakes, wetlands) TNT Topographical Riparian Mapping VRI Forest Vegetation Composite R1 Layer (2023) OGSR_TAP Old Forest Mapping – Seral Stage	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/ https://catalogue.data.gov.bc.ca	• All potential sensitive ecosystems, *except old and mature forest*, were selected from the SE_Pot column of the crosswalked TEM data (**Appendix E**) • Forested site series were selected from the crosswalked TEM data (**Appendix E**) and modified using VRI to excise and remove recent cutblocks, and update the age class of remaining portions. • VRI and TAP data were used to depict old and mature forest in areas without TEM coverage (Age Class 9 = old; Age Classes 5-8 = mature). • Bioterrain attributes in the TEM were used separately to depict Ri:gully (selecting site modifier = “gully”, and geomorph processes =

THEME	SPATIAL DATA SOURCE	LINK	COMMENTS
			gullying) • Because Ri:fringe class cannot be distinguished using TEM, TNT topographical riparian mapping and FWA Stream, Lakes & Wetlands (with 30m buffer) and major rivers (50m buffer) were used to help depict RI: fringe. This also allowed riparian ecosystems to be reasonably depicted in areas without TEM coverage.
• Karst	Reconnaissance Karst Potential Mapping	https://catalogue.data.gov.bc.ca	Shows generalized areas with high potential for Karst; however, appears to miss important Karst areas (e.g. Stromberg Karst cave systems on Texada)
OGSR Technical Advisory Panel mapping			
• TAP Old seral stage	OGSR_TAP Old Forest Mapping – Seral Stage	https://catalogue.data.gov.bc.ca	• Used to fill in gaps in VRI coverage, notably in the Inland Lake – Powell River area.
• TAP priority old forest	OGSR_TAP Old Forest Mapping – Priority Deferral Areas	https://catalogue.data.gov.bc.ca	• Priority Deferral Areas defined and published by the Old Growth Technical Advisory Panel (TAP) on November 2, 2021. It gives an overall picture of the Technical Advisory Panel's priority recommendations for harvest deferrals and is a combination of: • Prioritized Big-treed Old Growth; • Ancient Forest; and • Remnant Old Ecosystems.
• Ancient forest (potential)	OGSR_TAP Old Forest Mapping – Ancient Forest SCFD_VRI_NRV Risk layer (as per forestry analysis in **Appendix C**) (based on VRI Forest Vegetation Composite R1 Layer 2023)	https://catalogue.data.gov.bc.ca	• The TAP layer depicts Ancient forests, which are defined as older than 400 years in ecosystems with rare stand-replacing disturbance. However, the TAP mapping relies on VRI forest age, which severely underestimates the actual amount of ancient forest in the field (OG TAP 2021b). • To more accurately reflect stands that have good likelihood of being ancient, we selected VRI polygons with leading species aged 350 yo and up (as classed in the forest analysis completed by James Tricker, **Appendix C).**
• TAP big tree old forest	OGSR_TAP Old Forest Mapping – Big Trees	https://catalogue.data.gov.bc.ca	• Depicts a selection of the remaining old forest with the largest trees in each ecosystem as described by tree height and diameter.
• TAP priority recruitment forest	OGSR_TAP Old Forest Mapping – Recruitment Forest	https://catalogue.data.gov.bc.ca	• This layer depicts "big tree" mature forest; important recruitment forests in landscape unit where little old forest remains.
• TAP intact forests	OGSR_TAP Old Forest Mapping – Intact Watersheds	https://catalogue.data.gov.bc.ca	• Shows watersheds where old forests remain relatively undisturbed by human activity.

SUNSHINE COAST PILOT MAPPING: For Conservation & Climate Resilience

THEME	SPATIAL DATA SOURCE	LINK	COMMENTS
NRV Risk			
• Natural range of variability & risk	VRI Forest Vegetation Composite R1 Layer (2023) BEC Biogeoclimatic V12	https://catalogue.data.gov.bc.ca	• Depicts the risk of losing species and ecosystem services across a given landscape unit, based on deviation from historically expected old growth percentages (for each BEC variant within the landscape unit). • Risk levels taken from **Table 4,** based on old forest analysis outlined in **Appendix C.**
Hydroriparian Ecosystems			
• Lakes & Wetlands	Freshwater Atlas Lakes Freshwater Atlas Wetlands	https://catalogue.data.gov.bc.ca	•
• Streams & rivers	Freshwater Atlas Stream Network Freshwater Atlas Major Rivers	https://catalogue.data.gov.bc.ca	•
• Wetland ecosystems	TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package Sunshine Coast SEI	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/ https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=3758	• TEM and SEI data crosswalked with sensitive ecosystems (Wetland classes selected from SE_Pot column)
• Riparian Ecosystems	TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package Sunshine Coast SEI Freshwater Atlas Stream Network TNT Topographical Riparian Mapping	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/ https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=3758 https://catalogue.data.gov.bc.ca	• Depicted using various sources: • TEM and SEI data crosswalked with sensitive ecosystems (Riparian class selected from SE_Pot column) • FWA streamlines (30m buffers added) • FWA main rivers (50m buffers added) • TNT topographical riparian mapping

• Fans & Cones	TEI _Non-PEM South Coast 202311 Distribution package
	TEI _ SWIYA package
		https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/	• For areas with TEM, selected polygons with:
			  • Site modifier = "fan',
			  • Surface Expression = 'fan', 'cone'

Sensitive (Nearshore) Marine Ecosystems			
Sens. nearshore ecosystems: • Shellfish beaches (clam beds) • Herring spawn areas	CRIMS Clam Beds CRIMS Herring Spawn	https://maps.gov.bc.ca/ess/hm/crims/	•
• Estuaries	TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/	• Depicted by selecting Estuary class from SE_Pot column in crosswalked TEM data • Augmented with PECP estuaries layer

THEME	SPATIAL DATA SOURCE	LINK	COMMENTS
	PECP Estuaries		
Climate Microrefugia			
• Lakes & Wetlands	Freshwater Atlas Lakes Freshwater Atlas Wetlands	https://catalogue.data.gov.bc.ca	
• Streams & rivers	Freshwater Atlas Stream Network Freshwater Atlas Major Rivers	https://catalogue.data.gov.bc.ca	
• Wetland ecosystems	Terrestrial Ecosystem Inventory – South Coast - short table layer (Dist_Pkg_NonPEM_Coast) Sunshine Coast SEI	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/ https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=3758	• TEM and SEI data crosswalked with sensitive ecosystems (Wetland classes selected from SE_Pot column)

• Riparian Ecosystems	TEI _Non-PEM South Coast 202311 Distribution package
	TEI _ SWIYA package
	Sunshine Coast SEI
	Freshwater Atlas Stream Network
	TNT Topographical Riparian Mapping
		https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/
		https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=3758
		https://catalogue.data.gov.bc.ca
			• Depicted using various sources:
			  • TEM and SEI data crosswalked with sensitive ecosystems (Riparian classes selected from SE_Pot column)
			  • FWA streamlines (30m buffers added)
			  • FWA main rivers (50m buffers added)
			  • TNT topographical riparian mapping

• Moist/cool forest	TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/	• Depicted using crosswalked TEM data: Moist Forest* selected from 'Climate Refuge' column *(*Note: includes forested site series with subhygric to hydric soil moisture regimes)*
• Old Forest	TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package VRI Forest Vegetation Composite R1 Layer (2023) OGSR_TAP Old Forest Mapping – Seral Stage	https://catalogue.data.gov.bc.ca	• Forested site series were selected from the crosswalked TEM data (**Appendix E**) and modified using VRI to excise and remove recent cutblocks, and update the age class of remaining portions. Old forest was selected from this layer. • VRI and TAP data were used to depict old and mature forest in areas without TEM coverage (Age Class 9 = old; Age Classes 5-8 = mature).
• Big tree old forest	OGSR_TAP Old Forest Mapping – Big Trees	https://catalogue.data.gov.bc.ca	
• Big tree mature forest	OGSR_TAP Old Forest Mapping – Recruitment Forest	https://catalogue.data.gov.bc.ca	
• Ancient Forest (potential)	SCFD_VRI_NRV Risk layer (as per forestry analysis in **Appendix C**) (based on VRI Forest Vegetation Composite R1 Layer 2023)	https://catalogue.data.gov.bc.ca	• Ancient forest (>400yo) cannot be adequately captured using VRI data. Instead selected stand ages >300 and >350 (typical upper limit of stand ages assigned in VRI) • To more accurately reflect stands that have good likelihood of being ancient, we selected VRI polygons with leading species aged 350 yo

THEME	SPATIAL DATA SOURCE	LINK	COMMENTS
			and up (as classed in the forest analysis completed by James Tricker, **Appendix C).**
• Talus slopes	Terrestrial Ecosystem Inventory – South Coast - short table layer (Dist_Pkg_NonPEM_Coast)	https://www.env.gov.bc.ca/esd/distdata/ecosystems/TEI/TEI_Data/	• Depicted using crosswalked TEM data (**Appendix E**) with Talus selected from 'Climate Refuge' column
• Coastal Fringe	FWA Coastlines CRIMS Clam beds & Herring Spawn TEI _Non-PEM South Coast 202311 Distribution package TEI _ SWIYA package PECP Estuaries	https://catalogue.data.gov.bc.ca	• Mapped using FWA Coastline layer: • Added 50m buffer where adjacent to shellfish beaches, herring spawning areas, and estuaries. • Added 30m buffer along all other coastline.

Table B-2. Terrestrial Ecosystem Inventory mapping projects used for the study.

