Action 4 Adaptation – South-west Coast

Spatial Data and Mapping

Interview Results (R2): Summary Report

Compiled by Kelly Chapman
March 2023

This project was undertaken with the financial support of:
Ce projet a été réalisé avec l'appui financier de :

Environment and Climate Change Canada
Environnement et Changement climatique Canada

Executive Summary

The Coastal Douglas-fir Conservation Partnership (CDFCP) secured funding in 2022 from the federal governments Nature Smart Climate Solutions Fund (NSCSF) to develop a regional framework of policies, decision-support tools and incentives for the protection and restoration of nature-based solutions to climate change and biodiversity protection that could be implemented by local government (Regional Districts and Municipalities) and First Nations in south-west British Columbia (BC).

In spring 2022, the CDFCP partnered with UBC Botanical Gardens for the delivery of this project as the Gardens have secured funding to undertake Climate Adaptation Planning and to produce a Biodiversity Atlas. It was identified that many of our collective objectives aligned and that we could deliver more for the natural environment working in partnership. The two projects are now aligned into the *Action 4 Adaptation* South-west Coast project (www.Action4Adatation.ca).

The first phase of the project was to undertake interviews with local government and First Nations representatives (end users) and technical specialists to understand where there are gaps and opportunities in the resources currently available to local governments, First Nations and ENGOS in relation to:

- climate change mitigation (carbon storage and sequestration),
- climate change adaptation (watershed and wildfire resilience),
- biodiversity conservation,
- culturally important ecosystems (i.e. habitats that support plants and animals important to indigenous communities).

An initial round (R1) of interviews was undertaken between December and March 2022, to scope gaps and limitations in biodiversity-related mapping/spatial data available to decision-makers in BC's Georgia Basin lowlands (the CDFCP study area). This was followed up with a second round (R2) of more focused interviews, targeting key subject matter experts (x19)**.** These included specialists in the areas of: remote sensing, ecosystem mapping, species and ecosystems at risk, climate shifts, modelling, and data aggregation.

This report summarizes the key issues, opportunities and suggestions highlighted by the R2 interviewees in relation to spatial data and mapping for the project study area. The raw interview results are compiled in **Appendix A**.

During the course of their interviews, interviewees also had many useful comments about policy, conservation planning, communications and outreach. These responses are compiled in a separate document titled *Action 4 Adaptation - South-west coast: Policy, Planning and Outreach Interview Results (R2) – Summary Report.*

The interviewee responses in this report helped inform the *Biodiversity Mapping in South-west BC: Solutions Workshop*[1] held in October 2022 at UBC Botanical Gardens, and will be used in conjunction with the workshop results to help design the next phases of the *Action 4 Adaptation* South-west Coast project.

Please note *the comments compiled and summarised in this report are the thoughts and opinions of interviewees. These may not reflect the thoughts and opinions of the CDFCP, UBC Botanical Gardens, or any other particular agencies, organisations or sectors.*

[1] https://www.cdfcp.ca/biodiversity-mapping-in-south-west-bc-solutions-workshop/

Table 1 Summary of issues and opportunities identified by interviewees.

Topic Area	Issues and Opportunities
General Mapping / Data Considerations	• National and international mapping is not suitable at a regional or local level. • Mapping tools need to make sense to the end user and need to be regularly updated. • LiDAR is of high quality and resolution, but collection of LiDAR needs to be consistent (quality and timing) and publicly available. • Satellite imagery can be a good alternative to LiDAR as it is collected regularly and some of the image libraries now extend back 50 years. However, high resolution imagery is expensive. • Online mapping tools make data accessible for local governments. However, the number of tools can mean that data is difficult to locate.
Land Cover Mapping	• LiDAR improves the accuracy of land cover classification, but coverage of LiDAR is not uniform. • Artificial Intelligence (AI) should be trained locally to classify land cover and paired with ground data to improve accuracy. • Use free satellite imagery to track change in land cover. • LiDAR and satellite imagery can be used to derive tree canopy cover, height at 1-2 m resolution. • Seasonality (leaf on or off) can impact on land cover classification and also change analysis.
Ecosystem Mapping	• There is the need for a better understanding of the resources currently available, and that ecosystem maps are typically a flagging tool that needs further investigation. • Sensitive ecosystem mapping needs to include buffers to ensure the integrity of the ecosystem. • The Biogeoclimatic Ecosystem Classification (BEC) considers climate, which means future ecosystems can be predicted. • The Provincial Terrestrial Ecosystem Information (TEI) Section is working on a method to update the age and structural stage of attributes in terrestrial mapping. • Ecosystem mapping / data will always be a patchwork of ages and quality. The user just needs to take that into consideration. • Predictive Ecosystem Mapping (PEM) may enable wall-to-wall ecosystem mapping to be generated, but it will not be as accurate as Terrestrial Ecosystem Mapping (TEM).
Species and Ecosystems at Risk (SEAR) Mapping	• Mapping of species and ecosystems at risk is difficult due to; limited records of species at risk; lack of consensus as to when an ecosystem is of a condition to be at risk; lack of access; culturally sensitive; bias in mapping e.g. birds vs invertebrates. • Garry oak ecosystems are difficult to map due to their small size, lack of access, application of the classification system and their transitional nature. • The Conservation Data Centre (CDC) element occurrence mapping is verified and therefore accurate, but does not provide wall-to-wall coverage. • There is no guidance for Qualified Environmental Professionals (QEPs) detailing when an ecosystem would be considered at risk (e.g. quality, extent, connectivity etc.) • Could iNaturalist software be modified to be used by the CDC and local governments to capture species and ecosytems at risk data submitted by consultants.

Topic Area	Issues and Opportunities
Climate Data and Modelling	• Modelling of how BEC zones will shift with climate change is completed at a 1 km resolution. This model would need to be run at a 200m resolution to understand how the CDF will be impacted and the location of climate refugia.
Corridors and Connectivity Analysis	• The approach to ecosystem connectivity mapping changes in response to scale. At a regional level the focus may be on structural connectivity and at a municipal level the focus may be on species groups. • Have clear objectives / parameters when undertaking ecosystem connectivity. Models reliant on species records can be compromised by limited data. • We need to build resilience into our corridor analysis as catastrophic events such as wildfire may increase with climate change. • Regional districts and municipalities need to work together to undertake connectivity mapping to overcome jurisdictional boundary concerns.
Cultural Ecosystem Mapping	• Removal of all human management from the land may lead to the loss of species as indigenous stewardship has been part of the landscape for thousands of years. • First Nations need the resources and the rights to implement traditional management of the land. • First Nations are actively working with the Province and eNGOS to undertaken ecological mapping.
Carbon Mapping	• LiDAR is the best technology for mapping above ground biomass, but it is expensive to collect. Therefore, map biomass accurately once and then track change using satellite imagery.
Watershed Resilience Mapping	• Wetland and riparian mapping could be used to develop a layer highlighting hydrologically sensitive areas.
Wildfire Resilience Modelling	• Transition Salt Spring Maxwell Creek project is developing methodologies for mapping fuel loads and fire risk using LiDAR and field surveys.
Marine and Coastal Ecosystems Mapping	• The Strait of Georgia (SoG) Data Centre has compiled marine ecosystem data and maps from many sources into an online data portal, with some datasets extending onto land.

Table of Contents

Introduction

1.1 Background

The Coastal Douglas-fir Conservation Partnership (CDFCP) secured funding in 2022 from the federal governments Nature Smart Climate Solutions Fund (NSCSF) to develop a regional framework of policies, decision-support tools and incentives for the protection and restoration of nature-based solutions to climate change and biodiversity loss that could be implemented by local government (Regional Districts and Municipalities) and First Nations in south-west BC (**Figure 1**).

In spring 2022 the CDFCP partnered with UBC Botanical Gardens for the delivery of this project as the Gardens have secured funding to undertake Climate Adaptation Planning and to produce a Biodiversity Atlas. It was identified that many of our collective objectives aligned and that we could deliver more for the natural environment working in partnership. The two projects are now aligned into the *Action 4 Adaptation* South-west coast project (www.Action4Adaptation.ca).

The intent is to develop the framework through a collaborative process to ensure that the resources produced are of value to the end users and to maximise the efforts of multiple organisations working within the same area (climate change resilience). The project phases are illustrated in **Figure 2.**

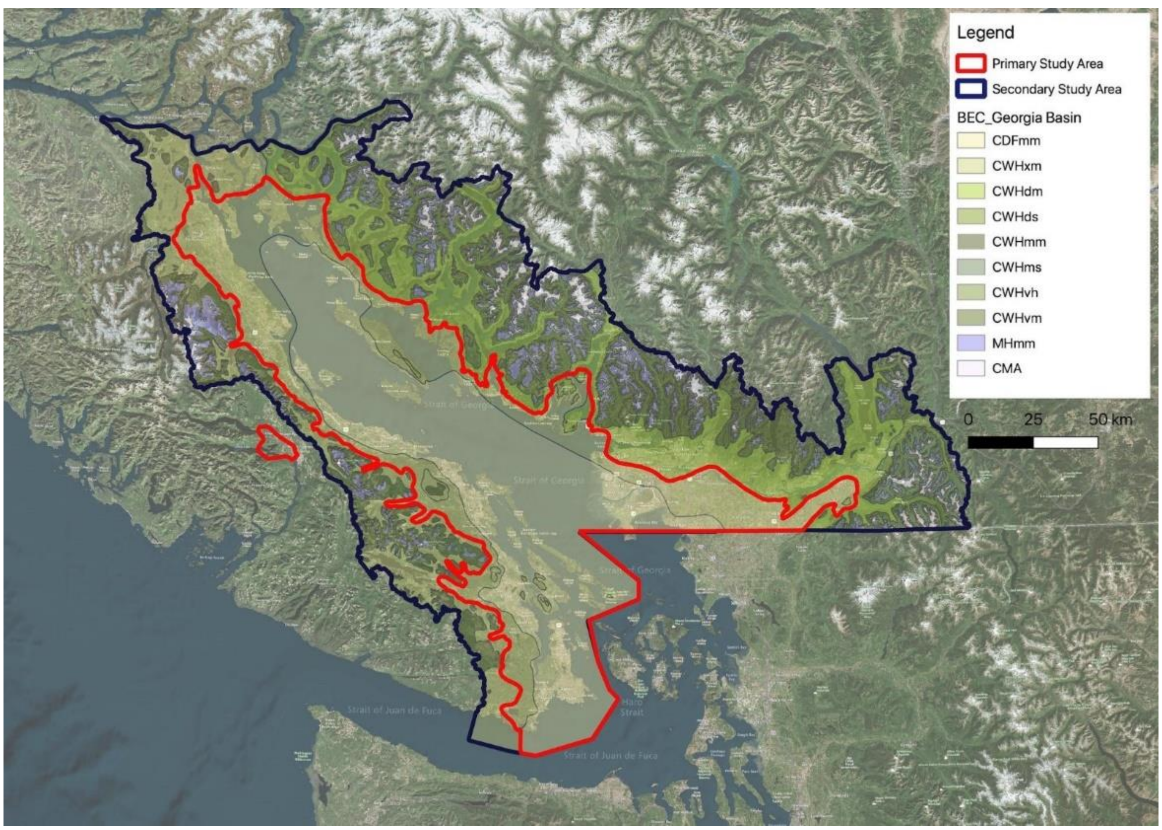

Figure 1. Primary study area outlined in red (Georgia Basin's dry lowlands – CDF and associated ecosystems), and secondary study area outlined in blue (lowlands and adjacent uplands combined).

