CDFCP

COASTAL DOUGLAS-FIR & ASSOCIATED ECOSYSTEMS CONSERVATION PARTNERSHIP

UBC Botanical Garden

Action 4 Adaptation – South-west Coast

Spatial Data and Mapping

Appendix A: Compiled Interview Results

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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

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1 General Mapping/Data Considerations

1.1 Pilot study

- *[LS: We need to provide local governments with information that's going to be useful to them. I'm wondering if Metro Vancouver would be the best pilot study, or would smaller local governments want something different?]* I don't know if Metro Van are the right people to go to for your goal. I don't know if Metro Van is focused on a regional scale. Their land cover maps are very much around land cover planning they are very interested in remnant vegetation, what forest is left in the urban areas, where are the threats to the forest. They do have some SEI people working with them who are interested in the size of patches and connectivity through the urban area, but they are not really interested in carbon as a resource. *[KC: a key outcome of this project is that we identify key data layers that should be priorities for improving or developing, and then try to get some pooled energy and resources towards developing those things across the region. I think the region is biogeographically consistent enough that there are some things we could aim to produce that would useful to everyone].*

1.2 Spatial Data: scale, storage and software

1.2.1 Scale issues

- When you call up layers by Googling land cover, you'll get a land cover map of Canada, but the classes are so broad because they have to incorporate all of Canada. They are irrelevant at the scale that we are working at, because they are going to say water, building, forests or grass. They are not really insightful at a local scale. At the other extreme is the very local scale that MetroVan is working at. They are so focused on Metro Vancouver that they are developing classes just relevant to Metro Vancouver. Using the best possible data available, they have made a map that is locally superb but which cannot be used in the wider region because the only area they mapped was Metro Vancouver. You probably have an excellent above ground carbon map for Victoria parks, one for Nanaimo foreshore and one for Stanley Park but nothing that has been done regionally. The challenge with these regional projects is that you are stuck in the middle. You don't want national estimates that are so broad that they are meaningless, and you can't work locally. You have to work regionally so you are in this middle scale and this is a difficult place to work. When you overlay the maps they are either too broad and no one uses them locally or they are too local and unable to be used regionally.
- *[KC: I have been looking at map layers from the UN Biodiversity Tool, Global Land Analysis and Discovery (GLAD), and others. They are producing some interesting products but typically at around 300m pixels, because they are global maps. Would you be able to take the algorithms and models they've used and apply them to finer resolution satellite imagery for a more localised region? Is that something that can happen or are you better to start from scratch?]* It wouldn't be as easy as plugging the data into the algorithm. The algorithm might be open source, but it is often the lowest common denominator in terms of what data they have available. I don't think that you should view it like that. I think that they are very good at showing you what is possible. So you would use it to say can we go away and produce a product like this locally using local data. The map of BC inspires everyone as to what can be done but you would still have to go away and build a methodology to do it locally. I regard them as aspirational: aspirational layers you might be able to get to, by running something similar yourself.