BAPID	Project Type[53]	Project Name	Project Map Scale	Geographic Location	Year Project Completed	Survey Year	Map codes	Comments
5638	NEMNSS	Sunshine Coast TSA Haslam LU TEM	20000	Haslam Landscape Unit; in vicinity of Powell River	<Null>	2009	Old MC labels	• No structural stage data • Coverage does not include private land, parks, etc.
5640	NEMNSS	Sunshine Coast TSA Bunster LU TEM	20000	Bunster Landscape Unit; just north of Powell River	<Null>	2009	Old MC labels	• No structural stage data • Coverage does not include private land, parks, etc.
4904	TEM	Powell River Block 1 TEM*	20000	North of Powell River	<Null>	2002	Old MC labels	• CWHxm1 is erroneously labeled xm2 in this project. Indicated as CWHxm1* in crosswalk table. • Overlaps with Weyerhauser TEM – same linework • Coverage does not include private land, parks, etc.
5646	TEM	Weyerhauser TEM*	<Null>	Haida Gwaii	<Null>	<Null>	Old MC labels	• CWHxm1 is erroneously labeled xm2 in this project. Indicated as CWHxm1* in crosswalk table. • Missing BEC zone/variant info • Only used to fill gaps where no other projects had coverage. • Overlaps with Powell River & Lois Lake E&W TEM – same linework • Coverage does not include private land, parks, etc.
6122	TEM	Lois Lake West TEM*	20000	East of Powell River	2000	1998	Old MC labels	• CWHxm1 is erroneously labeled xm2 in this project. Indicated as CWHxm1* in crosswalk table. • Missing BEC zone/variant info • Overlaps with Weyerhauser TEM – same linework • Coverage does not include private land, parks, etc.
6123	TEM	Lois Lake East TEM*	20000	South East of Powell River	2000	1999	Old MC labels	• CWHxm1 is erroneously labeled xm2 in this project. Indicated as CWHxm1* in crosswalk table. • Missing BEC zone/variant info • Overlaps with Weyerhauser SWIYA TEM – same linework

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[53] **NEMNSS:** Terrestrial Ecosystem Mapping with no Bioterrain or Structural Stage.
TEM: Terrestrial Ecosystem Mapping that includes ecosystem, structural stage and bioterrain attributes.
SEI: Sensitive Ecosystem Inventory Mapping.

BAPID	Project Type[53]	Project Name	Project Map Scale	Geographic Location	Year Project Completed	Survey Year	Map codes	Comments
								• Coverage does not include private land, parks, etc.
6628	TEM OTHER	Shishalh Swiya Seamless TEM	20000	shíshálh Nation Traditional Territory; Sunshine Coast		New, not finalized	New SS Labels ONLY??	• Long table only, old map code labels not included • Consolidates all the TEM layers below, as well as Lois East TEM – some changes in linework/additions – see report • Added new Beach & Estuary polygons (OTHER)
6556	TEM	Texada TEM	10000	Southeast Texada Island	2020	2020	Old MC labels New SS Labels	• Only covers south half of Texada • Overlaps CDFmm TEM, mostly uses same linework but splits polygons (at finer scale)
6547	TEM	Ts'unay (Deserted) Watershed TEM	10000	Deserted River Watershed	2022	2019	New SS Labels ONLY??	• Long table only • Overlaps part of Jervis TEM – new linework at finer scale
6557	TEM	Tzoonie TEM	20000	Tzoonie River Watershed	2021	2020	New SS Labels ONLY??	• Long table only • Overlaps part of Narrows TEM, new linework
4677	NEMNSS	Chapman LU TEM	20000	Chapman Landscape Unit; Between Gibsons and Sechelt	<Null>	2007	Old MC labels	• No structural stage data (provided in SWIYA TEM, which overlaps this project) • Coverage does not include private land, parks, etc.
4678	NEMNSS	Sechelt LU TEM	20000	Sechelt LU; Sechelt Peninsula	<Null>	2007	Old MC labels	• No structural stage data (provided in SWIYA TEM, which overlaps this project) • Coverage does not include private land, parks, etc.
4684	NEMNSS	Howe LU TEM	20000	Howe Landscape Unit; NE of Gibsons	<Null>	2007	Old MC labels	• No structural stage data (provided in SWIYA TEM, which overlaps this project) • Coverage does not include private land, parks, etc.
4913	NEMNSS	Jervis LU TEM	20000	Jervis LU; Jervis Inlet, north of Sechelt	2009	2008	Old MC labels	• No structural stage data (provided in SWIYA TEM, which overlaps this project) • Coverage does not include private land, parks, etc.
4915	NEMNSS	Brittain LU TEM	20000	Brittain LU; west side of Jervis Inlet	2009	2008	Old MC labels	• No structural stage data (provided in SWIYA TEM, which overlaps this project) • Coverage does not include private land, parks, etc.
5639	NEMNSS	Sunshine Coast TSA Skwawka LU TEM	20000	Skwawka Landscape Unit; watershed	<Null>	2009	Old MC labels	• No structural stage data (provided in SWIYA TEM, which overlaps this project)

BAPID	Project Type[53]	Project Name	Project Map Scale	Geographic Location	Year Project Completed	Survey Year	Map codes	Comments
				draining into northern tip of Jervis Inlet				• Coverage does not include private land, parks, etc.
6118	NEMNSS	Narrows LU TEM	20000	Narrows Landscape Unit; Narrows Inlet	<Null>	2007	Old MC labels	• No structural stage data (provided in SWIYA TEM, which overlaps this project) • Coverage does not include private land, parks, etc.
4914	TEM	Salmon LU TEM	20000	Salmon LU; Salmon Inlet, northeast of Sechelt	2009	2008	Old MC labels	• No structural stage data (provided in SWIYA TEM, which overlaps this project) • Coverage does not include private land, parks, etc.
245	TEMWHR	Jedediah Island TEM	5000	Sabine Channel	1999	1998	Old MC labels	• Uses some unique mapcodes not used in other TEM projects • Includes private lands and parks. • Overlaps CDFmm TEM, but at a finer scale
4522	TEM	CDFmm TEM	20000	CDFmm BEC Zone in BC, Strait of Georgia, Georgia Lowland, Nanaimo Lowland and Southern Gulf Islands	2008	2008	Old MC labels	• Overlaps other projects that have coverage in CDFmm. • Uses mapcodes not used in other projects • Includes private lands and parks.
301	SEI	SEI of the Sunshine Coast and Adjacent Islands**	20000	Sunshine Coast	2005	2000	Old MC labels SE labels	• Only 'sensitive' ecosystems were mapped – not wall-to-wall. • Overlaps several other TEM projects having coverage in CDFmm, CWHxm1,dm • Map codes often differ from those used in TEM projects • Includes private lands and parks.
4195	SEI	Bowen-Gambier	20000	Howe Sound, Bowen-Gambier and the smaller islands of Howe Sound	<Null>	<Null>	SE labels only	• Only 'sensitive' ecosystems were mapped – not wall-to-wall. • Partly overlaps Howe LU TEM • Includes private lands and parks.

* No legend or report available for project
** Legend available for project, but no report.

Appendix B References

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APPENDIX C: FORESTRY ANALYSIS BY BEC-LANDSCAPE UNIT COMBINATION

(by James Tricker)

DATA SOURCES

1. Study area
Provided by Kelly

2. Fires
2.1 Fire burn severity - Historical
Data source: https://catalogue.data.gov.bc.ca/dataset/fire-burn-severity-historical
Object name: WHSE_FOREST_VEGETATION. VEG_BURN_SEVERITY_SP
Short name: BURN_SVRTY
Object comments: Burn Severity Rating for multiple years, starting in 2015 for the province of BC.

2.1 Fire burn severity – Same Year
Data source: https://catalogue.data.gov.bc.ca/dataset/fire-burn-severity-same-year
Object name: WHSE_FOREST_VEGETATION. VEG_BURN_SEVERITY_SAME_YR_SP
Short name: VEGBURNSEV
Object comments: Burn severity mapping for the same year wildfire season for fires that are 100 ha or greater in area. The burn severity mapping is conducted using current season pre- and post-fire multispectral satellite imagery (Sentinel-2, Landsat-8/9).

3. Logging
3.1 Harvested Areas of BC (Consolidated Cutblocks)
Data source: https://catalogue.data.gov.bc.ca/dataset/harvested-areas-of-bc-consolidated-cutblocks-
Object name: WHSE_FOREST_VEGETATION. VEG_CONSOLIDATED_CUT_BLOCKS_SP
Short name: CNS_CUT_BL
Purpose: The consolidated cut blocks dataset consolidates multiple sources of provincial harvesting data into a single dataset. The dataset can be used to locate and summarize historical harvesting areas across the province.
Description: The consolidated cut blocks dataset spatially combines forest harvesting data from multiple datasets (i.e . Reporting Silviculture Updates and Land Status Tracking System (RESULTS), Forest Cover Inventory (VRI) and Landsat satellite change detection). The dataset depicts historical cut blocks on all land owner types that are recorded in Ministry of Forest's system and includes an estimate of the year of harvest.

4. BEC
4.1 Biogeoclimatic Ecosystem Classification (BEC)
Data source: https://catalogue.data.gov.bc.ca/dataset/bec-map
Object name: WHSE_FOREST_VEGETATION. BEC_BIOGEOCLIMATIC_POLY
Short name: BEC_POLY
Purpose: The GIS layer is used for a wide variety of applications in British Columbia. A few examples include: Delineation of Natural Disturbance Types for Landscape Unit Planning. Delineation of Select Seed - Seed Planning Zones. As an input for Predictive Ecosystem Mapping. Reporting on the ecological representation of the Protected Areas Strategy. As a level in the classification hierarchy for Broad Ecosystem Units.
Description: The current and most detailed version of the approved corporate provincial digital Biogeoclimatic Ecosystem Classification (BEC) Zone/Subzone/Variant/Phase map (version 12, September 2, 2021). Use this version when performing GIS analysis regardless of scale. This mapping is deliberately extended across the ocean, lakes, glaciers, etc to facilitate intersection with a terrestrial landcover layer of your choice.