The first phase of the project was to undertake interviews to understand where there are gaps and opportunities in the resources currently available to local governments, First Nations and ENGOS in relation to:

- climate change mitigation (carbon storage and sequestration),
- climate change adaptation (watershed and wildfire resilience),
- biodiversity conservation,
- culturally important ecosystems (i.e. habitats that support plants and animals important to indigenous communities).

The interview results have been grouped either by end users or in relation to specific topic areas:

- Policy, Tools and Incentives - Local Government Perspective
- Policy, Tools and Incentives - First Nations Perspective
- Spatial data review (Biodiversity Mapping)
- Carbon and other Incentives

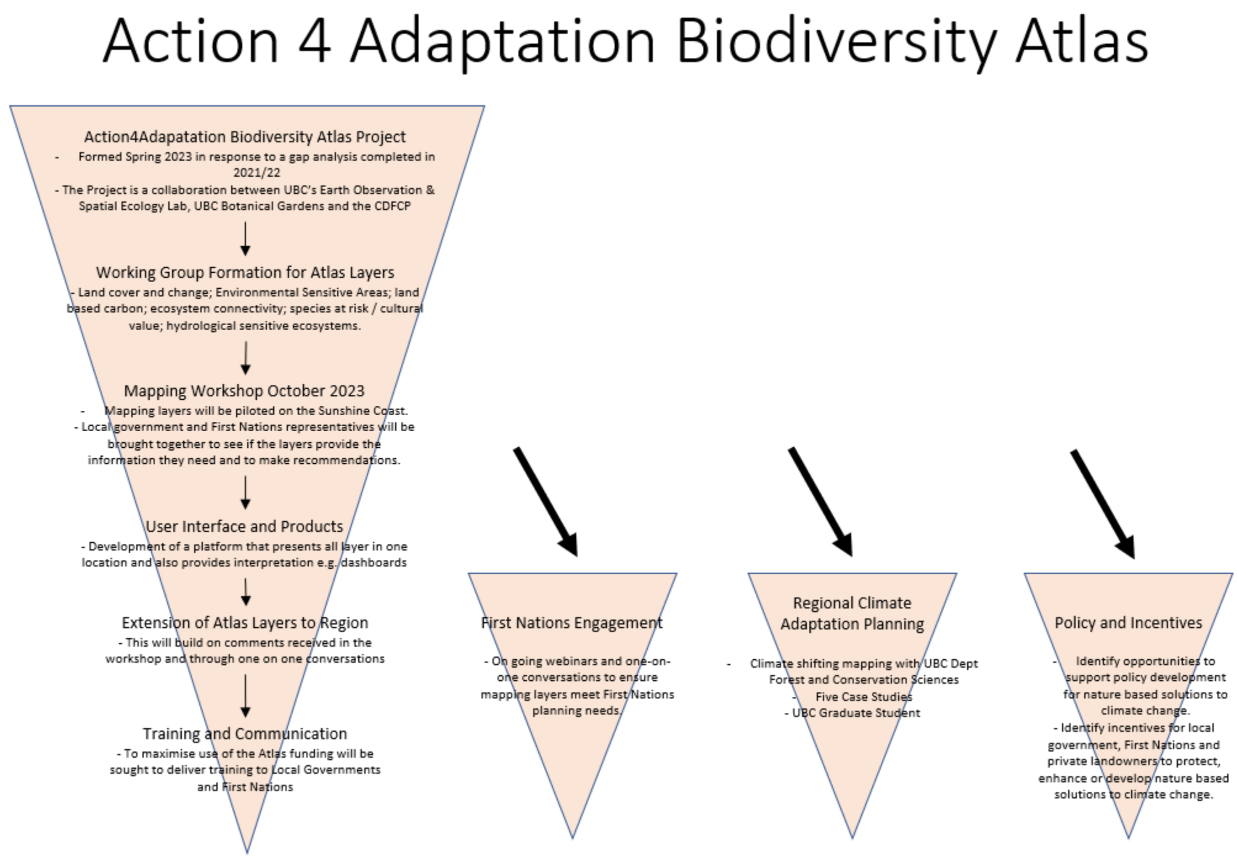

Figure 2: Project process, steps and outputs – FY23 - 25

1.2 Purpose of this Report

The interviews in this report build on an initial round (R1) of in-depth interviews undertaken with a set of representative stakeholders, between December and March 2022[2]. The purpose of these interviews was to begin identifying:

- Gaps and limitations in biodiversity and ecosystem-related mapping/spatial data for the CDFCP study area (the CDFmm[3] and CWHxm[4] biogeoclimatic subzones), for the purpose of land-use decision-making by local governments, Firsts Nations, land trusts and environmental non-governmental organisations (ENGOs).

- Opportunities for pooling knowledge and resources to innovate, improve, and update data and mapping products that currently exist, and to integrate them with nature-based carbon mitigation and adaptation objectives.

Between July and September 2022, these initial interviews were followed up with a second round (R2) of more focused interviews targeting key subject matter experts (x19). These included specialists in the areas of remote sensing; ecosystem mapping; species and ecosystems at risk; climate shifts; modelling; and data aggregation.

This report summarizes the key issues, opportunities and suggestions highlighted by the R2 interviewees in relation to spatial data and mapping for the project study area (**Figure 1**). This information helped inform the *Biodiversity Mapping in South-west BC: Solutions Workshop*[5] held in October 2022 at UBC Botanical Gardens, and will be used in conjunction with the workshop results to help design the next phases of the project, as per **Figure 2.**

The report is broken down into the following topic areas;

- General mapping and data considerations (relevant to multiple topic areas)
- Land cover and change mapping
- Ecosystem mapping
- Species and ecosystems at risk mapping
- Climate data and modelling
- Corridors and connectivity analysis
- Cultural ecosystems
- Carbon mapping
- Watershed resilience mapping
- Wildfire resilience mapping
- Marine and coastal ecosystems mapping

For each topic area the gaps and limitations highlighted by the interviewees are summarized, together with relevant suggestions and opportunities that could start the process of addressing gaps.

Appendix A of this report contains the compiled interviews, themed and sorted in their raw format.

Appendix B contains a table of potentially useful spatial data layers suggested during both the round 1 and 2 interviews (updated from the table in the October 2022 workshop report), and their relevance to different ecosystem service categories.

---

[2] *A Regional Framework for Nature-based Solutions on BC's Southwest Coast: Spatial Data Review -Compiled Interview Results – Round 1* (June 2022) *DRAFT*
[3] CDFmm Coastal Douglas-fir Moist Maritime Biogeoclimatic Zone.
[4] CWHxm1 – Coastal Western Hemlock Eastern Very Dry Maritime.
[5] https://www.cdfcp.ca/biodiversity-mapping-in-south-west-bc-solutions-workshop/

Appendix C contains a summary table of preliminary recommendations and proposed layers for the Biodiversity Atlas (for discussion purposes).

This report 'Spatial Data and Mapping Interview Results (R2)' is one of a series of reports summarizing the results of interviews carried out for the first phase of this project:

- Spatial Data and Mapping Interview Results (R1)
- Incentives – Carbon
- Policy, Tools and Incentives: Issues and Opportunities – Local Government Perspective
- Policy, Tools and Incentives: Issues and Opportunities – First Nations Perspective

***Please note** the comments compiled and summarised in this report are the thoughts and opinions of interviewees. These may not reflect the thoughts and opinions of the CDFCP, UBC Botanical Gardens, or any other particular agencies, organisations or sectors.*

Summarized Interview Results

1 General Mapping/Data Considerations

1.1 Spatial data: scale, storage and software

- Regional scale is difficult to work with.
- National and international mapping tools are aspirational, but not suitable for regional/local scale.
- Too many portals: piggyback off of existing portals, partner with more mature groups.
- A good tool and website that makes sense to users is needed, but beyond capacity of local governments.
- Geo BC is the appropriate data host but is slow to update and distribute data.
- Sharing and storing data is a barrier, and BC Data Services may not be ideal.
- Some regional districts could host and store data, but most lack the capacity.
- Find a permanent host with the Federal government or a university.
- Need to find a balance between proprietary and open source Geographical Information System (GIS) software.
- Engines such as Feature Manipulation Engine (FME) can be incorporated into maps and save time.

1.2 LiDAR (general)

- There is no uniform LiDAR data set for the Georgia Basin - the data sets have been acquired at different times by different companies, with different point densities and coverages.
- LiDAR exceeds all other data types in terms of quality and resolution, and should be used as a benchmark, despite issues with having to use a patchwork of data sets over such a large area.
- Companies will not give you their LiDAR, but may enter agreements allowing you to use it to derive and distribute layers.
- Contract someone to develop a map of LiDAR holdings in the study area, and a table of who owns it and the data type and age - then begin negotiating user agreements with the owners.
- LiDAR data in the primary study area will primarily be held by local and provincial governments, NGOs and a bit of forestry – maybe 15 groups.
- Getting LiDAR for secondary study area will be harder; it's a much bigger area but there will be fewer owners, such as Western Forest Products, the Province and First Nations.
- There won't be much LiDAR coverage for alpine areas where there is permanent snow cover.
- There is a huge amount of information in LiDAR point cloud data, but it requires work to analyse.
- LiDAR BC has used 2019 data to produce digital elevation models (DEMs), and digital surface models (DSMs) for the lower mainland, but no tree canopy models.
- Geo BC manages all provincial LiDAR data sets and the BC LiDAR portal, but the portal isn't regularly updated, so recent acquisitions might be missing.
- Environment Canada Open Maps has LiDAR derived high resolution (1m) digital elevation models (DEMs), digital surface models (DSMs), and digital terrain models (DTMs) for most of the primary study area.

- The industry standard of 12 points per square metre will provide good information about terrain and canopy.
- To ensure regional accuracy of derived layers, good ground plot data is needed to train LIDAR and imagery - a variety of sources are available.
- There may not be a lot of plot data in the CDF, because most of the land is private.
- Push for repeat LiDAR, ideally every 5 years.