1.2.2 Data hosting, sharing and storing

- *[LS: Do you have any thoughts in terms of where we could host the mapping layers we have discussed or can you advise on things that we should take into consideration about maintaining these products in the long term?] I* hate to say it, but I think Geo BC would be the perfect match and they probably would not want to hear that because they're busy doing a bunch of other things. But really they are the geospatial data managers for the province of BC. They acquire all the data, they manage all the data and they house all the data and they interface the data with the public. I think that's probably one of your best bets. For a starting point. I guess, UBC could help but over the long term, I'm not sure they would be right. It probably needs to be a government agency to hold that information.
- Depending on the scale of the mapping, you can also partner with existing groups that already have portals. As I mentioned, the CRD already have their own beautiful portal with all kinds of data on it. Then there's other non-profits, for example, the Peninsula Streams. I don't know if you know about them, they're a local salmon rehabilitation, environmental group, and they also host data for various things. I think it's better to piggyback off existing portals so that when people go to look for data that they already are interested in, then they'll be more likely to run across your data set and integrate it into their work. I think we're running into a situation now where everybody's trying to create their own portal, creating their own map, and it's really hard to know about their existence. So, if it's possible to partner with other more mature groups, then that would be my suggestion.
- *[LS: my only concern with the provincial datasets is the lag in time for updating this information e.g. two+ years behind changes.]* Yeah, it is unfortunate, and I'm not sure why. The government's really good at collecting data, but they're bad at managing / distributing the data. The lag is really persistent in a lot of the different projects that we've seen.
- I think those remain really large barriers to things like mapping but can potentially be overcome by really well developed, well organized systems of storing and sharing data. If there's a cross regional mapping service, I know we have BC data services, but that's for users to make maps and then upload if they've gone through the provincial requirements. So, it all comes down to what's available to people who are on the ground and who's producing that and where it's stored and how it's stored. The CRD has the potential to manage and store things like maps of habitat and habitat quality. They could potentially if they have the right amount of resources, restrict certain portions of that to certain users, but that takes a lot of development.
- I've noticed that local governments struggle to have enough capacity for things like data management, data design, web development and web design. I do think that there's a bottleneck around capacity development. So having someone who can build a good website, and who can create a user tool for that website that makes sense for a user is a lot of money. It's a lot of resources, and pretty much Google does that, not government organizations. That's one of the big barriers that I see. The only way to overcome them is with a fairly sophisticated development of a tool, which I don't see local governments having the capacity to do anytime soon.
- *[LS: Do you have any suggestions as to where we should / could store our layers developed for local government and First Nations once we have developed them?].* There are really amazing, enormous data storage repositories now and they're permanent. There's one through the federal government in Canada, that might be a viable option. Universities have some. I do think there are public domains that store data, especially if there's some funding to work with them to specialize and be specific about what you're putting in and why and who gets access. I would say that would probably be my first go to is to think about hosting it somewhere that's permanent. So either hosting it with an existing data repository, or figuring out some connection with a University Library, because you know, it'll be around for a million years, and hosting it on the server like Amazon web server, which is what we're thinking about doing with some of our data, and ensuring that there's an MOU between the webserver itself and the data uploads and whoever's working on it and the library for long term maintenance. I haven't seen that be successful here, but that's because I'm working on small scales with not very much money. I do feel like that seems like it has the most potential to me.
- *[LS: I was just wondering how you make sure that these tools that you've developed will be maintained and how they are funded in the long term?]* As a non-profit, we have ongoing fundraising activities that will support the data centre. We also seek additional funding opportunities specific to the data centre to support it. We plan for the project to continue with our program planning and will strongly make the case for it to continue, ultimately it is dependent on allocation decisions by the PSF board.

- I would just add that we are very low cost. We have been lucky to have UBC as a partner who supports a lot of our architecture storage. We take advantage of non-profit licensing for technology. We've been able to sustain ourselves for 12 years by just trying to be savvy and by not take leaps into things that would ultimately be detrimental to the longevity of our project.

1.2.3 Software and engines

- *[LS: are there things that you've learned along the way not to do?]* There's certainly been learning experiences. One of the things that still rocks me is, the whole open source versus ArcGIS dilemma when it comes to GIS. There's the whole proprietary versus the open source technology community. As far as software availability goes we've got a hybrid model now where we do use proprietary which you have to pay for and then open source which is generally created and made available for free. Sometimes we've leaned too heavily on proprietary software maybe other times we relied too heavily on open-source software, you have to find a balance of getting what you pay for but also free is better.
- *[LS: any other thoughts?]* I read your notes, and you'd mentioned in your notes that you were thinking about Feature Manipulation Engine (FME) from Safe software for potentially incorporating with your map. I'll just throw a quick plug in for that software. It's been a really big time saver for us.

1.3 Remote sensing (general)

1.3.1 LIDAR

- We should try and find all the LIDAR data we possibly can…*[KC: who would be best positioned, if they were adequately resourced to do such a thing?]* I don't think that its particularly complicated. I don't think that companies and governments are going to be any more responsive to a university than to an NGO than they are to anyone else. It pretty simple*. [KC: Its just contract dollars?]* You could write a contract for a consultant or a university to compile and work out where all the data is and who owns it. It can be a pain to find the right person and to work it out and you probably need someone who is familiar with LIDAR and knows the difference between point cloud, versus product like canopy height models. So you need a bit of understanding as to what you are asking for. In the Metro Van area a lot of it will be public, but it's a question of getting it, grabbing it and making maps. And along the coast as you go up and come back down there are going to be areas that are going to be harder to be find, and there might be user agreements that need to be signed regarding restrictions for using the data. Its not a particularly huge job or long one, it might take a month. I think that you could get a pretty good map and table and understanding of where we stand pretty quickly.
- *[KC: Is there LIDAR coverage in the lowlands and would it extend up to the Georgia Basin boundary?]* In your primary study area (Georgia Basin lowlands) will be local governments, provincial governments, NGOs and a bit of forestry. There could be 15 groups holding LIDAR data. Certainly it will be harder to get LIDAR for your extended study area (the Georgia Basin uplands). It is a much bigger area, but there are not likely to be many players; Western Forest Products, First Nations, Provincial Governments, etc. We may not have too much LIDAR coverage at the very top of the alpine. People aren't really going to be flying if there is permanent snow cover. Its unlikely that we'll have large amounts of alpine flown - you may not have the top of the mountains, which is ok.
- It appears that BC LIDAR portal has 1m pixel data for most of the primary study area (some areas like Cortez and Redonda missing), including
  - DSM - for lower mainland only
  - DEM - most primary study area, plus some upland areas (Cowichan, Aberni, Duncan, Squamish to Pemberton, Harrison Lake)
  - Point cloud – most primary study area, plus some upland areas (Cowichan, Aberni, Duncan, Squamish to Pemberton, Harrison Lake)
- Environment Canada Open Maps[1] has 1m pixel LIDAR derived products:

[1] https://www.nrcan.gc.ca/science-and-data/science-and-research/topographic-information/whats-new/new-LIDAR-derived-data-available-on-open-maps/24414
https://open.canada.ca/data/en/dataset/957782bf-847c-4644-a757-e383c0057995

  - DSM – most primary study area, plus some upland areas (Cowichan, Aberni, Duncan, Squamish to Pemberton, Harrison Lake)
  - DTM – most primary study area, plus some upland areas (Cowichan, Aberni, Duncan, Squamish to Pemberton, Harrison Lake)

- *[LS: so what I'm hearing is that we would not be wasting our time if we were trying to collect a LIDAR layer for our study area?]* Not at all no, I think it's a great starting point. It's a benchmark, it's the present day. You can either go back through time with the satellite image archive, or you can go forward. I think it's really powerful from that standpoint, and you're really dealing with the finest resolution that anyone uses. I think that's a great starting point. Often, people try to scale down really low-resolution data to try to get better information, which is impossible. I think this approach is better because you're dealing with the best starting data you can possibly get, and dumbing it down as you go forward, or as you go back and you're not dumbing it down, you're just making it more manageable. The resolution of LIDAR is in centimetres. You want to capture 10 metres in a pixel, so you can actually do that rather well. Going forward or going back through time.
- *[LS: all LIDAR the same?]* A lot of it's already been collected, and this is the multi return sensors. You can get a single photon which is really super expensive and it showers the land with a whole bunch of points, or you can do a lower resolution, which is typical, and is the one that was flown for the 2019 data set. So, I think you already have that data set in hand for the area.
- In terms of the point densities and things like that, there's been a push for higher densities and lower densities because of cost but I think the industry standard is about 12 points per square metre. At that resolution, you get good terrain information, you can get some good ground hits, and you get some good canopy hits, which is always the compromise for our work in forestry. You can turn up the sensor and get 100 points per square metre if you want but that's overkill, and you're going to pay for that as well too. The low-density stuff, one point per square metre, is not ideal because you actually have to define that ground surface to actually do measurements off that ground surface. There is a compromise, and the industry standard is about 12 points per square metre to that.
- *[LS: Do you think that in 2019 the federal government flew our whole study area to collect LIDAR?]* I believe so, I haven't really checked the portal that closely and we have other resources that are not on the portal, like in terms of some of our licensees like BC timber sales, which is an internal government entity. We can look around the data sets for those but they're integrating into the portal over time. The portal is not being updated with any frequency. The data on the portal may not have been updated for two years. So there might be more current acquisitions that are not on the portal.
- *[LS: if I wanted to contact the province to see if they hold any additional LIDAR that is not on the portal who would I contact?]* All the LIDAR acquisitions for our ministry are managed by Geo BC. They are the geospatial managers and acquisition people that deal with all of the spatial data in BC. If we want to fly an area they will set up the contract and we give them 10% of the value of the contract. They run the LIDAR portal too.
- *[LS: it's been suggested that LIDAR would be the best imagery to use for undertaken land cover mapping, carbon etc. for the region. Do you have any thoughts on that?]*I think I like the LIDAR idea. I think that's probably going to be your best way to get those land cover questions answered. Then you would of course have to do analysis to get the carbon sequestration potential.
- *[LS: Natural Resources Canada is currently mapping carbon. They highlighted that when they get to a fine scale and they try and place it on a web portal that it would be expensive and would need a lot of memory to power it. Would we have the same problem when mapping on a regional scale?]* Assuming we compiled everything we had and we thought of it as one GIS file that covers the Georgia Basin (extended study area), it would comprise about 10% of the province so it would be a massive data set. We do not have LIDAR data as big as that area. Maybe we do in the middle of Ontario. You would never be in a situation where we would want it on a portal.
- If we were going to get access to the LIDAR data it is going to be covered in user agreements, and user agreements are going to be you can't distribute the point cloud publicly. You can use it for your project, you can go and predict biomass you could even use it for landcover, you can use it for anything, but there are always going to be layers. The layers you make you could likely distribute, but not the raw data - that's a very common restriction we have for LIDAR agreements. The companies

want to maintain ownership of the point cloud, but they're more than happy for you to go and use the point cloud to make some thing and then distribute what you have made.