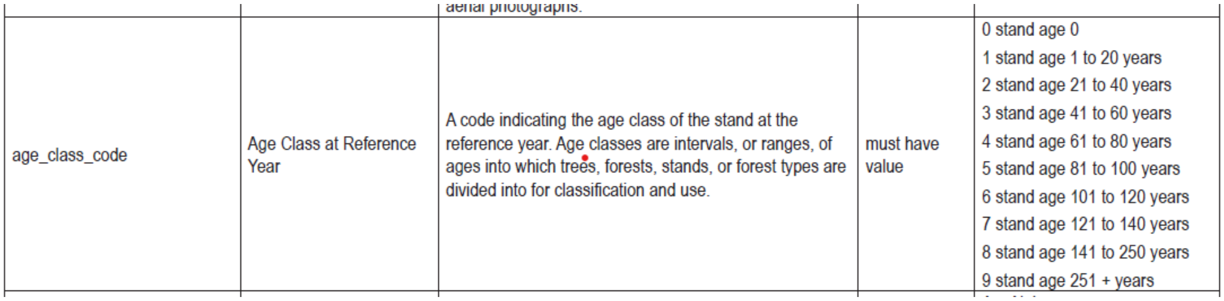
5. VRI

5.1 Vegetation Resources Inventory (VRI)
Data source: https://catalogue.data.gov.bc.ca/dataset/vri-2023-forest-vegetation-composite-rank-1-layer-r1-
Data dictionary: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/data-management-and-access/vri-data-standards
Description: Geospatial forest inventory dataset updated for depletions, such as harvesting, and projected annually for growth. Sample attributes in this dataset include: age, species, volume, height.
The Vegetation Resources Inventory (VRI) spatial datasets describe both where a vegetation resource (ie timber volume, tree species) is located and how much of a given resource is within an inventory unit.

ANALYSIS

Workspace projection = NAD 1983 BC Environment Albers

1. Clipped all layers to study area extent.
2. Created union using study area, BEC, VRI, cutblocks and fire datasets.
3. Calculated area (in hectares) for all records.
4. Created new field called “Age_gt_350”. Queried the leading species age column in the VRI (Proj_age_1) and the secondary species age column (proj_age_2) to identify polygons that are >= 350 – 399 (labelled “age1,2 gte 350”) and >=400+ (labelled “age1,2 gte 400”).
5. Created new field called “ageclass_update” and created 9 age class categories by querying the PROJ_AGE_1 field. Recent cutblocks (2004-present) and a single area of med/high burn severity (all other burns areas were already present in the VRI dataset) were set to age class 1. The 9 age classes are defined as follows in the Ecora User’s guide to VRI:



		aerial photographs.		
age_class_code	Age Class at Reference Year	A code indicating the age class of the stand at the reference year. Age classes are intervals, or ranges, of ages into which trees, forests, stands, or forest types are divided into for classification and use.	must have value	0 stand age 0 1 stand age 1 to 20 years 2 stand age 21 to 40 years 3 stand age 41 to 60 years 4 stand age 61 to 80 years 5 stand age 81 to 100 years 6 stand age 101 to 120 years 7 stand age 121 to 140 years 8 stand age 141 to 250 years 9 stand age 251 + years

Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.for.gov.bc.ca/hfd/library/documents/bib106996.pdf

6. Queried the new agelcass_update field to determine seral stage groupings (Early, Mid, Mature, Old) for the five ZONE/NTRLDSTRBN combinations present in the study area:

Zone	Early	Mid	Mature	Old
CDF NDT2	0 - 40	41 - 80	81 - 250	250+
CMA NDT5*	N/A	N/A	N/A	N/A
CWH NDT1	0 - 40	41 - 80	81 - 250	250+
CWH NDT2	0 - 40	41 - 80	81 - 250	250+
MH NDT1	0 - 40	41 - 120	121 - 250	250+

Adapted from the Forest Practices Code of BC Biodiversity Guidebook
Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/frep/frep-docs/biodiversityguidebook.pdf

* Note that there are no seral classes for NDT5.

OLD FOREST & RISK ANALYSIS

Age class data was used to determine percentage old forest for each BEC-Landscape Unit combo, and associated NRV risk ratings, based on deviation from historically expected old forest precentages (**Table C-1**).

(Refer also to spreadsheet APPENDIX C_6APR2024_AGECLASS_SUMMARY+RISK_final.xlsx)

Table C-1. Age class data, percent old forest and NRV risk, by BEC-Landscape Unit combination.

LU-BEC Combo	HECTARES (Ha)												PERCENT (%)				
	0	1	2	3	4	5	6	7	8	9	GRAND TOTAL HA	Total Forest	% old forest	Historically Expected	Low Risk Threshold	High Risk Threshold	NRV RISK
Brem	**42785.3**	**1315.1**	**682.2**	**1469.2**	**445.7**	**1106.6**	**890.0**	**152.0**	**1128.8**	**11164.4**	**61139.2**	**18353.9**	**60.8**				
CMA unp	21256.7			8.7			0.3	0.0	85.7	898.8	22250.3	993.5	90.5				
CWH dm	3779.9	634.2	128.2	62.4	212.0	514.9	375.3	47.6	59.7	294.6	6108.9	2329.0	12.7	70.0	49.0	21.0	HIGH
CWH ms 1	203.4								0.3	4.6	208.2	4.8	94.4	60.0	42.0	18.0	LOW
CWH vm 1	2918.4	621.5	526.2	1167.4	176.2	466.2	293.8	62.0	161.8	2596.8	8990.3	6071.8	42.8	85-90	61.0	26.0	VARIABLE
CWH vm 2	4514.1	59.5	27.7	178.5	41.1	116.1	170.7	20.7	174.0	3237.7	8540.1	4026.0	80.4	85-90	61.0	26.0	LOW
MH mm 1	9781.6			52.2	16.4	9.4	49.9	21.7	647.3	4112.8	14691.3	4909.7	83.8	90-95	65.0	28.0	LOW
MH mm 2	331.2									19.0	350.1	19.0	100.0	90-95	65.0	28.0	LOW
Brittain	**17739.7**	**967.0**	**1685.7**	**3937.5**	**5945.3**	**2916.5**	**5417.1**	**1608.8**	**7141.9**	**7168.9**	**54528.4**	**36788.7**	**19.5**				
CMA unp	2696.9		5.9	3.8	132.8	75.5	1537.0	31.2	869.5	436.7	5789.3	3092.5	14.1				
CWH dm	10940.5	652.2	814.3	1474.8	2584.1	1502.0	1664.7	710.1	1201.3	477.1	22021.0	11080.5	4.3	70.0	49.0	21.0	HIGH
CWH vm 1	229.9	137.3	85.4	761.6	1622.3	379.9	133.9	75.7	137.9	223.7	3787.7	3557.8	6.3	85-90	61.0	26.0	HIGH
CWH vm 2	1387.2	170.7	660.5	1519.2	1337.8	719.4	868.0	405.3	1917.2	3025.0	12010.2	10623.0	28.5	85-90	61.0	26.0	VARIABLE
MH mm 1	2485.3	6.9	119.7	178.2	268.3	239.6	1213.5	386.4	3016.0	3006.4	10920.3	8435.0	35.6	90-95	65.0	28.0	VARIABLE
Bunster	**16490.5**	**2760.3**	**3540.0**	**3183.6**	**2275.5**	**5145.0**	**11377.5**	**4306.7**	**1846.8**	**4499.2**	**55425.0**	**38934.6**	**11.6**				
CDF mm	3018.5	50.4	5.0	33.7	176.5	693.3	814.0	299.4	11.9		5102.5	2084.1	0.0	29.0	20.0	12.0	HIGH
CMA unp	514.0		3.5	18.6	14.3	10.1	46.5	19.4	182.6	17.7	826.6	312.6	5.7				
CWH dm	3886.9	1825.9	1221.4	709.7	660.5	2077.6	5226.2	1399.2	290.4	389.5	17687.3	13800.4	2.8	70.0	49.0	21.0	HIGH
CWH vm 2	1533.6	291.2	1133.5	1669.7	438.2	516.5	1038.1	347.4	278.0	2402.9	9649.0	8115.4	29.6	85-90	61.0	26.0	VARIABLE
CWH xm 1	5513.4	590.7	724.0	383.9	844.8	1674.0	4058.2	2201.0	617.9	330.2	16938.0	11424.6	2.9	70.0	49.0	21.0	HIGH
MH mm 1	2024.1	2.0	452.7	368.1	141.2	173.5	194.5	40.3	466.2	1358.9	5221.6	3197.5	42.5	90-95	65.0	28.0	VARIABLE
Chapman	**36055.9**	**1620.6**	**3729.3**	**5242.4**	**6764.4**	**3158.5**	**3125.5**	**1296.1**	**1839.6**	**6257.7**	**69089.9**	**33034.0**	**18.9**				
CDF mm	21889.4										21889.4	0.0	0.0	29.0	20.0	12.0	HIGH
CMA unp	92.4				0.2					29.6	122.2	29.8	99.4				
CWH dm	1372.9	1113.0	1436.5	1400.7	2984.0	1326.4	1896.7	823.3	1060.8	226.2	13640.4	12267.5	1.8	70.0	49.0	21.0	HIGH
CWH vm 1	12.6	7.3	25.8	259.8	395.3	42.2	26.5	3.5	25.6	33.2	831.8	819.2	4.1	85-90	61.0	26.0	HIGH