1.3 Satellite Imagery (general)

- Landsat is much lower resolution (~30m) than LiDAR, but its free, with eight day temporal resolution and continuous imaging going back about 50 years.
- The volume of data generated by LiDAR can be hard to analyze; commercial satellites offering very high-resolution imagery can serve as an 'in between' option.
- Paid commercial satellite imagery, such as Planet Scope and Sky Sat, can provide high resolution imagery from 3.5m to under 1m, but they are expensive.
- Sentinel is currently producing the highest resolution free satellite imagery; Sentinel 2 has 10m spatial resolution and 5-10 day temporal resolution.
- Some commercial satellite companies provide funding and assistance to communities and First Nations using imagery to solve big issues like climate change adaptation.
- Sentinel 3 collects ground temperature and moisture data, with applications for hydrology, flood and drought forecasting, wildfire probability, monitoring wetland and riparian areas and predicting water/heat stress on ecosystems.

1.4 Data portals and visualization tools

- Visually presenting data is useful for local government and lets them know what tools and data exist.
- Online mapping tools and portals are making data more accessible – important areas are highlighted where mapping layers overlap.
- There are already many portals – find a niche and don't replicate efforts of others.
- If you build a new portal, make sure it communicates with the others.
- Promote and track portal use.

1.5 Finding and accessing spatial data

- There are datasets everywhere, hosted by different government and non-government organizations – its difficult to know what's available and where to find it.
- There is a need to provide up to date information on what spatial information is available and where it can be found.
- Develop with Care guidance document has a list of mapping sources in Appendix D of that document, but something broken down by relevant data types with links would be preferable.

1.6 Miscellaneous

- More data is useful, but how much more do we really need given the climate crisis?
- Clip data to each local government boundary, and provide helpful metadata and explanations for using mapping tools
- Local governments often don't publish their spatial data and biodiversity information–they should be advised that it should be public
- Add caveats to spatial data, indicating it's a tool for flagging potentially important areas, but shouldn't be relied on as a complete data set
- Publishing paper maps in local government offices can draw awareness to ecological values

2 Land Cover Mapping

2.1 Using remote sensing and Artificial Intelligence (AI) to generate land cover

- Available pretrained land cover products/classifications might be too generalized – accuracy would require local training and ground data.
- Metro Vancouver's land cover modelling program uses a combination of LiDAR and high resolution spatial imagery, and ten land cover classes.
- The lack of uniform LiDAR coverage for the region creates issues for land cover mapping, but they are outweighed by its benefit over satellite imagery, which is poor at describing land cover classes.
- LiDAR provides the highest resolution data, and is the best starting point for a land cover layer, especially when matched with ground samples.
- With LiDAR and ground plot data, a reasonable pixel size for a land cover layer is 5-10m; less than 5m is problematic because you end up with classes for individual trees.
- The smallest pixel size you'll get for land cover depends on how much you pay: 10m pixels with free imagery, and 3-5m pixels with paid imagery.
- Experts can use Google Earth Engine and Planetary Computer to extract needed information at 10, 20 or 30m, but local governments lack expertise to use these technologies.
- The University of Victoria's Mountain Legacy Project is using AI and machine learning to develop land use classifications.
- Also see **Section 1.2**

2.2 Land cover classification systems

- Cross walking and rolling up different land cover classification systems across the region presents many challenges and issues.

2.3 Tracking land cover change

- LiDAR is very costly – use it to develop a base land cover layer, then track land cover change using satellite imagery.
- Sentinel or Landsat time series at pixel size of 10, 20 or 30m have the best spectral characteristics for tracking land cover change.
- With good ground sampling, updating land cover change layers could be largely automated.
- To track forest change, use ground samples going backward or forward three years from the date of LiDAR acquisition.
- With training and consistent classification, manually updating land cover can be cost effective if covering a small area or using students.
- Using planning permit data from local governments (instead of remote sensing) to track development wouldn't work because many land use changes in regional districts don't require permits.

2.4 Remote sensing tree canopy cover

- LiDAR and satellite imagery can be used to derive tree canopy cover and height – at 1-2 m resolution it can pick out individual trees and timber quality and track forest condition.
- LiDAR BC has released digital elevation and surface models, but not canopy height models, which can be derived by subtracting the two.
- To pick up vegetation differences, free satellite imagery can't have less than 20 m pixels.
- With LiDAR and ground plot data, the smallest pixel size for a map layer showing vegetation structure and canopy height would likely be 10-20 m.

- Stitching together LiDAR and imagery from different years makes it difficult to track tree canopy change.
- Measuring individual tree loss in urban environments would require very high-resolution satellite imagery (15-30 cm).
- Also see **Section 1.3.**

2.5 Leaf cover issues

- Seasonality of leaf cover makes deriving canopy from LIDAR and aerial imagery challenging; standards and consistency in data collection timing is needed
- Collecting imagery during leaf fall can result in inaccurate land cover change estimates – more human interpretation may be required

3 Ecosystem Mapping

3.1 Data consistency, accuracy, scale and data storage

- Mapping consistency, accuracy and application isn't great - refined ecosystem mapping is important, given how much of the Coastal Douglas-fir (CDF) is at risk.
- The Province's Terrestrial Ecosystem Information (TEI) Section should house ecosystem mapping data –better outreach and data exchange with local government is needed.
- Ecosystem maps are flagging tools and will never be 100% accurate even at 1:1000 scale; site level verification and delineation by a QEP is always necessary.
- Lower resolution ecosystem mapping is still a useful tool for flagging areas that should be field verified for sensitive features.
- The implications of working at different scales need to be carefully considered – important ecological variations can be lost by scaling up.

3.2 Mapping buffers

- To be effective, mapping of sensitive ecosystems needs to include buffers – buffers should be mandatory.

3.3 Mapping undeveloped areas

- Map all remaining undeveloped habitat and show what biodiversity values these areas have - we need to overcome the notion that degraded areas aren't worthy habitats.

3.4 Biogeoclimatic Ecosystem Classification (BEC) system

- Both Terrestrial Ecosystem Mapping (TEM) and Predictive Ecosystem Mapping (PEM) use the Biogeoclimatic Ecosystem Classification (BEC)system[6] to identify ecosystems.
- BC has very knowledgeable ecosystem classification experts.
- Climate is built into the BEC system, so when the climate changes BEC can be adapted and future ecosystem trends predicted.
- The updated coastal BEC classifications will be published around March 2023, meaning the CDF TEM coding will be out-dated (e.g. the updated system will include specific Garry Oak units), and the subzone/variant boundaries will shift. Crosswalks between old and new system will be provided

[6] See: https://www.for.gov.bc.ca/hre/becweb/

3.5 Updating ecosystem mapping (interpretive methods)

- Documentation is lacking on when and how ecosystem mapping is updated.
- Updating ecosystem mapping in the CDF is difficult because most of the land is private and can't be ground-truthed.
- Change can't be tracked by updating ecosystem mapping because the change is smaller than the inbuilt error of interpretive mapping.
- The TEI is working on a standardized method to update age and structural stage attributes in ecosystem mapping.
- Develop an updated version of Sensitive Ecosystem Inventory SEI from existing TEM as an interim solution while TEM is being updated.
- Remotely sensed land cover change could augment the TEI structural stage modelling.
- Caution and manual checking is needed when updating older mapping products.
- It is better to update (or create) TEM mapping than to update stand alone SEI products.
- The Province has produced a 2021 disturbance layer for cumulative effects, which could be used to help identify converted ecosystems.
- In areas with high development pressures ideally track ecosystem loss with minimum six month updates.
- Updating the age of SEI polygons isn't that important, as long as its noted that the mapping is 20 years old and some polygons might now be old or mature forest.

3.6 Terrestrial and sensitive ecosystem mapping (TEM and SEI)

- Seamless, consistent TEM coverage is needed for the region – it can be themed to create SEI, wildlife habitat maps, and other useful layers.
- TEM is a patchwork of mapping from different dates.
- Gulf Islands National Park has higher resolution (1:5,000 and 1:10,000) TEM mapping, which includes in-depth Garry Oak mapping, and disturbance and fuels.
- Publicly posted ecosystem data from the TEI group is only current as of 2016; there is a lag time in uploading new ecosystem maps.
- TEM can be themed using higher-level classifications such as floodplain, wetlands, forest, etc.
- Sensitive ecosystems are classified at the site series level, but aren't usefully mapped beyond a strategic scale.
- SEI mapping is biased toward habitat for species at risk - it doesn't prioritize ecosystems that are important to First Nations or people on the land.
- People are largely unaware the TEI group can be contacted directly to get more recent data – the CDFCP website should link to the TEI website and other Provincial mapping sources.
- Help improve awareness of the Provincial TEI group, the kinds of data they can provide, and how TEM can be interpreted.
- Local governments need to be educated about the different ways TEM can be used.
- Most communities and local government staff don't have the capacity to interpret TEM – ecosystem mapping needs to be very straightforward and easy to use.

3.7 Forest Productivity Mapping

- The Province generates site productivity layers, identifying areas that support big trees.

3.8 Mapping small ecosystems

- Point feature mapping can be used to identify elements that aren't picked up in the ecosystem mapping polygons (e.g. Garry Oak patches, vernal pools and other small wetlands).
- 1:20,000 TEM with composite polygons and ecosystem deciles is not very useful for local level planning, especially in relation to smaller features such as wetlands and small forest patches.

- It may not be necessary to know what *kind* of Garry Oak or wetland ecosystem it is to take appropriate conservation action.

3.9 Wetlands and Riparian Mapping

- The National wetland inventory does a good job of showing where wetlands are, but less so for identifying what kind of wetland at a local scale.
- The CWS and Nature Trust of BC have developed province-wide topographical riparian area and wetland maps.
- The Williston Wetland Explorer[7] tool is a good user-friendly example of how wetland data can be viewed.

3.10 Predictive Ecosystem Mapping (PEM)

- Historically, PEM hasn't done a great job mapping non-forested BEC site series and uncommon ecosystems; TEM has been better.
- A Provincial PEM pilot project is underway, using climate, land cover and remote sensing data, with the aim of improved wall-to-wall provincial mapping and better identification of non-forested and rare ecosystems.
- LIDAR is a key input for the PEM pilot: it picks up detailed topography and aspect and can help predict small ecosystem features, such as wetlands and rock outcrops.
- By using a high resolution 5mx5m Digital Elevation Model (DEM) grid, the PEM pilot is aiming to capture small ecosystems like Garry Oak, but it may never be as good as TEM.
- If you want forest age and structure information, TEM is better than PEM, which currently isn't focused on forest structure.
- PEM might replace TEM provincially, but it hasn't worked so well on the coast where it is still in the research phase and TEM remains the favoured product.
- PEM might not entirely replace TEM on the coast, but it could be used to help update TEM and fill gaps.
- TEM and PEM have different applications - a document and table should be produced outlining their source data with recommendations on how each should be applied.
- Its unknown whether PEM will be able to improve or replace methods for mapping SEI.
- The PEM pilot is looking for ways of using machine learning to improve and automate ecosystem prediction, and to make mapping updates easier.
- The new PEM mapping will be transparent, with accuracy statistics and open source scripting, so others can use and improve on it.