- We are never going to be in a situation where we will be giving out terabites of point cloud data. Its not our job to be a data distributor, as we will be tied up with user agreements and you wouldn't have the infrastructure to support that anyway. I don't see that as a goal. If we were going to get access to the LIDAR data it is going to be covered in user agreements, and user agreements are going to be you can't distribute the point cloud publicly. You can use it for your project, you can go and predict biomass you could even use it for landcover, you can use it for anything, but there are always going to be layers. The layers you make you could likely distribute, but not the raw data - that's a very common restriction we have for LIDAR agreements. The companies want to maintain ownership of the point cloud, but they're more than happy for you to go and use the point cloud to make some thing and then distribute what you have made.
- You have taken the LIDAR data, used it to make your prediction and then made your layer. It's the layer that you would send out and share, and the layer is going to be much smaller than the LIDAR point cloud itself. I don't think that you are going to run into those problems. You are going to have to invest in some sort of data delivery at the front end to make it look good. It depends on how much you want to get into pointing and clicking and allowing the user to do different operations, but in terms of you making the layers, they're not going to be enormous.
- The other key thing is to push for repeat LIDAR. The 2010 LIDAR for this area has proved to be a diamond. Now we have the 2019 data from LIDAR BC. That's two different data sets - we can look at all kinds of growth. We really need LIDAR every 5 years in these areas.
- If you're in QGIS and you want to look at LIDAR data, you need to go into symbology and change the rendering to hillshade, and the resampling from from 'nearest neighbor' to cubic. It's wonderful when you look at it the right way, you can see every last detail.

1.3.2 Satellite imagery

- My understanding is that LIDAR provides super, super high resolution, whereas Landsat is a much lower resolution image, but it is free. Landsat is a great dataset for going back through time because I think it's almost 50 years old now. So, you have continuous imaging for about 50 years, and it's free, which is awesome. There are commercial satellite options for imagery that are a metre or less. LIDAR is great, but it is a ton of data, which may make it harder to visually analyze or analyzing different code. Another option to think about would be commercial satellites, because those can be pretty good resolution as well and potentially an in between option. *[LS: and does Planet fall into that classification?]* I think so. I'm not too familiar with commercial satellites, but I believe I've heard of that one.
- Its right to be excited about Sentinel satellite imagery. The European space agency and Sentinel 2, 3, 4, and 5, are all producing this wonderful free data high resolution data. And because those satellites are repeating in this area very often (on Salt Spring we get cloud free data 2 or 3 times a month), so we get good images a few times a month. I don't know how it is on everyone on the other side of the strait.
- We need to have our government mapping units and local government actually looking at satellite data. The one key data set that is really worth exploring is the Sentinel 3 data which shows ground temperature and moisture. I haven't looked at it yet, but it shouts out for potential applications.
- *[NOTE: Potential applications of satellite derived temperature and soil moisture observations/maps include:*
    - *Hydrology (run-off management, landslide prediction, quantifying groundwater storage, changes in terrestrial water cycle)*
    - *Flood and drought forecasting*
    - *Irrigation/agriculture management (high resolution required for farm level)*
    - *Monitoring wetlands and riparian zones (high resolution required)*
    - *Predicting water/heat stress on ecosystems (e.g. forest die-offs)*
    - *Monitoring wildfire probability*
    - *Monitoring urban heat islands (for planners and developers)*
    - *https://www.sciencedirect.com/science/article/pii/S0034425720305356*

    - *https://www.esa.int/ESA_Multimedia/Images/2016/11/Sentinel-3A_takes_Earth_s_temperature]*
- If we're talking about data, there's so many satellites going up we've got the Sentinels; Sentinel-2, A and B in tandem, so we can be revisited about every five days. Then there's paid solutions, which are at an even higher resolution like Planet Scope, and you can get daily imagery at three and a half metres. If you've got real big bucks, then you can get down to sub metre resolution for some of these satellites (Sky Sat).
- Some companies like Planet have ways where you can reduce costs by applying for funding with them. They have their own funding sources where they will help out local communities, especially if it's something related to these big issues like climate change and adaptation or indigenous communities adapting to these things. They have feeds where the change is actually done by the company so you don't have to do the algorithm piece yourself.