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LU-BEC Combo	HECTARES (Ha)												PERCENT (%)				
	0	1	2	3	4	5	6	7	8	9	GRAND TOTAL HA	Total Forest	% old forest	Historically Expected	Low Risk Threshold	High Risk Threshold	NRV RISK
CWH vm 2	113.5	117.2	1106.5	2078.2	1856.4	227.5	112.8	49.9	350.5	2050.2	8062.7	7949.2	25.8	85-90	61.0	26.0	HIGH
CWH xm 1	12321.4	346.6	504.7	851.8	1474.0	1560.2	1089.5	419.4	264.9	1.0	18833.5	6512.1	0.0	70.0	49.0	21.0	HIGH
MH mm 1	253.7	36.4	655.9	652.0	54.5	2.2			137.9	3917.4	5709.9	5456.2	71.8	90-95	65.0	28.0	LOW
Cortes	**52633.1**	**3295.0**	**1513.8**	**4806.1**	**4036.9**	**5421.0**	**9550.5**	**7654.3**	**8376.3**	**7026.5**	**104313.3**	**51680.2**	**13.6**				
CMA unp	43.2									29.7	72.9	29.7	100.0				
CWH dm	18668.4	1862.0	588.0	1449.7	1805.8	2409.4	2960.5	1742.6	3408.1	1865.7	36760.2	18091.8	10.3	70.0	49.0	21.0	HIGH
CWH mm 1	16.9		10.8	147.0	3.1	12.8		22.9	72.2	123.7	409.5	392.6	31.5				
CWH vm 1	88.1	277.4	159.7	865.2	638.7	378.5	607.0	627.2	887.9	1057.3	5587.2	5499.1	19.2	85-90	61.0	26.0	HIGH
CWH vm 2	72.9	31.3	258.5	367.9	241.6	110.7	223.2	243.2	380.8	1143.0	3073.0	3000.1	38.1	85-90	61.0	26.0	VARIABLE
CWH xm 1	26279.7	220.2	128.1	1311.4	849.0	1554.1	3178.0	3684.3	2016.5	393.8	39615.1	13335.4	3.0	70.0	49.0	21.0	HIGH
CWH xm 2	7342.2	904.1	368.7	663.3	487.7	930.3	2578.8	1299.0	1533.3	1089.1	17196.5	9854.3	11.1	70.0	49.0	21.0	HIGH
MH mm 1	121.7			1.5	11.0	25.1	3.0	35.0	77.4	1324.1	1598.9	1477.1	89.6	90-95	65.0	28.0	LOW
Deserted	**6163.9**	**410.7**	**382.2**	**354.6**	**1264.6**	**613.0**	**231.8**	**107.1**	**231.3**	**4121.1**	**13880.4**	**7716.5**	**53.4**				
CMA unp	3946.1		3.1	0.3	0.3	10.3	8.3	4.6	7.3	547.2	4527.5	581.4	94.1				
CWH dm	3.7	52.4	24.6	23.6	232.0	77.3	89.4		30.8	15.9	549.6	545.9	2.9	70.0	49.0	21.0	HIGH
CWH vm 1	338.0	204.4	36.9	116.0	885.0	332.0	36.8	23.7	60.0	780.0	2812.7	2474.7	31.5	85-90	61.0	26.0	VARIABLE
CWH vm 2	814.7	151.3	182.5	108.5	141.6	141.1	45.5	35.5	59.5	1150.0	2830.2	2015.5	57.1	85-90	61.0	26.0	VARIABLE
MH mm 1	1061.4	2.6	135.0	106.3	5.7	52.3	51.8	43.3	73.8	1628.1	3160.3	2099.0	77.6	90-95	65.0	28.0	LOW
Haslam	**20476.0**	**2957.9**	**1604.1**	**1334.7**	**1901.6**	**5201.5**	**4784.9**	**669.5**	**144.5**	**222.7**	**39297.3**	**18821.3**	**1.2**				
CDF mm	6811.7	168.6	17.5		27.4	145.4	554.6	223.5			7948.8	1137.1	0.0	29.0	20.0	12.0	HIGH
CWH dm	7145.0	1959.0	764.6	257.8	1120.8	3278.9	2095.1	211.7	100.2	100.3	17033.5	9888.5	1.0	70.0	49.0	21.0	HIGH
CWH vm 2	1015.0	30.6	240.4	854.4	669.2	435.5	254.2	152.0	35.8	94.3	3781.5	2766.4	3.4	85-90	61.0	26.0	HIGH
CWH xm 1	5437.5	799.7	546.2	27.7	60.1	1315.8	1881.1	82.4	8.4		10158.8	4721.3	0.0	70.0	49.0	21.0	HIGH
MH mm 1	66.7	0.0	35.3	194.9	24.0	25.8				28.0	374.7	308.0	9.1	90-95	65.0	28.0	HIGH
Homfray	**23714.1**	**1134.8**	**2273.4**	**1600.1**	**2432.4**	**1679.4**	**2530.0**	**1358.9**	**4013.0**	**10123.7**	**50859.8**	**27145.7**	**37.3**				
CMA unp	7938.5			0.6	6.0	0.3	1.9	0.7	154.7	713.2	8815.9	877.4	81.3				
CWH dm	8886.5	844.4	378.5	411.5	647.9	940.9	1833.5	981.7	1266.8	618.5	16810.2	7923.6	7.8	70.0	49.0	21.0	HIGH
CWH vm 1	501.6	232.6	895.5	332.6	1044.3	279.6	268.5	100.8	540.3	820.3	5016.2	4514.6	18.2	85-90	61.0	26.0	HIGH

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LU-BEC Combo	HECTARES (Ha)												PERCENT (%)				
	0	1	2	3	4	5	6	7	8	9	GRAND TOTAL HA	Total Forest	% old forest	Historically Expected	Low Risk Threshold	High Risk Threshold	NRV RISK
CWH vm 2	1500.8	55.6	913.7	607.5	549.6	230.5	185.7	54.4	604.4	2628.5	7330.8	5829.9	45.1	85-90	61.0	26.0	VARIABLE
CWH xm 1	942.9		0.1	37.8	74.4	86.7	172.3	184.9	335.0	7.7	1841.8	898.9	0.9	70.0	49.0	21.0	HIGH
MH mm 1	3943.7	2.3	85.5	210.1	110.3	141.4	68.2	36.3	1111.7	5335.5	11045.0	7101.3	75.1	90-95	65.0	28.0	LOW

Howe	**20732.8**	**1122.1**	**3481.7**	**3916.6**	**3081.2**	**3486.3**	**2577.3**	**2702.6**	**4926.3**	**7254.7**	**53281.5**	**32548.7**	**22.3**				
CDF mm	63.6										63.6	0.0	0.0	29.0	20.0	12.0	HIGH
CMA unp	278.9				10.2	9.0			44.9	50.5	393.5	114.5	44.1				
CWH dm	6145.7	150.8	230.6	366.9	1014.0	1028.7	1256.7	790.2	882.7	208.3	12074.6	5928.9	3.5	70.0	49.0	21.0	HIGH
CWH vm 1	1148.1	773.7	1695.4	1700.8	994.3	748.9	199.9	419.1	1024.0	446.4	9150.5	8002.4	5.6	85-90	61.0	26.0	HIGH
CWH vm 2	389.4	149.2	1324.3	1499.4	334.2	290.0	106.2	406.1	1160.9	3073.7	8733.4	8344.1	36.8	85-90	61.0	26.0	VARIABLE
CWH xm 1	11911.5	47.6	54.8	162.8	580.3	932.5	991.2	816.9	386.6	17.7	15902.0	3990.5	0.4	70.0	49.0	21.0	HIGH
MH mm 1	795.6	0.8	176.5	186.6	148.3	477.2	23.3	270.3	1427.2	3458.1	6963.8	6168.2	56.1	90-95	65.0	28.0	VARIABLE
Jervis	**20627.1**	**3106.3**	**2898.5**	**6772.4**	**3024.5**	**2876.8**	**3051.8**	**1132.6**	**4310.7**	**24361.8**	**72162.6**	**51535.5**	**47.3**				
CMA unp	7192.7		79.8	88.5	127.2	382.2	196.9	100.7	560.1	6088.5	14816.5	7623.9	79.9				
CWH dm	10013.9	1132.0	948.5	953.2	1066.6	951.8	1623.3	632.9	1295.5	1285.8	19903.4	9889.6	13.0	70.0	49.0	21.0	HIGH
CWH vm 1	576.3	1630.0	272.4	867.9	738.4	585.2	242.1	39.1	190.2	862.2	6003.7	5427.4	15.9	85-90	61.0	26.0	HIGH
CWH vm 2	1256.1	341.2	1226.9	4140.7	886.1	530.5	558.3	285.1	1250.1	8034.9	18510.0	17253.9	46.6	85-90	61.0	26.0	VARIABLE
MH mm 1	1588.1	3.2	370.9	722.0	206.2	427.1	431.2	74.9	1014.9	8090.4	12928.9	11340.8	71.3	90-95	65.0	28.0	LOW
Lois	**22799.2**	**6393.8**	**4522.9**	**6798.1**	**6639.7**	**6202.7**	**3620.2**	**1477.0**	**3369.6**	**2727.4**	**64550.6**	**41751.4**	**6.5**				
CMA unp	1276.1	1.1	11.6	12.6		1.9	106.9	6.8	6.4	149.8	1573.2	297.2	50.4				
CWH dm	11614.3	4480.4	3344.7	2166.8	3669.1	4431.9	2104.7	911.1	1007.0	213.4	33943.4	22329.1	1.0	70.0	49.0	21.0	HIGH
CWH vm 2	1283.4	1444.7	688.0	2574.9	2564.3	1126.2	564.2	289.2	1086.0	652.9	12274.0	10990.5	5.9	85-90	61.0	26.0	HIGH
CWH xm 1	5489.3	252.1	75.7	39.5	130.5	472.9	577.6	84.2	0.6	10.1	7132.7	1643.4	0.6	70.0	49.0	21.0	HIGH
MH mm 1	3136.1	215.3	402.8	2004.3	275.7	169.9	266.8	185.7	1269.6	1701.2	9627.3	6491.2	26.2	90-95	65.0	28.0	HIGH
Lower Squamish	**9895.2**	**638.3**	**835.9**	**1606.6**	**2246.0**	**2716.6**	**1369.5**	**1330.8**	**3361.7**	**10922.5**	**34923.2**	**25028.0**	**43.6**				
CMA unp	4213.8			5.2	38.3	16.2	20.1	7.2	275.0	1376.5	5952.5	1738.6	79.2				
CWH dm	3026.9	255.4	293.4	691.0	1671.7	1875.5	1123.7	686.6	980.4	663.4	11268.2	8241.3	8.0	70.0	49.0	21.0	HIGH
CWH ds 1	6.8	21.4		206.5	7.3	89.2	86.1	11.3	124.1	74.2	626.9	620.1	12.0	60.0	42.0	18.0	HIGH

CWH ms 1	4.4	13.1	19.1	264.8	101.3	33.6	1.8	21.8	91.1	137.5	688.5	684.1	20.1	60.0	42.0	18.0	VARIABLE
CWH vm 1	89.4	279.1	234.2	235.6	212.7	94.0	14.1	49.9	62.0	467.4	1738.5	1649.1	28.3	85-90	61.0	26.0	VARIABLE
CWH vm 2	700.8	66.6	257.6	119.8	112.6	403.4	54.0	415.1	791.0	3101.6	6022.5	5321.7	58.3	85-90	61.0	26.0	VARIABLE
MH mm 1	1849.1	2.7	31.6	80.0	98.1	204.7	69.0	135.7	929.5	4936.1	8336.4	6487.3	76.1	90-95	65.0	28.0	LOW
MH mm 2	4.0			3.7	3.8		0.8	3.2	108.6	165.7	289.8	285.8	58.0	90-95	65.0	28.0	VARIABLE