3.11 Using remote sensing to update/improve ecosystem mapping

- Remote sensing can only be part of ecosystem mapping – it must be augmented with ground plots and interpretation by ecologists.
- Ecosystem mapping is very expensive and time consuming to update and cannot effectively be done using automated methods.
- Remote sensing is useful for mapping and tracking land cover change - use it as an alternative/interim to updating or redoing ecosystem mapping, by overlaying ecosystem mapping with a land cover change layer.
- LiDAR could be used to help update forest structural stage and age.
- LiDAR can be used to identify vegetation corridors, structure, complexity, age, disturbance and fuel.
- LiDAR can be used to identify where 'big trees' are.
- LiDAR is useful for measuring dominant overstorey structure, not so much for shrubs, herbs and understorey.

[7] https://governmentofbc.maps.arcgis.com/apps/MapSeries/index.html?appid=5a59fc13b9064cf7b19398f29ceaac9e

3.12 Terrain, soils and karst

- Terrain and bio-terrain data is the foundation of TEM, and can be used to delineate alluvial fans and riparian areas, and help with carbon mapping.
- A coarse potential Karst layer is available from the Province.
- Soil and agricultural capability mapping for much of the study area is available on the Province's Soil Information Finder Tool[8].

3.13 Ecosystem mapping decision trees, guidance and best practices

- Decision trees and best practices for ecosystem mapping would help standardize ecosystem mapping and its application, and help local governments with less resources.
- Clear provincial guidance on identifying and delineating wetlands is needed for local governments, QEPs and Provincial staff.
- Look at the strategic plan for mapping done for Kootenay Boundary Regions, for flow charts and tools.
- QEP checklists and best practices for mapping and site level assessments would be useful.
- Some local governments have developed their own environmental checklists for QEPs; e.g. Port Moody's sustainability checklist.

4 Species and Ecosystems at Risk (SEAR) Mapping

4.1 SEAR mapping constraints and suggestions (general)

- Providing local governments with an easy to use tool showing where species and ecosystems at risk are, and consequences of developing them, would be very useful.
- Provide local governments with guidance on where resources are for identifying SEAR locations.
- Many red-listed ecosystems are not mapped – need to change the perception that it's not red listed if it's not mapped.
- QEP environmental reports vary widely in terms of quality and detail, and what features they identify as sensitive or at-risk.
- There is a lack of consensus on what at risk ecosystems and habitats should be mapped in terms of quality and connectivity.
- Mapping SEAR on private land is almost impossible, because most owners don't want it mapped.
- First Nations communities usually don't want to share locations of their valued ecosystems at risk.
- Wildlife habitat can be difficult to define – all undeveloped land is potential habitat and should be considered for protection.
- There is a mapping bias that underrepresents invertebrates, nonvascular plants, bryophytes, lichens and fungi.

4.2 Garry oak systems

- There are many Garry oak ecosystem datasets, but they are difficult to find and you have to know people to get them.
- Garry oak ecosystems are very difficult to accurately map without field verification.
- Garry oak is now a fragmented ecosystem scattered across the landscape, making it difficult to map.
- For the CWHxm1, Garry oak polygons are embedded in the TEM and as a stand alone product; this hasn't been done yet for the CDFmm.

[8] https://www2.gov.bc.ca/gov/content/environment/air-land-water/land/soil/soil-information-finder

- A Garry oak potential layer could be derived from the TEM, to flag areas that need site level assessments for Garry oak elements
- There is an established Garry oak classification system, but its difficult for non-experts to use.
- Consensus is lacking around when a Garry oak site becomes too degraded to be classified as needing protection (vs. restoration).
- There is a need to differentiate between Garry oak trees and Garry oak ecosystems – using a tree's name to label these savannah ecosystems can be a problem.
- The long-term integrity of Gary oak / savannah ecosystems is reliant on human stewardship.
- Bird models can potentially be used to predict where Garry oak / Savannah systems are.

4.3 Mapping restoration sites

- Nancy Shackleford's lab has created a Garry oak restoration map.
- Madrone mapped CDF restoration and recruitment sites in the 2000s; many of these areas are probably gone now.
- A remotely sensed summer vs. winter leaf index could be used as a measure of conifer encroachment on Garry Oak systems, and help identify areas for restoration work.

4.4 Conservation Data Centre (CDC) Element Occurrence Mapping

- The CDC's element occurrence mapping is verified, and precisely and accurately shows where SEAR are known to occur – this should be communicated.
- TEM is used by the CDC to help identify Garry Oak element occurrences, but verification is still required.
- The CDC's element occurrence mapping has a major bias against SEAR that have been poorly surveyed, and sites that are difficult to access (e.g. private land, remote areas).
- The CDC uses TEM mapping to help identify potential locations of ecosystems at risk – there isn't wall-to-wall element occurrence mapping because the CWHxm1 wasn't mapped until recently.
- Now that TEM has been completed for the CWHxm1, a layer identifying potential ecosystems at risk could be developed for the area – it hasn't been done because of lack of funding and delays in publishing the TEM.
- Element occurrence mapping isn't lagging too far behind for CDF ecosystems, but should probably be updated as many have likely since been altered.
- The condition/quality of an ecosystem determines whether or not it will meet the threshold for a CDC element occurrence.
- A more direct link between TEM/BEC site series at ecosystems at risk would reduce confusion; there's not always a one-to-one relationship.
- Cross-walking the new BEC ecosystem classification system with TEM and ecological communities at risk is complicated.

4.5 Guidance on condition, structural stage and at risk status

- Floodplain, wetland, grassland, and Garry oak ecosystems are clearly sensitive and should be protected, regardless of structural stage or condition.
- Its not always clear what constitutes an ecosystem at risk, especially for forested ecosystems and degraded Gary oak systems – clearer criteria are needed.
- Many QEPS automatically assume a forest is not at risk if has ever been logged or if its under 250 years old. Clear guidance and mapping is needed showing what forests are considered at risk.
- The Great Bear Rainforest Order criteria for at risk forests criteria for could be modified for use in the study area – e.g. all sufficiently established 80+ year old stands and all floodplain forests of any age/establishment.
- Assemble a working group with the Province to develop and publish clear guidance as to what constitutes sensitive/at risk ecosystems in the study area.

4.6 Species at risk range and habitat mapping

- The Province has started developing range maps and habitat models for species at risk, to help mitigate sampling bias in the element occurrences database and flag areas where at risk species can potentially be found.
- The Province is working on a provincial standard for species habitat modelling - presently there are no consistent guidelines or access to existing models.
- Whereas species range maps are accurate they are not precise, as they do not identify habitat preferences of the species within that range.
- Habitat models can more precisely identify suitable habitat within a species range, but their accuracy depends on the quality of data used to build them – this data is often lacking or biased.
- Species habitat suitability/capability models would be helpful if done at a scale useful to decision-makers.
- Many species habitat models are "garbage" because of poor and biased data and inventory – need to be very transparent on the limitations of these models.
- Despite poor data, there is a need to start somewhere with species habitat modelling, and to document data gaps and needs.

4.7 Climate effects on species and ecosystems at risk

- Human land use decisions will determine the future of SEAR more than climate change, because degraded and fragmented ecosystems are less resilient.
- Europe has well developed tools that project species' future ranges, to help with conservation and restoration decisions.
- BC's 'Flying BEC Zone' work is being used to predict changes in BEC zones and variants (also see **Section 5.1**).
- Humans have a role to play in managing climate refugia for certain ecosystem types and preserving genetic material.

4.8 SEAR data collection, storage and sharing

- Trend data for SEAR and biodiversity is lacking, because its expensive to collect and baseline data is lacking.
- Methodologies for doing surveys and inventories are forestry based and not always applicable to urban and rural landscapes so everyone is doing it differently; a standardized system is needed.
- Useful data collected by QEPs is largely unavailable – it mostly stays in the consultants' hands or consultants' reports.
- There should be a centralized data storage system where QEP's are required to upload their data, as part of local governments' development permit systems.
- People should be encouraged and shown how to submit SEAR observations to the CDC, to add to its inventory.
- The CDC lacks the capacity to efficiently receive and process large amounts of SEAR data from local governments and the public.
- There are barriers to accessing CDC data that didn't exist in the past – a training program is required for a data request.
- The data systems that feed into the BC Species and Ecosystems Explorer need to be examined.
- The capacity of iNaturalist to efficiently upload rare species' occurrences dwarfs that of the government; however iNaturalist lacks the vetting and verification of observations.
- iNaturalist[9], QEP data and other inputs could be used to help fill the gaps in CDC SEAR element occurrence data, as long as quality standards are maintained.
- The Wildlife Tree Stewardship Initiative (WiTS)[10] crowd sources eagle nest data; iNaturalist is easier to upload observations to, but it doesn't allow you to report on the activity status of the nest.

[9] See: https://www.inaturalist.org

- BC Report-a-Weed [11]a good example of an app for crowdsourcing public observations.

4.9 Biodiversity Galiano

- Biodiversity Galiano[12] consolidates biodiversity data by aggregating historical data and using iNaturalist to crowd source new observations; it then uses visual tools to present the data.
- Project objectives include: extending the project to other communities, developing predictive ecosystem models, and developing a community curated atlas (with protocols).

4.10 Key Biodiversity Areas(KBAs)

- The Key Biodiversity Areas[13](KBAs) project is identifying sites critical to the conservation of biodiversity at the national scale.
- KBAs focus on federally listed species at risk and endemic species, as well as important aggregations and life cycle areas for species not at risk.
- Important Bird and Biodiversity Areas[14] (IBAs) are being incorporated into the KBA process.
- KBAs don't confer any protections or management prescriptions - they flag high priority areas for protection, for consideration by other groups and organizations.

5 Climate Data and Modelling

5.1 Climate and ecosystem shifting

- The Climate BC Map Tool generates maps showing how BEC zones are predicted to shift with climate change, at a 1km resolution.
- The Province's new Future Ecosystem Forecast Centre should also look at how BEC zones shift, and may include better resolution climate data.
- For our study area, the Climate BC model should be run with resolution of around 200m to make it more accurate – extra support and resources would be required.
- The Climate BC model shows the CDF will shift to a novel climate, and become a new BEC zone with no current BC analog.
- Will McKenzie is finalizing a project to develop extended BEC zones that go into the USA and Alberta – this will improve the Climate BC projections for the CDF.
- Although models show cedar persisting in many areas, their prognosis is not good on sites with shallow soils and steep slopes, and on the east side of Vancouver Island, where climate suitability for cedar is declining dramatically
- Old growth should be retained in areas where the climate suitability for cedar is projected to shift, because we don't know if we'll get regeneration in these areas.
- Projected climate shifts can help decide what trees to plant in an area, but shouldn't be used to decide what areas should or shouldn't be protected – protection should be spread across BEC units as they are now.

[10] See: https://bcnature.org/wildlife-tree-stewardship-initiative
[11] See: https://www.reportaweedbc.ca
[12] See: https://bdj.pensoft.net/article/76050/ and https://biogaliano.org
[13] See: https://kbacanada.org/about/
[14] See: https://www.ibacanada.com

5.2 Climate Refugia

- Local topography and geomorphology form enduring features that often host special/sensitive ecosystems, and can support cooler, wetter microclimates; these can serve as climate refugia for biodiversity.
- With higher resolution data, Climate BC could be used to identify these potential climate refuge areas, and where CDF species are likely to remain (25m elevation data, and 100-200m climate data resolution would be sufficient).
- High resolution layers comparing current and future climate suitability for cedar could be valuable for looking at information about microclimate conditions.

5.3 Other

- Climate BC data are monthly; providing daily or hourly data needed for wildfire modelling is outside their scope.
- Climate BC is lacking information about protected areas (especially private holdings) in the CDF – providing that data for them would be helpful.

6 Corridors and Connectivity Analysis

6.1 Ecological connectivity analysis and inputs

- At a regional level focus on structural connectivity – connecting large forest stands with wide linkages; at a municipal level define linkages using suitable habitat for species groups.
- Its important to map landscape connectivity at a relatable scale and show how fragmented most are.
- Connectivity methodologies will vary by local government, depending on available data and mapping, their existing natural assets, and their emphasis on enhancing existing connectivity vs. creating new corridors.
- You need to think about what you are trying to connect – no single corridor model applied across a local government area will solve all your problems.
- LiDAR/remote sensing can be used to more accurately map remaining relatively intact forest/ ecosystems and their boundaries, and to help identify corridors; ground truthing is still needed.
- The resolution of ecosystem mapping available to most local governments (e.g. 1:20,000 TEM or SEI) isn't sufficiently detailed for connectivity analysis at the local level – 1:500 or 1:1,000 or better is preferred.
- Least-cost analysis can be used, with detailed ecosystem/vegetation mapping and projected development patterns, to determine the most connected parts of a landscape.
- Mapping biodiversity hotspots highlights where there is connectivity and older features
- Nancy Shackleton's research showed that the best success indicator for restoring Garry Oak ecosystems is connectivity.
- Municipal connectivity analysis can incorporate backyard connectivity that includes trees and gardens on private property, to increase connectivity for pollinators and songbirds, etc.
- Connectivity models can work like spatial prioritization models – how well they work depends on the quality of data inputs
- Other human values, such as equitable park access can also be inputs.

6.2 Wildlife habitat connectivity

- Habitat connectivity is different from ecosystem connectivity, but the terms are often used interchangeably.
- LiDAR can help with mapping habitat corridors in forested ecosystems, but raises the question of for what species?.

- Using proxy species to map habitat connectivity will be difficult to scale up regionally and to other municipalities.
- Habitat connectivity methodologies and output quality will depend on how many species you look at, the quality and detail of information on their habitat requirements, and the quality of the available spatial data.
- If there are too many species inputs the modelling it won't make sense - stick to a simple approach with fewer inputs and clear assumptions.
- The quality of the model outputs depends on how many species you look at, the quality and detail of information on their habitat requirements, and the quality of the available spatial data.
- Cole Burton's Wildlife Coexistence Lab could help with determining wildlife habitat requirements.
- Each species has different habitat requirements, so trying create one definition for habitat corridors doesn't work well – better to provide good information to users and let them decide.
- People's expectations of habitat connectivity modelling are too high - professional judgement is often just as good or better.
- Parks aren't necessarily the best hubs for connectivity networks – they may not have good habitat for species of concern, and have different levels of protection and allowed activities.

6.3 Climate change considerations

- Climate BC could contribute to the corridor analysis by identifying cooler microclimates as potential refugia, and showing how tree species and suitable ecosystem conditions are predicted to shift.
- With increasing catastrophic events such as wildfire, redundancy needs to be built into the corridor analysis, to ensure multiple representative populations are protected.

6.4 Local government scale and boundary crossing

- Doing a corridor/connectivity analysis at a regional scale is appropriate, but regional districts have very little control over land use – most of these decisions are at the municipal level.
- Municipalities typically make decisions in their own best interests, so its extremely difficult to get them to agree to cross-boundary corridors.
- Municipalities won't extend their connectivity analyses across their borders –regional initiatives work well in these situations.
- Regional district staff don't feel they have the authority to undertake regional connectivity analyses without clear direction from municipalities.

6.5 Local government applications

- Local governments have used connectivity analyses to inform: new environmental policy, protections, and procedures; development permit areas; prioritizing and funding land acquisitions; enhancing existing corridors; and density bonusing.
- Protections for corridors focused on water courses are easier to implement because of Provincial legislative protections for water and riparian areas.
- Implementing corridor protections for upland natural areas on private land is more difficult, because there are fewer options for restricting development.
- There are complaints that the development permit process tied to Surrey's Green Infrastructure Network is too expensive and onerous for small single family lots – there isn't a streamlining process for these situations.

6.6 Nature Conservancy of Canada (NCC) prioritization tool

- The NCC prioritization tool uses a country-wide national data set, which is currently under review; it's the first attempt at national connectivity data set.
- The national data set used by the NCC tool lacks the necessary local level data for analysing connectivity for CDF species.

- The Where We Work component of the NCC tool allows users to add local data to the national data, so results can be fine tuned to the local and regional scales.

6.7 Other Projects

- Corridor/connectivity work from other areas, such as Montreal, can serve as examples.
- Diamond head has developed a connectivity analysis methodology using LiDAR, ecosystem mapping and wildlife habitat models.
- The City of Surrey developed a Green Infrastructure Network as part of their Biodiversity Strategy, using high resolution habitat mapping and Least Cost Path Analysis.
- A connectivity analysis was done for the Southern Gulf Island, with Nicholas Coops.

7 Cultural Ecosystems Mapping

7.1 Integrating knowledge collection with stewardship

- With proper resources there is an opportunity integrate the process of collecting knowledge about at risk ecosystems with active First Nations stewardship of, as part of an adaptive management cycle.
- First Nations need not only the financial resources to do stewardship, but also the right to do so on private lands.

7.2 Culturally maintained at risk ecosystems

- There is a problem with the assumption that ecosystems unaffected by humans are in good condition, when many at risk ecosystems depend on active maintenance by indigenous stewards.

7.3 Crowd sourced data

- iNaturalist plant observations appear to have good correspondence with culturally significant sites.

7.4 Culturally significant ecosystem projects

- The Terrestrial Ecosystem Inventory (TEI) unit has a research project with Sechelt Nation looking at whether TEM and LiDAR can be used to predict occurrence of culturally significant plants.
- The Ministry of Forests worked with Sechelt on a simpler modelling approach combining expert opinion with TEM – it could be a 'quick and dirty' way of flagging where culturally significant plants are likely to occur.
- The CDC is working with Syilx Nation to identify culturally sensitive ecosystems, and is looking for resources to initiate more projects.
- IMERSS is working with White Swan Environmental on a pilot eco-cultural mapping project on Galiano Island; they're looking to expand their mapping across the Salish Sea.
- There are a number of researchers working directly with First Nations - Pamela Spalding at UVic is doing some good work with T'Sou-ke Nation.

8 Carbon Mapping

8.1 General considerations

- Maps showing high carbon storage/sequestration areas would be a useful planning tool for local government and others.

- The Province hasn't done any formal carbon storage mapping, and referrals staff don't look at impacts on carbon storage when assessing development applications.

8.2 Mapping forest carbon with LiDAR

- Also see **Section 1.2.**
- LiDAR is by far the best technology for predicting above ground carbon/biomass – it will provide much more accurate estimates (70-80%) than VRI or satellite and aerial imagery.
- LiDAR won't give you species and its difficult to process, but these are minor issues compared to value of biomass mapping it will provide.
- The methodology for biomass mapping with LIDAR is commonly understood, but it requires ground plot data, ideally 200-300 plots; Provincial plots across the area could be used.
- The pixel size of the carbon/biomass map should be the same as the ground plot size, so likely a 20x20m grid over the entire area.
- With LiDAR and ground plot data, the smallest pixel size for an above ground biomass layer would likely be 10-20 m.
- Areas with no biomass (e.g. water, urban, non-vegetated etc.) would have to be 'burned through' the map, using LiDAR to identify areas with no height, or a land cover layer.
- Reach out to the Ministry of Forests Forest Carbon Branch – they are looking to do a LiDAR based carbon inventory somewhere.

8.3 Tracking change in forest carbon

- We can't afford to track biomass change by using LiDAR to remap it every few years – its too expensive and time consuming to do across the study area.
- Invest once in accurately mapping biomass across the study area using LiDAR, then track change by mapping the things that influence it (e.g. land cover and disturbance) using other methods.

8.4 Canadian Forest Service carbon mapping

- Canadian Forest Service carbon mapping does not use LiDAR and is for National scale reporting, so the product is poor at local scales.

9 Watershed Resilience Mapping

9.1 Watercourses

- LIDAR is very helpful for refining topography, drainage and detailed watercourse mapping.

9.2 Hydrologically sensitive areas

- TEM, terrain and soil mapping can help identify features associated with water retention, to help develop a layer highlighting hydrologically sensitive areas.
- Available wetland and riparian mapping (See **Section 3.9**) could be used to help develop a layer highlighting hydrologically sensitive areas.
- A missing piece in the Old Growth Strategic review was identification of old forests on hydrologically sensitive areas, as priorities for deferrals, retention and recruitment.
- A hydrologically sensitive index or ranking for SEI categories would be too generalized –better to identify features at a watershed level so people can recognize them on their properties.

- Islands Trust has mapped groundwater recharge potential[15], based on precipitation, land/vegetation cover, soil, geology, slope, faults, etc..
- High and low rankings can be given to deep and shallow aquifer recharge areas, but a low ranking doesn't mean a recharge area is unimportant.
- The model used for Tara Martin Lab's Salt Spring Island pilot asks questions about big trees, which probably captures moist, high water table areas.

9.3 Water Quality

- Mapping that shows the impact of development and human activity on water quality is a gap - it would help people understand how they impact streams.

9.4 Hydrological/stream flow modelling

- Different types of consultants use very different hydrological models - forest cover and other local considerations are frequently omitted.
- Hydrological models need to account for how climate change will change stream flows – we will see higher peak flows, and lower base flows.

10 Wildfire Resilience Mapping

10.1 Wildfire risk and resilience

- Identify fire risk zones, but include guidance on reducing fire risk without impacting ecosystems.
- LiDAR can be used for mapping wildfire fuel structure and density, but its not incredibly accurate.
- LiDAR derived digital elevation models can provide accurate information about wetter and drier parts of the landscape, which can factor into fire risk.
- Riparian areas need to be identified as important fire breaks – it doesn't have to be bare earth.
- Native vegetation with high structural complexity and high soil moisture reduces fire risk –wildfire resilience is linked to biodiversity.
- Historical and projected climate data can be used to calculate fire hazard and how its going to change.