Narrows	**6990.8**	**856.1**	**4401.3**	**4465.0**	**2290.6**	**2327.9**	**1847.8**	**852.1**	**3797.2**	**11748.4**	**39577.3**	**32586.4**	**36.1**				
CMA unp	2958.9		37.5	97.1	57.6	230.8	123.2	9.3	1073.4	3290.2	7878.0	4919.1	66.9				
CWH dm	3155.4	637.7	1669.6	375.1	930.5	782.3	823.8	471.1	563.2	303.8	9712.4	6557.0	4.6	70.0	49.0	21.0	HIGH
CWH vm 1	42.1	116.5	607.8	681.4	352.3	346.8	121.4	88.3	288.1	431.6	3076.3	3034.2	14.2	85-90	61.0	26.0	HIGH
CWH vm 2	233.5	98.2	1358.1	2688.0	748.5	595.7	481.2	205.6	1276.6	3148.0	10833.5	10600.0	29.7	85-90	61.0	26.0	VARIABLE
MH mm 1	600.9	3.7	728.4	623.4	201.7	372.3	298.2	77.7	595.9	4574.8	8077.0	7476.2	61.2	90-95	65.0	28.0	VARIABLE
Powell Daniels	**28791.4**	**567.4**	**2905.8**	**1910.7**	**125.0**	**101.9**	**972.7**	**221.6**	**52.5**	**5627.9**	**41276.7**	**12485.4**	**45.1**				
CMA unp	12140.3									173.3	12313.6	173.3	100.0				
CWH dm	485.0	23.6	129.6	136.6	97.7	58.8	260.3	20.8		36.6	1249.0	764.0	4.8	70.0	49.0	21.0	HIGH
CWH vm 1	1686.5	406.2	1761.6	1500.6	19.8	39.3	556.4	109.3	50.0	1492.8	7622.5	5936.0	25.1	85-90	61.0	26.0	HIGH
CWH vm 2	4513.8	106.3	907.7	273.5	7.5	3.8	141.5	78.6	2.5	2512.3	8547.3	4033.6	62.3	85-90	61.0	26.0	LOW
MH mm 1	9965.8	31.3	106.9				14.5	12.9		1412.9	11544.3	1578.5	89.5	90-95	65.0	28.0	LOW
Powell Lake	**36284.1**	**2826.3**	**3841.1**	**2946.1**	**997.3**	**2693.6**	**6129.4**	**1631.8**	**263.5**	**5874.5**	**63487.7**	**27203.6**	**21.6**				
CMA unp	9262.6		7.7	0.4			7.4	3.5	8.6	223.6	9513.7	251.1	89.1				
CWH dm	10155.5	1754.3	1193.0	13.5	358.2	1232.0	4358.7	906.2	60.3	18.2	20050.0	9894.5	0.2	70.0	49.0	21.0	HIGH
CWH vm 1	904.9	97.1	136.2	1573.4	421.3	676.1	276.1	238.5	129.4	280.9	4734.0	3829.1	7.3	85-90	61.0	26.0	HIGH
CWH vm 2	5107.1	846.7	1652.3	1219.8	213.8	751.0	1330.2	402.0	50.3	2022.0	13595.2	8488.1	23.8	85-90	61.0	26.0	HIGH
MH mm 1	10854.1	128.2	851.9	139.0	3.9	34.5	156.9	81.6	14.9	3329.7	15594.9	4740.8	70.2	90-95	65.0	28.0	LOW
Salmon Inlet	**16345.4**	**2288.2**	**6982.5**	**6560.5**	**2068.1**	**2134.7**	**2830.6**	**1820.2**	**6097.6**	**21632.5**	**68760.4**	**52414.9**	**41.3**				
CMA unp	7605.7		0.2	8.8	53.5	182.7	203.3	188.9	1083.5	3451.5	12778.0	5172.3	66.7				
CWH dm	4529.7	830.8	1988.1	837.3	562.2	429.1	988.6	716.3	956.3	884.2	12722.5	8192.8	10.8	70.0	49.0	21.0	HIGH
CWH vm 1	594.0	766.1	1566.5	2055.8	582.4	170.8	198.8	110.7	837.8	716.8	7599.6	7005.6	10.2	85-90	61.0	26.0	HIGH
CWH vm 2	931.2	638.6	2642.0	2912.1	435.0	663.2	715.0	522.8	1850.6	5387.2	16697.7	15766.5	34.2	85-90	61.0	26.0	VARIABLE
MH mm 1	2684.8	52.7	785.8	746.4	435.1	689.0	723.4	281.5	1369.5	11180.8	18949.0	16264.1	68.7	90-95	65.0	28.0	LOW

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MH mm 2	0.1						1.5			12.1	13.6	13.6	88.9	90-95	65.0	28.0	LOW
Sechelt	**56614.9**	**3898.8**	**4824.7**	**4257.4**	**8288.9**	**9204.2**	**6596.3**	**6008.1**	**4654.6**	**2155.0**	**106502.9**	**49888.0**	**4.3**				
CDF mm	26005.0	16.2	47.5	48.6	421.9	536.4	683.1	882.4	435.6		29076.7	3071.7	0.0	29.0	20.0	12.0	HIGH
CWH dm	7267.1	2019.2	1491.5	1236.9	3511.6	3518.2	2469.0	2448.7	1993.7	794.0	26749.8	19482.7	4.1	70.0	49.0	21.0	HIGH
CWH vm 2	201.0	148.9	995.8	1227.4	1538.1	609.9	99.3	61.4	166.0	1110.2	6157.9	5957.0	18.6	85-90	61.0	26.0	HIGH
CWH xm 1	23132.6	1714.4	2162.0	1665.9	2813.7	4519.5	3330.6	2615.6	2047.7	116.6	44118.6	20986.0	0.6	70.0	49.0	21.0	HIGH
MH mm 1	9.3		127.9	78.5	3.6	20.1	14.4		11.6	134.4	399.8	390.6	34.4	90-95	65.0	28.0	VARIABLE
Skwawka	**26278.2**	**328.8**	**1075.9**	**1879.8**	**578.7**	**545.8**	**326.3**	**177.3**	**1402.6**	**6162.4**	**38755.8**	**12477.6**	**49.4**				
CMA unp	16031.2				3.5	37.4	12.0		93.9	363.6	16541.6	510.4	71.2				
CWH dm	130.2	30.8	162.6	27.2	132.5	54.3	175.3	34.7	53.3	32.4	833.4	703.2	4.6	70.0	49.0	21.0	HIGH
CWH vm 1	1439.4	131.3	562.6	1672.5	337.7	329.6	134.5	120.8	372.9	1219.5	6320.6	4881.2	25.0	85-90	61.0	26.0	HIGH
CWH vm 2	2939.3	166.6	338.2	165.8	52.1	77.0	2.7	14.9	502.5	2297.1	6556.2	3616.9	63.5	85-90	61.0	26.0	LOW
MH mm 1	5738.1	0.1	12.5	14.4	52.9	47.4	1.7	6.9	380.0	2249.9	8503.9	2765.8	81.3	90-95	65.0	28.0	LOW
Texada	**147746.7**	**1348.7**	**1736.4**	**4628.4**	**8280.9**	**4034.2**	**5734.6**	**3497.7**	**6165.1**	**1665.0**	**184837.6**	**37090.8**	**4.5**				
CDF mm	124049.1	643.2	299.1	962.6	3603.4	2720.3	3815.3	1952.3	3980.6	1093.0	143118.9	19069.8	5.7	29.0	20.0	12.0	HIGH
CWH dm	38.1	16.7	80.6	894.5	98.5	32.5	208.5	1.2	343.2	20.5	1734.3	1696.3	1.2	70.0	49.0	21.0	HIGH
CWH xm 1	23659.6	688.8	1356.7	2771.2	4579.0	1281.3	1710.9	1544.1	1841.3	551.5	39984.3	16324.7	3.4	70.0	49.0	21.0	HIGH
Toba	**133115.0**	**1669.5**	**385.3**	**4943.2**	**2995.0**	**1894.6**	**1884.8**	**834.1**	**3997.8**	**24418.6**	**176138.0**	**43023.0**	**56.8**				
CMA unp	96361.1			14.8	5.0	32.2	8.2	51.9	562.4	2364.9	99400.5	3039.4	77.8				
CWH dm	1584.8	76.4	32.2	715.1	1317.6	946.5	471.2	231.7	245.0	896.8	6517.2	4932.4	18.2	70.0	49.0	21.0	HIGH
CWH ds 1	1422.3	741.1	102.1	1679.6	317.4	300.6	737.5	25.7	318.8	1496.1	7141.2	5718.9	26.2	60.0	42.0	18.0	VARIABLE
CWH ms 1	8744.0	526.9	51.1	1256.1	415.7	164.7	328.8	177.4	757.5	5603.0	18025.3	9281.4	60.4	60.0	42.0	18.0	LOW
CWH vm 1	1496.9	175.6	161.2	719.5	668.2	223.9	150.6	47.5	161.3	1775.9	5580.7	4083.7	43.5	85-90	61.0	26.0	VARIABLE
CWH vm 2	3762.5	91.3	38.7	256.3	169.5	72.1	95.2	63.8	215.7	2784.0	7549.0	3786.5	73.5	85-90	61.0	26.0	LOW
MH mm 1	6176.5	2.3		1.3		24.7	33.4	124.1	348.9	3263.0	9974.4	3797.8	85.9	90-95	65.0	28.0	LOW
MH mm 2	13566.9	55.8	0.0	300.5	101.7	130.0	59.9	112.0	1388.1	6234.9	21949.7	8382.8	74.4	90-95	65.0	28.0	LOW
GRAND TOTAL HA	**742279.3**	**39505.7**	**53302.6**	**72612.9**	**65682.4**	**63460.6**	**74848.8**	**38839.1**	**67121.2**	**175135.0**	**1392787.6**	**650508.3**	**26.9**				

APPENDIX D: ECOLOGICAL COMMUNITIES AT RISK

BC CDC Element Occurrences

Table D-1. Ecological communities at risk mapped as Element Occurrences in the study area by the BC CDC.

Scientific Name	English Name	BC_LIST
Abies amabilis - Picea sitchensis / Oplopanax horridus	amabilis fir - Sitka spruce / devil's club	Blue
Populus trichocarpa - Alnus rubra / Rubus spectabilis	black cottonwood - red alder / salmonberry	Blue
Pseudotsuga menziesii - Arbutus menziesii	Douglas-fir - arbutus	Red
Pseudotsuga menziesii / Mahonia nervosa	Douglas-fir / dull Oregon-grape	Red
Leymus mollis ssp. mollis - Lathyrus japonicus	dune wildrye - beach pea	Red
Abies grandis / Mahonia nervosa	grand fir / dull Oregon-grape	Red
Abies grandis / Tiarella trifoliata	grand fir / three-leaved foamflower	Red
Rhododendron groenlandicum / Kalmia microphylla / Sphagnum spp.	Labrador-tea / western bog-laurel / peat-mosses	Blue
Carex macrocephala Herbaceous Vegetation	large-headed sedge Herbaceous Vegetation	Red
Pinus contorta / Sphagnum spp. CDFmm	lodgepole pine / peat-mosses CDFmm	Red
Artemisia campestris - Festuca rubra / Racomitrium canescens	northern wormwood - red fescue / grey rock-moss	Red
Pinus contorta var. contorta / Juniperus communis - Arctostaphylos columbiana	shore pine / common juniper - hairy manzanita	Red
Picea sitchensis / Rubus spectabilis Dry	Sitka spruce / salmonberry Dry	Red
Picea sitchensis / Rubus spectabilis Very Dry Maritime	Sitka spruce / salmonberry Very Dry Maritime	Red
Myrica gale / Carex sitchensis	sweet gale / Sitka sedge	Blue
Thuja plicata / Symphoricarpos albus	western redcedar / common snowberry	Red
Thuja plicata / Rubus spectabilis	western redcedar / salmonberry	Red
Thuja plicata / Carex obnupta	western redcedar / slough sedge	Red
Thuja plicata / Tiarella trifoliata Dry Maritime	western redcedar / three-leaved foamflower Dry Maritime	Blue

BC Species & Ecosystems Explorer Search Results

Table D-2. Results of *BC Species & Ecosystems Explorer* search for the Sunshine Coast Regional District and qathet Regional District (Feb 2024).

Scientific Name	English Name	BC List	Spatial Pattern	Presence	
				qRD	SCRD
Abies amabilis - Picea sitchensis / Oplopanax horridus	amabilis fir - Sitka spruce / devil's club	Blue	Linear	Y	Y
Abies amabilis - Thuja plicata / Oplopanax horridus Moist Submaritime	amabilis fir - western redcedar / devil's club Moist Submaritime	Blue	Large patch; Small patch	Y	
Abies amabilis - Thuja plicata / Gymnocarpium dryopteris	amabilis fir - western redcedar / oak fern	Blue	Large patch; Small patch	Y	
Abies amabilis - Thuja plicata / Rubus spectabilis Very Wet Maritime	amabilis fir - western redcedar / salmonberry Very Wet Maritime	Blue			Y
Populus trichocarpa - Alnus rubra / Rubus spectabilis	black cottonwood - red alder / salmonberry	Blue		Y	Y
Populus trichocarpa / Salix sitchensis	black cottonwood / Sitka willow	Blue	Linear	Y	Y
Populus trichocarpa / Salix spp. Dry Submaritime	black cottonwood / willows Dry Submaritime	Blue	Linear	Y	
Menyanthes trifoliata - Carex lasiocarpa	buckbean - slender sedge	Blue	Large patch; Small patch	Y	Y
Typha latifolia Marsh	common cattail Marsh	Blue	Small patch	Y	Y
Eleocharis palustris Herbaceous Vegetation	common spike-rush Herbaceous Vegetation	Blue	Small patch	Y	Y
Pseudotsuga menziesii - Pinus contorta / Arctostaphylos uva-ursi Moist Submaritime	Douglas-fir - lodgepole pine / kinnikinnick Moist Submaritime	Blue	Small patch	Y	
Pseudotsuga menziesii - Tsuga heterophylla / Paxistima myrsinites	Douglas-fir - western hemlock / falsebox	Blue	Small patch		
Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon Moist Maritime	Douglas-fir - western hemlock / salal Moist Maritime	Blue	Small patch	Y	
Poa glauca ssp. *rupicola* Herbaceous Vegetation	glaucous bluegrass Herbaceous Vegetation	Blue	Small patch		
Schoenoplectus acutus Deep Marsh	hard-stemmed bulrush Deep Marsh	Blue	Small patch	Y	Y
Rhododendron groenlandicum / Kalmia microphylla / Sphagnum spp.	Labrador-tea / western bog-laurel / peat-mosses	Blue	Small patch	Y	Y
Pinus contorta / Sphagnum spp. *Very Dry Maritime*	lodgepole pine / peat-mosses Very Dry Maritime	Blue	Small patch	Y	Y
Eriophorum angustifolium - Carex limosa	narrow-leaved cotton-grass - shore sedge	Blue	Small patch		
Alnus rubra / Rubus spectabilis / Equisetum arvense	red alder / salmonberry / common horsetail	Blue	Linear	Y	Y
Carex sitchensis - Oenanthe sarmentosa	Sitka sedge - Pacific water-parsley	Blue	Small patch	Y	Y
Salix sitchensis - Salix lasiandra var. *lasiandra / Lysichiton americanus*	Sitka willow - Pacific willow / skunk cabbage	Blue	Linear; Small patch	Y	Y
Salix sitchensis / Carex sitchensis	Sitka willow / Sitka sedge	Blue	Small patch	Y	Y
Equisetum fluviatile - Carex utriculata	swamp horsetail - beaked sedge	Blue	Small patch		
Myrica gale / Carex sitchensis	sweet gale / Sitka sedge	Blue	Small patch	Y	Y
Selaginella wallacei / Cladina spp.	Wallace's selaginella / reindeer lichens	Blue	Small patch	Y	Y

Scientific Name	English Name	BC List	Spatial Pattern	Presence	
				qRD	SCR D
Tsuga heterophylla - Abies amabilis / Struthiopteris spicant	western hemlock - amabilis fir / deer fern	Blue		Y	
Tsuga heterophylla - Abies amabilis / Hylocomium splendens	western hemlock - amabilis fir / step moss	Blue	Matrix	Y	Y
Tsuga heterophylla - Pseudotsuga menziesii / Hylocomiadelphus triquetrus Dry Submaritime 1	western hemlock - Douglas-fir / electrified cat's-tail moss Dry Submaritime 1	Blue	Matrix	Y	
Tsuga heterophylla - Thuja plicata / Gaultheria shallon Very Wet Maritime	western hemlock - western redcedar / salal Very Wet Maritime	Blue	Matrix	Y	Y
Tsuga heterophylla / Buckiella undulata	western hemlock / flat-moss	Blue	Matrix	Y	Y
Thuja plicata - Pseudotsuga menziesii / Acer circinatum	western redcedar - Douglas-fir / vine maple	Blue	Large patch	Y	
Thuja plicata - Picea sitchensis / Lysichiton americanus	western redcedar - Sitka spruce / skunk cabbage	Blue	Small patch	Y	Y
Thuja plicata - Tsuga heterophylla / Polystichum munitum	western redcedar - western hemlock / sword fern	Blue	Small patch	Y	Y
Thuja plicata / Oplopanax horridus	western redcedar / devil's club	Blue	Linear; Small patch	Y	
Thuja plicata / Polystichum munitum - Lysichiton americanus	western redcedar / sword fern - skunk cabbage	Blue		Y	Y
Thuja plicata / Tiarella trifoliata Dry Maritime	western redcedar / three-leaved foamflower Dry Maritime	Blue		Y	Y
Thuja plicata / Tiarella trifoliata Very Dry Maritime	western redcedar / three-leaved foamflower Very Dry Maritime	Blue	Linear; Small patch	Y	Y
Abies amabilis - Thuja plicata / Rubus spectabilis Moist Maritime 1	amabilis fir - western redcedar / salmonberry Moist Maritime 1	Red	Linear; Small patch	Y	
Abies amabilis - Thuja plicata / Tiarella trifoliata Moist Maritime 1	amabilis fir - western redcedar / three-leaved foamflower Moist Maritime 1	Red	Large patch; Matrix		
Sarcocornia pacifica -_Lysimachia maritima	American glasswort - sea-milkwort	Red	Small patch	Y	Y
Arbutus menziesii / Arctostaphylos columbiana	arbutus / hairy manzanita	Red	Small patch	Y	Y
Juncus arcticus - Plantago macrocarpa	arctic rush - Alaska plantain	Red	Small patch	Y	Y
Ruppia maritima Herbaceous Vegetation	beaked ditch-grass Herbaceous Vegetation	Red	Small patch	Y	Y
Populus trichocarpa / Salix sitchensis - Rubus parviflorus	black cottonwood / Sitka willow - thimbleberry	Red	Linear	Y	
Pseudotsuga menziesii - Arbutus menziesii	Douglas-fir - arbutus	Red	Small patch	Y	Y
Pseudotsuga menziesii - Pinus contorta / Arctostaphylos uva-ursi Dry Submaritime	Douglas-fir - lodgepole pine / kinnikinnick Dry Submaritime	Red	Small patch	Y	
Pseudotsuga menziesii - Pinus contorta / Cladina spp.	Douglas-fir - lodgepole pine / reindeer lichens	Red	Small patch		
Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon Dry Maritime	Douglas-fir - western hemlock / salal Dry Maritime	Red		Y	Y
Pseudotsuga menziesii / Melica subulata	Douglas-fir / Alaska oniongrass	Red	Small patch	Y	Y
Pseudotsuga menziesii / Acer glabrum / Prosartes hookeri	Douglas-fir / Douglas maple / Hooker's fairybells	Red	Small patch	Y	
Pseudotsuga menziesii / Mahonia nervosa	Douglas-fir / dull Oregon-grape	Red	Matrix	Y	Y
Pseudotsuga menziesii / Polystichum munitum	Douglas-fir / sword fern	Red	Large patch; Matrix	Y	Y
Leymus mollis ssp. *mollis - Lathyrus japonicus*	dune wildrye - beach pea	Red	Small patch	Y	Y
Quercus garryana - Arbutus menziesii	Garry oak - arbutus	Red	Small patch	Y	Y
Quercus garryana / Bromus carinatus	Garry oak / California brome	Red	Small patch	Y	Y