10.2 Burn severity mapping

- The Province does annual burn severity mapping.

10.3 Transition Salt Spring Maxwell Creek Project

- The Maxwell Creek project is developing methodologies for mapping fuel loads and fire risk using LIDAR and field surveys, and identifying priority areas for reducing fuel loads, restoring hydrology and optimizing biodiversity.
- The project results will be used to develop a toolkit of methodologies that can be applied elsewhere, starting with remote sensing and identifying hotspots.
- The mapping layers will be used develop and demonstrate restoration prescriptions that reduce fire risk while optimizing biodiversity.

[15] https://islandstrust.bc.ca/document/islands-trust-groundwater-recharge-mapping-potential-project-report-ver-2021/

11 Marine and Coastal Ecosystems Mapping

11.1 Strait of Georgia Data Centre and Marine Reference Guide

- The Strait of Georgia (SoG) Data Centre has compiled marine ecosystem data and maps from many sources into an online data portal, with some datasets extending onto land.
- The Strait of Georgia Marine Reference Guide takes all the data from the portal and puts them on one centralized map, allowing visualization and comparison of 400+ data sets.
- SoG Data Centre includes a map of 300+ NGOs working on aquatic initiatives in BC.
- There are opportunities to collaborate and share spatial data with SoG Data Centre, especially where relationships between marine, aquatic and terrestrial ecosystems are clear.
- The project offers collaboration and outreach to First Nations but applies no pressure for their data.
- The Resilient Coasts for Salmon program is coordinating community mapping of Vancouver Island's east coast, to determine extent of shoreline armouring, for compilation in the SoG Marine Reference Guide.
- Key targets for shoreline armouring mapping are local government councillors and planners, and shoreline landowners.

11.2 Citizen Science

- Citizen science can be used to collect quality marine data and fill data gaps if a detailed methodology is applied.

11.3 Átl'ḵa7tsem/Howe Sound Marine Stewardship Initiative

- Engage Átl'ḵa7tsem/Howe Sound Marine Stewardship Initiative – they are also focused on building a refined list of layers tailored specifically for First Nations and local government.

12 Additional Related Initiatives

- Stolo and Squamish Connect are referral systems First Nations have created to understand how projects affect the attributes in their mapping layers – its project tracking and management are integrated with data.
- Monica Pearson is working on a Provincial spatial tool that collates natural resource and conservation information to assist with internal reviews of project applications – there is also a public version
- A number of local governments have developed sophisticated mapping of biodiversity, natural assets, etc.
- The Nature Conservancy of Canada and WWF do complicated spatial analysis at the national level – it would be good to connect them with local level applications.

Recommendations

Collaboration:

For the purposes of developing the proposed *Action 4 Adaptation* Biodiversity Atlas, establish a working relationship with the Provincial Terrestrial Ecosystems Inventory (TEI) team, and set up a working group, or series of working groups to provide support and peer review for assembling a set of themed layers for the study area, as tentatively outlined in **Appendix C** for discussion purposes. Key organizations to involve in this process include:

- BC Terrestrial Ecosystems Inventory (TEI) team
- BC Predictive Ecosystems Mapping (PEM) team
- BC Community Mapping Network (CMN)
- Canadian Wildlife Service (Kathleen Moore)
- BC Conservation Data Centre (CDC)
- Climate BC (Tongli Wang, UBC)
- IMERSS (Andrew Simon)

General Considerations:

For the purposes of assembling spatial layers in a South-west Coast Biodiversity Atlas, general considerations include:

1. Aim for wall-to-wall mapping for study area, where possible.
2. Where possible, make mapping relevant for local government and First Nations applications, by updating it and improving its resolution, using remote sensing, modelling, and automated processing /machine learning.
3. Assemble layers in an easily viewed and user-friendly interface/portal, which is intuitive, uncomplicated, and allows layers to be stacked 'heat map' style.
4. Accompany spatial layers with:
    a) Clear 'upfront' indication (and metadata) of data scale, vintage, accuracy and original data source.
    b) Clear explanations of the data's: meaning, relevance to biodiversity and climate resilience on the south-west coast, limitations, and planning applications.
5. Make layers available for easy and intuitive download in both ArcGIS and QGIS formats, pre-themed with extraneous data columns removed.
6. Clip spatial layers to regional district boundaries, for convenient download.

7. Look for a university or similar institution to be a permanent host for the data/portal, and ensure capacity for regular and timely updates by project team.

Proposed mapping themes

The following mapping themes should be considered for inclusion in the proposed Biodiversity Atlas. The *italicized* themes are recommended as priorities for development or enhancement by the project, pending further discussion with the working groups proposed above. See **Appendix C** for more detailed preliminary recommendations and potential data sources.

1. **Land cover**
   - *a) Land cover and land cover change*
   - b) Disturbance
2. **Ecosystems**
   - *a) Tree canopy cover and height*
   - *b) Environmentally Sensitive Areas with buffers (updated to capture mature, old and at risk forest ecosystems, and to reflect converted ecosystems)*
   - *c) Climate shifts*
     - *i. Future BEC subzones/variants*
     - *ii. Future climate refugia*
   - d) Terrestrial Ecosystem Mapping/ Predictive Ecosystem Mapping
   - e) TEM sensitive point features, with buffers
   - f) Forest productivity
3. **Species and ecosystems at risk**
   - *a) Verified occurrences of species and ecosystems at risk, with buffers*
     - *i. CDC Element Occurrences*
     - *ii. Observations from QEP reports*
   - *b) Potential ecosystems at risk (including forests @ risk)*
   - b) Crowd-sourced observations (e.g. iNaturalist, Biodiversity Galiano)
   - c) Species at risk range maps
   - d) Species at risk potential habitat (future)
   - e) Key biodiversity areas, with buffers

4. Corridors and Connectivity
    a) *Regional structural connectivity – an integration of:*
        i. *Forest/vegetation cover fragmentation/contiguity*
        ii. *Biodiversity hotspots/priority areas*
        iii. *Conservation lands*
        iv. *Ecosystems shifts*
        v. *Climate refugia*
5. Cultural Ecosystems (TBD)
6. Carbon Mapping
    a) *Above ground biomass/carbon storage*
    b) Below ground biomass/carbon storage
7. Watershed Resilience
    a) *High resolution topography and drainage*
    b) *Hydrologically sensitive/ hydroriparian features*
        i. *Wetlands and riparian areas*
        ii. *Floodplains*
        iii. *Karst features*
        iv. *Unstable soils/steep slopes (landslide risk)*
        v. *Alluvial sediments*
2. Wildfire Resilience
    a) Wildfire risk
    b) Fuels

Decision Trees and Best Practices

Work with the TEI team, Canadian Wildlife Service (CWS) and the CDC to develop (where lacking) and compile decision-trees, best practice guidance, and checklists for mapping, for QEPs, First Nations and local governments doing their own site/local level mapping. Consider the following (extracted from interview results summarized above):

- Decision trees and best practices for ecosystem mapping would help standardize ecosystem mapping and its application, and help local governments with less resources.

- Clear provincial guidance on identifying and delineating wetlands is needed for local governments, QEPs and Provincial staff.
- Look at strategic plan for mapping done for Kootenay Boundary Regions for flow charts and tools
- QEP checklists and best practices for mapping and site level assessments would be useful.
- Some local governments have developed their own environmental checklists for QEPs; e.g. Port Moody's sustainability checklist.
- Its not always clear what constitutes an ecosystem at risk, especially for forested ecosystems and degraded Gary oak systems – clearer criteria are needed.
- Many QEPS automatically assume a forest is not at risk if has ever been logged or if its under 250yo: clear guidance and mapping is needed showing what forests are considered at risk.
- Assemble a working group with the Province to develop and publish clear guidance as to what constitutes sensitive/at risk ecosystems in the study area.
- Identify fire risk zones, but include guidance on reducing fire risk without impacting ecosystems.
- The Maxwell Creek project is developing methodologies for mapping fuel loads and fire risk using LIDAR and field surveys, and identifying priority areas for reducing fuel loads, restoring hydrology and optimizing biodiversity; the project results will be used to develop a toolkit of methodologies that can be applied elsewhere, starting with remote sensing and identifying hotspots.

APPENDIX A: Compiled Interviews Results

Note: Provided only on request

APPENDIX B: Data Layer Types and Sources

APPENDIX C: Proposed Biodiversity Atlas layers

APPENDIX C

Preliminary Recommendations and Proposed Biodiversity Atlas Layers

(Areas highlighted in red = high priority for project)

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who
Land cover	Land cover	Natural vs disturbed/ converted areas Broad vegetation/ecosystem type Agriculture Urban/built up areas Roads	• Derive high resolution layer from LIDAR, satellite imagery and ground plots	BC Lidar portal Individual Lidar holders Sentinel Satellite CWS BC Landcover Frankenmap CEF Human Disturbance data set Road Atlas (BC Government) TEM BC Road Atlas	• Available products too generalized • 10m pixels? (free satellite imagery) • Contract someone to assemble map and table of LIDAR holdings for study area: owner, vintage, type, and coverage of each holding • Begin negotiations with holders to use their data	
	Land cover change	Ecosystem conversion	• Derive from satellite imagery/AI • Regularly updated •	BC Lidar Portal Sentinel Satellite	• 10m pixels? (free satellite imagery) • Update yearly if automated, every 5 years of manual interpretation required • Use to update land cover and other layers, by 'burning out' converted areas	
	Disturbance	Disturbance types	• Use existing CEF mapping & BC Road Atlas	CEF Human Disturbance data set BC Road Atlas	• Updated yearly	
Tree cover	Tree Canopy	Extent of tree cover Connectivity	• Derive high resolution layer from LIDAR, satellite imagery and ground plots (tree canopy model)	BC Lidar Portal Sentinel Satellite	• Track changes for report card	Consult with TEI & PEM teams
	Tree height	Forest structure Big trees	• Derive high resolution layer from LIDAR, satellite imagery and ground plots	BC Lidar Portal Sentinel Satellite	• Use to help update age/structure classes of ecosystem mapping (e.g SEI, TEM) • Use to identify big tree forest stands (OGSR identifies them as being at risk of near-term & irreversible biodiversity loss) – very high priority for retention	Consult with TEI & PEM teams
	Forest Integrity/intactness	Forest condition Connectivity	• Derive high resolution layer from LIDAR, satellite imagery and ground plots	BC Lidar Portal Sentinel Satellite	•	Consult with TEI & PEM teams
Ecosystems	Sensitive Ecosystems / Environmentally Sensitive Areas	At risk or ecologically fragile ecosystems	• Use tree canopy layer, VRI, modeling, etc. to update structural stage & capture forest which is now mature & old (i.e. established forests) • Burn out converted/developed	TEM PEM Terrain mapping Provincial SEI mapping VRI (for areas not covered by TEM or PEM)	• Establish working group/advisory panel • Work with TEI and PEM teams to: support and resource updates and improved coverage, resolution and accuracy of PEM and TEM in area, and 2) while waiting for above, help develop an interim improved SEI layer for the Atlas using other methods (LIDAR	TEI team PEM team OGSR Technical Advisory Panel Madrone/Tania Trip