Scientific Name	English Name	BC List	Spatial Pattern	Presence	
				qRD	SCRD
Quercus garryana / Holodiscus discolor	Garry oak / oceanspray	Red	Small patch	Y	Y
Abies grandis / Mahonia nervosa	grand fir / dull Oregon-grape	Red	Small patch	Y	Y
Abies grandis / Tiarella trifoliata	grand fir / three-leaved foamflower	Red	Small patch	Y	Y
Sidalcea hendersonii Tidal Marsh	Henderson's checker-mallow Tidal Marsh	Red	Small patch	Y	Y
Carex macrocephala Herbaceous Vegetation	large-headed sedge Herbaceous Vegetation	Red	Small patch	Y	Y
Pinus contorta / Sphagnum spp. CDFmm	lodgepole pine / peat-mosses CDFmm	Red	Small patch	Y	Y
Carex lyngbyei Herbaceous Vegetation	Lyngbye's sedge herbaceous vegetation	Red	Small patch	Y	Y
Artemisia campestris - Festuca rubra / Racomitrium canescens	northern wormwood - red fescue / grey rock-moss	Red	Small patch	Y	Y
Alnus rubra / Lysichiton americanus	red alder / skunk cabbage	Red	Small patch	Y	Y
Alnus rubra / *Carex obnupta* [*Populus trichocarpa*]	red alder / slough sedge [black cottonwood]	Red	Small patch	Y	Y
Festuca roemeri - Koeleria macrantha	Roemer's fescue - junegrass	Red	Small patch	Y	Y
Bolboschoenus maritimus var. *paludosus* Alkali Marsh	seacoast bulrush Alkali Marsh	Red		Y	Y
Distichlis spicata - Sarcocornia pacifica	seashore saltgrass - Pacific swampfire	Red	Small patch	Y	Y
Pinus contorta var. *contorta / Juniperus communis - Arctostaphylos columbiana*	shore pine / common juniper - hairy manzanita	Red	Small patch		
Carex sitchensis / Sphagnum spp.	Sitka sedge / peat-mosses	Red	Small patch	Y	Y
Picea sitchensis / Rubus spectabilis Dry	Sitka spruce / salmonberry Dry	Red	Linear	Y	Y
Picea sitchensis / Rubus spectabilis Moist Submaritime	Sitka spruce / salmonberry Moist Submaritime	Red	Linear	Y	Y
Picea sitchensis / Rubus spectabilis Very Dry Maritime	Sitka spruce / salmonberry Very Dry Maritime	Red	Linear	Y	Y
Picea sitchensis / Rubus spectabilis Very Wet Maritime	Sitka spruce / salmonberry Very Wet Maritime	Red	Linear	Y	
Carex lasiocarpa - Rhynchospora alba	slender sedge - white beak-rush	Red	Small patch	Y	Y
Dulichium arundinaceum Herbaceous Vegetation	three-way sedge	Red	Small patch	Y	Y
Myosurus minimus - Montia spp. - *Limnanthes macounii*	tiny mousetail - montias - Macoun's meadow-foam	Red	Small patch	Y	Y
Populus tremuloides / Malus fusca / Carex obnupta	trembling aspen / Pacific crab apple / slough sedge	Red	Small patch	Y	Y
Deschampsia cespitosa - Sidalcea hendersonii	tufted hairgrass - Henderson's checker-mallow	Red	Small patch	Y	Y
Deschampsia cespitosa ssp. *beringensis - Hordeum brachyantherum*	tufted hairgrass - meadow barley	Red	Small patch	Y	Y
Tsuga heterophylla - Abies amabilis / Struthiopteris spicant Moist Maritime	western hemlock - amabilis fir / deer fern Moist Maritime	Red	Small patch		
Tsuga heterophylla - Abies amabilis / Rhytidiopsis robusta	western hemlock - amabilis fir / pipecleaner moss	Red	Matrix		
Tsuga heterophylla - Pseudotsuga menziesii / Kindbergia oregana	western hemlock - Douglas-fir / Oregon beaked-moss	Red	Matrix	Y	Y
Tsuga heterophylla - Thuja plicata / Struthiopteris spicant	western hemlock - western redcedar / deer fern	Red	Small patch	Y	Y
Tsuga heterophylla - Thuja plicata / Gaultheria shallon Moist Maritime 1	western hemlock - western redcedar / salal Moist Maritime 1	Red	Small patch		
Tsuga heterophylla / Clintonia uniflora	western hemlock / queen's cup	Red	Small patch	Y	

Scientific Name	**English Name**	**BC List**	**Spatial Pattern**	**Presence**	
				qRD	**SCRD**
Thuja plicata - Pseudotsuga menziesii / Kindbergia oregana	western redcedar - Douglas-fir / Oregon beaked-moss	Red	Small patch	Y	Y
Thuja plicata / Lonicera involucrata	western redcedar / black twinberry	Red	Small patch	Y	Y
Thuja plicata / Symphoricarpos albus	western redcedar / common snowberry	Red	Small patch	Y	Y
Thuja plicata / Oemleria cerasiformis	Western Redcedar / Osoberry	Red	Small patch	Y	Y
Thuja plicata / Rubus spectabilis	western redcedar / salmonberry	Red	Small patch	Y	Y
Thuja plicata / Carex obnupta	western redcedar / slough sedge	Red	Small patch	Y	Y
Thuja plicata / Polystichum munitum Dry Maritime	western redcedar / sword fern Dry Maritime	Red	Large patch	Y	Y
Thuja plicata / Polystichum munitum Very Dry Maritime	western redcedar / sword fern Very Dry Maritime	Red	Large patch	Y	Y
Thuja plicata / Achlys triphylla	western redcedar / vanilla-leaf	Red	Small patch	Y	Y

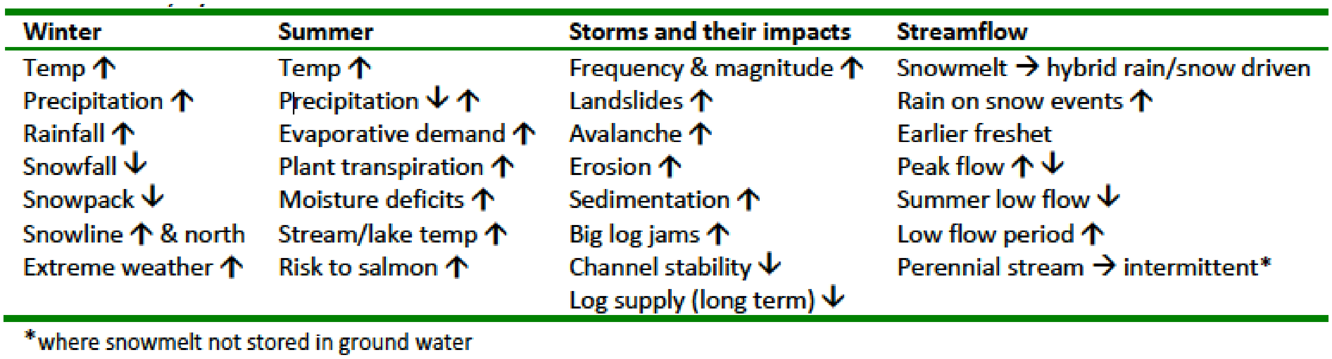
APPENDIX E: ECOSYSTEM CROSSWALK & RATINGS TABLES

(Refer to Excel Spreadsheet: APPENDIX E_SCFD_TEI Xwalk and Ratings Table_V44.xlsx)

APPENDIX F: CLIMATE IMPACTS ON HYDROLOGY & AQUATIC ECOSYSTEMS[54]

The effects of climate change are increasingly compounding watershed pressures from human activity. Summers are becoming dryer and hotter with more frequent heat waves and increased year-to-year variability compared to historical levels. Winters will likely become increasingly warmer and wetter. Large and frequent winter rainstorms and large decreases in snowfall are expected (Little 2012). These changes in precipitation and temperature will have significant implications for hydrology and aquatic ecosystems (**Table F-1**).

Table F-1. Projected climate related changes in winter weather, storm impacts and streamflow in BC (source: Price & Daust 2013, citing others).



Winter	Summer	Storms and their impacts	Streamflow
Temp ↑	Temp ↑	Frequency & magnitude ↑	Snowmelt → hybrid rain/snow driven
Precipitation ↑	Precipitation ↓ ↑	Landslides ↑	Rain on snow events ↑
Rainfall ↑	Evaporative demand ↑	Avalanche ↑	Earlier freshet
Snowfall ↓	Plant transpiration ↑	Erosion ↑	Peak flow ↑ ↓
Snowpack ↓	Moisture deficits ↑	Sedimentation ↑	Summer low flow ↓
Snowline ↑ & north	Stream/lake temp ↑	Big log jams ↑	Low flow period ↑
Extreme weather ↑	Risk to salmon ↑	Channel stability ↓	Perennial stream → intermittent*
		Log supply (long term) ↓	

*where snowmelt not stored in ground water

The following is a summary of some of the predicted climate change impacts on coastal aquatic ecosystems (adapted from: Pike et al. 2010, Klassen & Hopkins 2016, and Price & Daust 2013 citing others).

Increased evaporation: Increased evaporation, due in part to increased air temperature, will reduce the water available in streams, lakes and reservoirs, decrease survival and growth of existing vegetation in drier areas (e.g. the CDFmm and CWHxm zones), with a big increase in fire severity and frequency in the Georgia Basin. Modeling predicts that water deficit will increase from 20 – 60% depending on location and climate scenario.

Altered vegetation composition affecting water interception: Vegetation intercepts precipitation and draws moisture from the soil through transpiration. Projected future climates will lead to changed productivity, changed dominant species. As vegetation communities shift to reflect climate, water interception, evaporation and transpiration will change.