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who

			ecosystems using high res land cover layer, to improve accuracy
			• Improve resolution with PEM, LIDAR, imagery, etc., preferably 1:5,000 for primary study area
			• Use TNT-CWS topographic riparian and wetland mapping to capture areas not covered by TEM – use LIDAR DEM to improve accuracy
			• Consider adding categories, including:
			  • Big tree old growth
			  • Hydro-riparian forests[i]: All forests on floodplains & active fluvial units/fans
			  • Ancient forest (300+yo)
			  • Old forest variants meeting OGSR review deferral criteria for being at imminent risk: e.g CDF, CWHxm & dm, and Variant-Landscape Unit combos with less than 10% old remaining
			  • Young forest (see MVSEI)
			• Add buffers around all features
				Old Growth Technical Advisory Panel deferral areas mapping
				Tree height/canopy cover (lidar derived)
				TNT-CWS topographic riparian mapping (province wide)
				TNT-CWS topographic wetland mapping (province wide)
				CWS wetland mapping
				CWS estuary mapping
					derived layers, TNT mapping, VRI etc)
					• Use land cover change layer to regularly update SEI layer by burning out converted ecosystems (ideally annually??)
					• Update forest structural stage/age every 10 years?
					• Maybe should be called ESA (Environmentally Sensitive Area) mapping instead of SEI, if categories and methods are used that are inconsistent with SEI methodology– need to weigh up with the 'name recognition' of SEI, and Provincial endorsement	

	Small point features	Sensitive features, too small to be picked up by TEM and SEI	• Consider including:
			  • Garry oak patches
			  • Vernal pools, groundwater seeps
			  • Small wetlands
			  • Karst features?
			  • Bear dens
			  • Wildlife trees
			  • Raptor/heron nests
			  • Caves, rocky outcrops
			  • Big trees
				TEM point feature mapping
				Wild Tree & raptor nest Atlas[ii]
				Local government raptor/heron nest mapping
				GOERT & CDC point feature mapping/data
				iNaturalist & other crowd sources
				Provincial Big Tree Registry
				LIDAR tree height/canopy cover model
					• Work with TEI team & LWRS to determine what features would be appropriate given data availability and sensitivity
					• Work with Andrew Simon on assembling crowd sourced data
					• Work with Rob Knight (CMN), CDC & GOERT re their data sources and mapping
					• Tie into Province's guidance on classing and mapping small wetlands, once its completed
						TEI team
						LWRS
						Andrew Simon/IMMERS
						CDC & GOERT
						CMN – Rob Knight

	Forest productivity	High productivity sites capable of producing big trees	• Using existing VRI data	VRI – High site index areas (>20) Old Growth Technical Advisory Panel	• Old and mature forests on high site index sites (big tree old forest) are very rare in the study area,	TEI team PEM team

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who
		Forests with high carbon sequestration potential		deferral areas mapping	especially primary study area, and very high priority for retention & recruitment (OGSR identifies them as being at risk of near-term & irreversible biodiversity loss) • High index forests have high carbon sequestration rates	OGSR Technical Advisory Panel Madrone/Tania Trip
Climate Shifts	Current & Future BEC subzones/variants	Current BEC distribution Predicted future distribution of BEC subvariants	• Improve resolution of Climate BC model, to pick up BEC subvariants	Climate BC model TEM mapping	• Secure funds for Tongli Wang (UBC) so he can run Climate BC model at higher resolution for study area	Tongli Wang UBC TEI team PEM team
	Climate Refugia	Predicted locations of climate refugia	• Improve resolution of Climate BC model, to pick up topographical details (lower lying areas, etc.) • Use LIDAR Digital Elevation Models to more accurately identify refugia	Climate BC model, (including projected suitability for cedar) TEM mapping LIDAR DEM	• Set up working group with Tongli Wang and TEI and PEM teams, to determine critieria for climate refugia • High resolution Climate BC model predicting future cedar suitability could help generate micro-climate information •	Tongli Wang UBC TEI team PEM team
Species & Ecosystems @Risk	CDC element occurrences (i.e. verified SEAR occurrences)	CDC vetted SEAR occurrences	• Ensure most recent data is used •	CDC element occurrences database	• Would need regular updates	Jason Straka, CDC
	QEP SEAR observations	SEAR observations made by QEPs during environmental assessments, etc.	• Build a centralized and automated portal and map system (like iNaturalist) that registered QEPs and local governments can easily upload SEAR data to (point data and spatial files) • Automated updating	Local government reports prepared by QEPs Eco cat Ecological Reports Catalogue Crowd sourced QEP uploads	• Might be beyond current scope of this project – but a good long range aspiration for the project • Set up a team and look for funds to hire contractors to work with local governments to do this – develop a centralized database where registered local government staff and QEPs can easily upload their SEAR mapping and observations • Would need to be automatically updating with little/no vetting to be cost effective • Some form of registration would be required (RPBio status?) to upload data • Could be an ongoing project/service offered to local government by Action 4 Adaptation • Would work best if Province, local government, or CAB required that QEPs upload their data on the portal	Jason Straka, CDC Local governments Andrew Simons (IMMERS) Tania Tripp, Madrone Rob Knight (CMN)??? College of Applied Biology
	Community SEAR observations	Crowd sourced SEAR observations	• Develop from various sources • Automated updating •	iNaturalist IMMERS	• Might be beyond current scope of this project – but a good long range project to work on with Andrew Simons	Andrew Simons IMMERS Jason Straka, CDC Rob Knight (CMN)???

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who
					• Work with Andrew Simons and CDC on this – look for funding and contractor to develop a portal and criteria for registering and uploading data and shapefiles • Would need to be automatically updating with little/no vetting to be cost effective • Consider involving CMN (Rob Knight)	

	Potential Ecosystems at risk	Areas which potentially host ecosystems at risk (unverified)	• Mine the TEM to produce a flagging layer which indicates the probability of ecosystems at risk occurring	TEM
				PEM
				VRI?
					• Establish working group with TEI team CDC and LWRS to develop clear guidance on what structural features are needed for a forest ecosystem to be considered at risk, example:
					  • 80+yo well established CDF &CWHxm forests and all forests on floodplains (and fans?), regardless of age/structure
					  • all old forests (250+yo) that meet OGSR deferral criteria:
					    • Any BEC variant with less than 10% old forest remaining today. (e.g.CDFmm, CWHxm, & CWHdm)
					    • Old forest in any BEC – Landscape Unit combination that has less than 10% old forest today (picks up old CHWvm & MHmm forests if less than 10% in a LU)
					    • Ancient forests (>500 years) – not reliably predicted by VRI, groundtruthing required – higher elevation forests and forests given a projected age of 300+years by VRI have high probability of being ancient).
					    • Areas with a Site Index of >20m (i.e. productive sites able to grow large trees).
					• Direct funding to a contractor work with working group to develop layer using TEM & VRI
					• VRI site index is more accurate than Ecosystem based site index – see Price et al 2023[iii]
					• Consider folding into updated SEI or ESA map, as outlined above under Ecosystem theme, instead of having as a stand alone layer	

	Species at Risk Range Maps	Range maps for SAR, based on ecosections	• CDC is developing range maps – so far only completed for amphibians and reptiles	CDC Amphibian and reptile SAR range mapping	• Additional maps likely beyond current scope of this project - opportunistically support CDC in developing more SAR range maps, through funding, partnerships, etc.	CDC Andrew Simon??

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who
					• In absence of more detailed SAR habitat modeling/mapping (see below), could attach a summary of known habitat requirements to each SAR range map (to include in a checklist for site level assessments by QEPs etc.)	
	Species at risk potential habitat	Potential habitat for SAR	• CDC is planning to develop SAR habitat models that could be used to generate potential habitat maps		• Likely beyond current scope of this project - aspirational • SAR models unlikely to be completed within timeframe of our project, even if funding was made available • CDC is now developing Provincial habitat modeling standards and guidance (include in our best practices/guidance section for local government?) •	CDC
Carbon	Above ground biomass		• Develop with LIDAR, satellite imagery and ground plots	BC Lidar portal Sentinel satellite MOF ground plots CFS ground plots TEM ground plots	• Use land cover change layer to regularly update biomass layer by burning out converted/cleared ecosystems (ideally annually??) •	MoF Brinkman? Local goverments Climate Action Secretariat?
	Below ground biomass		• Develop, unaware of methodology	??	• Likely beyond current scope of this project - aspirational	
Watershed Resilience	Drainage & topography	High resolution drainage & topography	• Derive from LIDAR DEMs	BC Lidar portal	• Establish an advisory team to explore using LIDAR derived DEM to augment or improve accuracy of Freshwater Atlas watercourse mapping (in areas which are not flat), and TNT/CWS topographic riparian and wetland mapping • Use to help identify climate refugia (moister, cooler microclimates)	Rob Knight (CMN) TNT Kathleen Moore, CWS Rob Knight, CMN ???
	watersheds	Third order Watershed boundaries	• Consider using LIDAR derived DEM to improve accuracy?	• Freshwater Atlas- watershed boundaries • PSF Salmon Explorer • Lidar (topography) • Topography/contour mapping • CMN – Aquatic Information Partnership Atlas - Watershed statistics https://cmnmaps.ca/AIP/	• Would there be an easy way to use this layer to more accurately define watershed boundaries ? (Freshwater Atlas boundaries aren't that accurate at local scale) – Talk to Tim Ennis about this – they did for watershed mapping in Comox valley area	
	Water courses	Rivers, streams, Creeks	• Consider improving accuracy for	• LIDAR DEM	• See comments above, on Drainage &Topography	Rob Knight, CMN