Increased water temperature: Water temperature in streams and lakes will increase with implications to aquatic ecology. Salmon species are tolerant to particular temperature windows. Increased water temperature has consequences for sensitive populations, including increased disease, altered growth and development, thermal barriers to migration, and altered species distribution. Small changes in water temperature will likely result in distribution shifts and loss of salmonids in areas already near their limit (see **Table F-1)** for details).

Increased frequency and magnitude of storms: Increased wind and precipitation will likely increase windthrow, flooding and landslides. Associated increases in erosion and landslide-derived log jams will destabilise channels and change the temporal input of woody structure, affecting stream ecology, hydroriparian function and fish populations.

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[54] This summary is adapted from the Tla'amin Nation Watershed Protection Plan (2021). https://www.tlaaminnation.com/tlaamin-watershed-protection-plan/

Decreased snow accumulation and accelerated snowmelt: Less water will be stored overwinter for release in spring to groundwater or streams, changing the streamflow regime. The central and northern coasts, and high-elevation sites on the south coast, are projected to have the biggest declines.

Altered timing and magnitude of streamflows: The impacts of climate change will vary with watershed hydrological regimes. Watersheds with rain-dominated regimes (with peak flows in winter and low flows in summer) will likely reflect projected changes in precipitation. For example, increased storms will lead to increased storm-related peak flows in winter, and drier summers will lead to more low-flow days. As snow decreases and rain increases in winter, hybrid rain and snow dominated watersheds (with peak flows in winter and spring and low flows in summer) may shift to rain-dominated regimes with more frequent winter peak flows. Larger and more frequent winter peak flows will be exacerbated by more frequent of rain-on-snow events, particularly in the shallow snowpack zone between 300 and 800m elevation.

Altered timing and magnitude spring peak flows in hybrid rain and snow dominated watersheds: As snow decreases and rain increases in winter, hybrid rain and snow dominated watersheds may shift to a rain-dominated regime with more frequent winter peak flows. Coastal watersheds with hybrid regimes often have 4-5m deep snowpacks above 1000m. Deep snowpacks can store a large amount of rain, dampening wateshed response to large midwinter rain events. If these snowpacks no longer form or are very shallow, and as winds and temperature increase, large midwinter snowfall events will become large rain or melt events, thereby increasing frequency of peak/flooding flows through the winter. With less snow, spring freshet will also be smaller and earlier, and summer low flows be lower and longer. Groundwater storage will also be decreased.

Appendix F References

Klassen, H. and K. Hopkins (2016). *Adapting natural resource management to climate change in the West and South Coast Regions: Considerations for practitioners and Government staff.* https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nrs-climate-change/regional-extension-notes/coasten160222.pdf

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APPENDIX G: WATERSHED HYDROLOGY - INSIGHTS FROM FREQUENCY PAIRED MODELLING APPROACHES

A watershed's hydrological regime dynamically emerges from the complex non-linear interplay between its biophysical components and the pattern of water flow across its landscape over time. Climate change and forest harvesting have complex and compounding impacts on watershed hydrology and aquatic ecosystems. In the last 15 years, probabilistic frequency pairing approaches comparing the effect of forest harvesting on stream flows have shown that the flood regimes of BC's forested watersheds are much more sensitive to clear cut logging than previously thought[55] (e.g. Alila et al. 2009, Green & Alila 2012, Johnson & Alila 2023, Yu & Alila 2019). UBC research has shown that harvesting can increase frequency of floods of all sizes (including extreme floods), with as little as 20% of watershed harvesting causing 20, 50 and 100 year flood events to become 4 to 10 times more frequent (Johnson & Alila 2023). This work suggests that previous estimates of the harvesting and disturbance effects on high flows, low flows, landslides, water quality, etc. have been underestimated.

Forest harvesting affects the probability of flood events via the following drivers. Firstly, at the stand level, it decreases evapotranspiration and interception of precipitation. This increases the frequency and magnitude of floods of all sizes by increasing a*ntecedent* soil moisture levels (soil moisture levels *prior* to a rain event)[56], and therefore the probability of a given storm producing large amounts of surface run-off (Alila et al. 2008, Green & Alila 2012, Johnson & Alila 2023). This is particularly relevant in rain-dominated watersheds. In snow-dominated watersheds, heterogeneous forest cover, such as that of forests with older structural stages, results in a heterogeneous snowpack, because some stands receive more direct solar radiation than others. This spreads snowmelt out over a longer time period (Perry et al. 2016, citing others; Johnson & Alila 2023). Forest harvesting reduces snowpack heterogeneity, leading to greater snowmelt synchrony (the snowpack melting all at once) and higher peak/flooding flows, with increases up to 50% reported in the literature (Johnson & Alila 2023; Perry et al. 2016, citing others). Forestry-related road networks also increase the risk of flood events by intercepting and channelling run-off from rain and meltwater into the stream network, therefore increasing drainage routing and efficiency within affected watersheds (Johnson & Alila 2023; Bathurst et al. 2020). These effects will be compounded by climate change as it increases the frequency and magnitude of storms and rain-on-snow events on BC's south coast. Forest harvesting in Pacific Northwest watersheds has also been shown to exacerbate summer low flows in the long term (while increasing low flows in the short term), with recent long-term studies indicating that streamflows in plantation forests do not return to original levels seen under mature/old growth forest cover, *even when riparian buffers are in place* (Perry & Jones 2017, Segura et al. 2020).

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[55] Forest cover was often thought to have little effect on larger floods (Bathurst et al. 2020), and from the 1990s (when forest harvesting was generally limited to 25% of a watershed) equivalent clearcut areas (ECAs) in BC have commonly increased to 40% or more.

[56] Antecedent moisture content (AMC) refers to moisture levels in the soil prior to a weather event – more surface run-off will occur if soils are already saturated prior to a storm event. Higher storm frequency increases the likelihood of storms occurring when AMC is already high due to previous storm events, therefore increasing the probability of flooding stream flows.

The degree to which forest harvesting and climate change will impact streams flows in a given watershed is further affected by a complex interplay of individual watershed characteristics, such size, shape, aspect, slope, vegetation composition, storage (wetlands, lakes, reservoirs, etc.), susceptibility to rain-on-snow events, and drainage density (density of the road and stream network) (Johnson & Alila 2023). These characteristics should also be considered (with assistance of a qualified hydrologist and ideally as part of a frequency paired modeling exercise) when deciding on how much harvesting should be permitted in a watershed, and where cutblocks vs. retention/reserve areas should be distributed. This is particularly so for watersheds with important salmon fisheries and fish habitat.

Appendix G References

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APPENDIX H: RELEVANT POLICY ARENAS & TOOLS

The following is a draft list of some of the key policy arenas and tools that affect biodiversity and climate resilience in the study area, and where the pilot mapping layers could be used to support decision-making.

Local Government

- Planning
- Regional Growth Strategies
- Urban Containment Boundaries
- OCPs/zoning
- Density bonuses/transfers
- Information requests
- Environmentally Sensitive Area mapping
- Urban Forest Plans
- Climate change strategies and carbon accounting
- Biodiversity Strategies
- Green Infrastructure Networks/Corridors
- EDPAs
- Wildfire Assessments/Plans
- Integrated stormwater plans
- Flood control planning
- Foreshore Planning
- Site level assessments
- Environmental assessments
- Development permit conditions/guidelines (e.g. updated and more detailed Develop with Care Guidelines, with NBS climate mitigation and adaptation objectives integrated with biodiversity objectives)
- Checklists for QEPs
- Land Acquisition
- Parks
- Drinking water watersheds
- Ecosystem/Resource Management
- Forest Stewardship Plans (where they have community forests)
- Community forest management
- Drinking water watersheds
- Parks management/restoration
- Stormwater management
- Wildfire risk management
- Water supply and demand management
- Carbon projects
- Estuary management
- Invasive species control
- Referrals/Consultation
- Development applications on crown land
- Environmental impact assessments

- Forestry plans on crown and PMFL?
- Old Growth Strategic Review
- Education & Outreach

First Nations

- Planning
- Indigenous Protected and Conserved Areas (IPCA)
- Community plans
- Stormwater and flood control plans
- Integrated watershed plans
- Wildfire assessment/plans
- Cumulative impacts on traditional territories and Aboriginal rights
- Foreshore planning
- Site level assessments
- Environmental assessments
- Development permit conditions/guidelines
- Checklists for QEPs
- Land Acquisition
- Treaty lands
- Treaty parks
- Land trust partnership acquisitions
- Ecosystem/Resource Management
- Forest stewardship planning
- Community forest management
- Drinking water watersheds
- Carbon projects
- Treaty/reserve lands management/restoration
- Stormwater management
- Wildfire risk management/Fire Smart guidelines
- Water supply and demand management
- Estuary management
- Fisheries/shellfish management
- Invasive species control
- Referrals/Consultation
- Development applications (local government, crown land)
- Environmental impact assessments
- Forestry plans on crown
- Old Growth Strategic Review
- Education & Outreach

Land Trusts & NGOS

- Land Securement
- Private land acquisition
- Conservation covenants
- Ecosystem/Resource Management
- Restoration projects

- Carbon projects
- Wildfire risk management
- Habitat enhancement
- Invasive species control
- Consultation/input
- Referrals/input for development applications (local government, crown land)
- Environmental Impact assessments
- Forestry plans on crown and PMFL?
- Old Growth Strategic Review
- Education & Outreach

Provincial & Federal Governments

- Land use Planning
- Modernized land use planning
- Section 17s
- Carbon offset protocols
- Conservation tax incentives
- Cumulative effects
- Old Growth Strategic Review implementation
- Species and ecosystems at risk
- Migratory Bird Areas
- Forest Stewardship Plans
- Fisheries Sensitive Watersheds
- Species at Risk Critical Habitat
- Site level assessments
- Permitting (e.g. under Water Sustainability Act)
- Referrals for development projects
- Crown Land Tenure
- Parks, Eco reserves, National Wildlife Areas, marine parks
- Land Use Orders
- Old Growth Management Areas, Wildlife Habitat Areas, Ungulate Winter Range
- Ecosystem/Resource Management
- Forest Stewardship
- Forest Fire Smart Plans
- Wildfire risk management
- Water supply and demand management?
- Carbon projects?
- Referrals/Consultation
- Development applications on crown land
- Environmental Impact Assessments
- Forestry plans on crown and PMFL?
- Education & Outreach