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who
			areas with topography, using LIDAR derived DEM	• Freshwater Atlas • Various watershed atlases on CMN (especialy for Fraser Valley & Lower mainland)	• LIDAR DEMs not very useful for mapping watercourses in flat terrain (roads look like water channels), e.g. in Fraser Valley, Lower Mainland; CMN atlases will provide most accurate watercourse mapping, because they were mapped with boots on the ground. Talk to Rob Knight about this	???
	Hydrologically sensitive areas	*Tentative list:* Flood plains Alluvial fans Unstable terrain (landslide/sediment risk) Torrented gullies (vulnerable to landslide and sediment recruitment) Groundwater recharge and discharge areas (don't know if this is possible) Karst landscapes (groundwater storage & vulnerability?) fluvial deposits (groundwater storage & vulnerabilty?) fractured bedrock (groundwater storage & vulnerability – don't know if this is possible) Small steep headwater streams Wetlands & riparian areas	• Derive layer from attributes in TEM and Terrain mapping (e.g. floodplains, alluvial fans, fluvial deposits, unstable terrain), available terrain stability mapping and existing riparian, wetland and stream mapping • Use TNT-CWS topographic riparian and wetland mapping to capture areas not covered by TEM – use LIDAR DEM to improve accuracy •	• TEM mapping • Available terrain stability and hazard mapping • Freshwater Atlas • TNT-CWS topographic riparian mapping • TNT-CWS topographic wetland mapping • CWS wetland mapping • Karst feature mapping	• Establish working group with TEI team to work on this – develop agreed set of features deemed to be hydrologically sensitive (e.g. feature classes identified in Hydroriparian Handbook), which can be pulled out of existing spatial data sets (e.g. TEM, terrain mapping, etc.) • Fund TEI or a contractor to put together the layer • Terrain stability mapping seems limited – speak to bioterrain specialists in TEI group to see if TEM can be themed to get a layer • I would not use this to replace floodplain mapping done by province, local governments, as part of their risk management – this layer should be focused on identifying floodplain ecosystems as sensitive areas • Look at the prioritization model that was used by Tara Martin's lab on Salt Spring, which integrated groundwater and biodiversity values	TEI team Peter Arcese ??
	Salmon Spawning lines	Anadramous salmon spawning streams, by species	• Use existing mapping	PSF Salmon Explorer SHIM FISS (see CMN)	• Work with PSF on this, they have good data on salmon spawning streams • Also involve Rob Knight (CMN) – he's very knowledgeable about fish, especially in Fraser Valley/lower mainland • Refer users to other mapping portals with more detailed fish habitat mapping (i.e. CMN), especially for Fraser Valley, for which CMN has several detailed atlases	PSF Rob Knight, CMN
	All fish points	All fish observations	• Use existing layers, or refer to	Known BC Fish Observations & Fish	• Not sure how much fish stuff we should include,	

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who
			other portals •	distributions[iv] Fisheries Information Summary System (FISS)	although the scatter of observation points give you a good idea of where fish bearing streams are. Maybe work with Rob Knight on this • Refer users to other mapping portals with more detailed fish habitat mapping (i.e. CMN), especially for Fraser Valley, for which CMN has several detailed atlases	Rob Knight, CMN LWRS
	Fish passage obstructions	Obstacles to fish passage	• Use existing mapping, or refer to other portals	• Provincial obstacles to Fish Passage[iv]	• Not sure how much fish stuff we should include. Maybe work with Rob Knight on this	Rob Knight
	Fish species at risk	Observations of at risk fish species Streams and lakes that support Cut Throat Trout (blue listed species)	• Use existing mapping • refer to other portals (ie. Cut Throat Atlas on CMN)	CDC BC Species explorer South Coast Cutthroat Atlas (CMN)	• Haven't really looked into this • Not many CDC records for fish– wondering if the provincial fish observations database has more records – CDC element occurrence mapping doesn't seem to include cut throat trout observations, even though they're blue listed (maybe because they haven't been vetted to be element occurences?) Talk to Jason and Rob Knight about this • Not sure whether to add data from Cut Throat Atlas – clutters things– Maybe just refer to the Atlas on CMN?. It does appear to give you a pretty good idea of where the fishbearing streams are, however, and could be helpful when deciding how sensitive upland watersheds values are to logging.	Rob Knight CDC
Wildfire Resilience	Wildfire Risk Fuels	Fuel loading Wildfire risk	• Theme existing Provincial fire risk mapping[v] or refer users to other portals/sources • Consider improving fuels and risk mapping using Lidar derived forest structure information	• Wild and Urban Interface Fire Risk maps (strategic level; based on VRI; does not include private land) https://www2.gov.bc.ca/gov/content/safety/wildfire-status/prevention/vegetation-and-fuel-management/fire-fuel-management/wui-risk-class-maps/wui-downloads • Hazardous fuels mapping (based on VRI with groundtruthing) • Community wildfire risk mapping	• Haven't really started looking into this • Strategic level mapping is done by Province. Doing finer scale community level wildfire risk mapping is likely beyond the scope of this project • Consider assembling a team to explore if LIDAR data can be used with VRI to develop a fuels map Coordinate with Maxwell Creek and BC Wildfire Services • Coordinate with Transition Salt Spring's Maxwell Creek project on this • Maybe consider microclimate conditions (cooler moister areas, riparian areas, etc.) which help create natural fire breaks – LIDAR and Climate BC data could be potential data sources • Have a look at community Wildfire Protection plans[vi] prepared by consultants like Blackwell, to get an idea	Ruth Waldick BC Wildfire Services

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who
					of what forest attributes they look at in their risk ratings	
Marine & Coastal Ecosystems	Estuarine and Intertidal Ecosystems	Estuary & intertidal ecosystems	• Estuary & intertidal ecosystems (e.g. MVSEI) • Refer users to more detailed mapping in other portals, such as PSF, at Strait of Georgia Marine Data portal	• CWS PECP Ranked estuaries[vii] • Strait of Georgia Data Centre & Marine Reference Guide • BEC site series • TEM/ SEI in some places • Georgia Basin Habitat Atlas (lower mainland tidal habitat)[viii]	• Haven't looked into this much	Kathleen Moore, CWS Strait of Georgia (SoG) Data Centre Resilient Coasts for Salmon program PSF
Connectivity	Corridors & connectivity	Natural vegetation cover Forest integrity/fragmentation Regional corridors	*Inputs* • Forest/vegetation cover fragmentation/contiguity • Biodiversity hotspots (SEAR mapping, KBAs, etc.) • Priority areas (run Oscar Ventner's prioritization model using above layers) • Conservation lands • Future BEC subvariant distribution • Climate refugia	As identified above	•	
Climate Resilience	Risk to ecological functioning	Old forest BEC subvariant Landscape units or third order watershed boundaries	• Develop using VRI and BEC data	VRI BEC Forestry landscape units	• Assemble working group and hire contractor to develop methodology and layer • Premised on OGSR guidance that once old forest cover drops below 70% of historic, the system/watershed begins to lose ecological function & resilience, and once below 30% of historic, system is at high risk of losing function, e.g. species losses, flooding, droughts, fire, pests, etc. • Colour code each forest variant in each Landscape Unit or third order watershed using red, yellow and green stoplight rating system, based on comparison to ecosystem based risk thresholds, as per OGSR[ix] • Not sure how this would work for savannah / Gary Oak systems - maybe include it as a layer under watershed resilience theme instead, as it should address Younes Alila's concerns in terms of flooding	OGSR Technical Advisory Panel, Rachel Holt, Karen Price Younes Alila, UBC

Theme	Layer	Relevant Features	Develop or Improve?	Potential sources – see Spatial Data matrix as well	Comments	Who
					and drought risk (which is largely based on percent mature/old forest cover) – consult with Younes about this	

[i] *Hydroriparian Planning Guide* for the Central and North Coasts (Coast Information Team 2004) https://www.for.gov.bc.ca/tasb/slrp/citbc/c-hpg-final-30Mar04.pdf
[ii] Community Mapping Network Atlas Gallery: https://cmnmaps.ca
[iii] Estimating the amount of British Columbia's "big-treed" old growth: Navigating messy indicators https://www.frontiersin.org/articles/10.3389/ffgc.2022.958719/full
[iv] Provincial fish and fish habitat data layers: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/fish/fish-and-fish-habitat-data-information/search-fish-fish-habitat-data-information
[v] https://www2.gov.bc.ca/gov/content/safety/wildfire-status/prevention/vegetation-and-fuel-management/fire-fuel-management
[vi] E.g. see Table 1 in the Powell River RD Community Wildfire Protection Plan https://www.qathet.ca/wp-content/uploads/2019/12/PRRD-CWPP.pdf
[vii] https://pacificbirds.org/2021/02/an-updated-ranking-of-british-columbias-estuaries/
[viii] https://cmnmaps.ca/GBHA/
[ix] See table below:

The Old Growth Strategic Review (ORSR; Gorley & Merkel 2020) states "Conservation science provides us with a general risk rating, telling us that if we retain 70% or more of the natural abundance of forest with old trees the risk of species loss, compromised ecosystem services, and losing ecosystem resilience is low. If we retain below 30%, the risk is high. At between 30% and 70%, the risk varies by ecosystem. "

Historically, approximate expected percentages of old forest in each BEC unit would be: CDFmm 40% (Price et al. 2020), CWHxm,dm,ms 70%, CWHds 60%, CWHvm 85-90%, and MHmm 90-95% (MOE 2020)

This means that as a general rule, once old forest cover in an area/watershed drops below 70% of historic levels, ecosystem services and ecological resilience start to become compromised, and the risks of drought, flooding, water shortages, wildfire, biodiversity loss, etc. may start to increase. Once old forest cover drops below 30% of historic levels, the system is in the red zone, and risk to ecological resilience and ecosystems becomes very high. This risk will be dramatically exacerbated by climate change.

- Remaining percentages of old growth in most BEC units in the study area are far below the amounts of old growth that would be expected based on historic disturbance regimes.
- Current Provincial targets for old growth retention (which set in land use plans for each landscape unit) are well below the minimum threshold for staying out of the high risk red zone.
- At a provincial scale, the OGSR identifies CDFmm, CWHxm and CWHdm forests has having less than 10% of their original old forest cover; most landscape units are well below their old growth targets for these forest types (which are typically on the most accessible and productive (grow big trees) sites, so they've been most extensively logged.
- Outside of the CDF, generally speaking once old forest cover drops below about 50%, ecological function/resilience starts to be impacted, and once it drops below about 20%, the risk of ecological functions being compromised becomes high (species loss, floods, droughts, fires, etc.).

BEC VARIANT	***HISTORIC % OLD GROWTH COVER**** *(prior to settlement)*	***% OG cover above which there is Low Risk to ecological function (>70% of historic OG coverage)***	***% OG cover below which there is High Risk to ecological function (<30% of historic OG coverage)***	***Current Provincial Objectives for % OG Retention**** *(by Landscape Unit)*
CDF				
mm	40%	>28%	<12%	9%
CWH				
xm	70%	>49%	<21%	9%
dm	70%	>49%	<21%	9%
ds	60%	>42%	<18%	9%
ms	70%	>49%	<21%	13%
vm	85-90%	>61%	<26%	13%
MH				
mm	90-95%	>65%	<28%	19%

* Based on figures from the Provincial Cumulative Effects Framework, as cited in *Standards for Assessing the Condition of Forest Biodiversity under British Columbia's Cumulative Effects Framework* (MOE 2020). The CDF figure is sourced from *Last Stand for Biodiversity* (Price et al. 2020).
** Can be a few percentage points higher (e.g. to 13% from 9%, or 19% from 13%) if it's a 'high biodiversity emphasis' landscape unit; as per : https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/policies-guides/old_growth_order_may18th_final.pdf