1.3.3 Ground plots

- All these kinds of data sources feed into a multiscale hierarchy of what you're looking for, but really it comes down to a set of ground samples to develop a training set for our work. So, you can say this land use is urban or forested or agriculture. Those are easily detected with the satellite, but it's the ground truthing piece that falls by the wayside an awful lot with projects. You can get all these different images, you can do multiscale analyses, but to ground it all to something substantial, like biomass or carbon removal or anything like that, it really takes some measurements on the ground to establish a relationships between what you're seeing in the imagery to what's on the ground.
- With LIDAR, you need some ground samples to actually measure that you're getting it right. The samples really help because you can do any stratification. You can come up with any sampling scheme in between, but the LIDAR as a wall-to-wall piece, or the satellite image as a wall-to-wall piece covers every piece of ground, which you can't get from a sampling perspective. You can extrapolate your measurements on the ground to areas where you haven't actually visited. I think that's the power of the remote sensing piece in this work. You can't cover every piece of ground in the coastal Douglas-fir BEC zone.
- *[LS: Is there any way that you can look on a layer to identify where all the ground plots would be across the region?]* I believe that's freely available. There's a bunch of different ground sample types. The first one is the permanent sample plots. They're called PSPs. We have about 6000 of those spread across the province. Unfortunately, they're a bit biased because they're not placed in a random fashion. There are other ground samples in the province that are unbiased and follow a stratified grid, 10 kilometres by 10 kilometres, or the National Forest Inventory grid, which is 20 kilometres by 20 kilometres across the province. There is a whole collection of these different ground samples and the layers are freely available.
- *[LS: would those pick up the federal government's monitoring plots that they use as part of their carbon annual reporting?]* You might have to go to them. We have the National Forest Inventory plots, we pay half and the Feds pay half and each one take four days to monitor. They're really intense plots and they're really valuable from that standpoint. I don't think they actually have any flux data or climate data associated with them, but that could have changed. They are pretty intense and they can be used to determine carbon biomass.
- *[LS: so the first step is to determine what plot data is available.]* Unfortunately, I'm not sure there will be a lot in the coastal Douglas-fir BEC zone. I'm not sure why. *[LS: maybe its because the majority of that land is private ownership rather than Crown land.]* Probably our focus is forestry on Crown land.

1.4 Data portals and visualization tools

- There is the move towards online tools and portals, like iMAP and ArcGIS, that is making mapping data much more accessible….The various mapping layers start to overlap and emphasize certain areas, which is good.
- *[LS: in the conversation that we've been having people have indicated don't build your own portal because there's plenty out there and there's plenty out there that haven't worked. I'd just be interested to hear your thoughts as to whether you would agree with that statement?]* Yes, I would agree with that. I think that there are plenty of portals out there. If you are running a portal, finding a niche, but more

importantly making sure your portal can communicate with other portals and through the data centre, we've ensured that all of our data are in a standard format and metadata are in a standard format that's harvestable and transferable to other portals. We've worked with the International Coastal Atlas network that's spread out around the world, but we deal with partners in the United States primarily, who talk of things like ensuring that you can access these portals from maybe a centralised website that's run at an international level. It's something that I think can be successful if you do it correctly, and should be done cautiously. I agree with that sentiment that you don't want to replicate efforts.

- *[LS: are you tracking use of the mapping portals that you've set up and are you able to understand who's visiting the site?]* We use Google Analytics and I check it and our communications folks at PSF check it. We do have a detailed breakdown available. Generally, I'm looking at how many users are using which parts of the website. I find that quite helpful, especially in collaboration with the communications teams, you can really report back to them with how social media outreach or conference attendance, has been able to impact certain parts of your website, depending on what is being publicised. But we don't really do the demographic breakdown.
- *[LS: you've found that there's been a need to do outreach to promote the tool?]* Yes, absolutely. We are going for the approach of being an educator at the data centre. Putting the resources out there and then making sure that folks are aware of them so that they can then ideally share them with their own networks.
- If you want an example of that, we have our Williston Wetland Explorer Tool Willaston Wetland Explorer – it's a good one. Check that out and it will give you an idea of a basic way of how you could view the data that way and it could be easier for others to use.
- Our SIFT tool for soils is kind of a similar format. It's a Soil Information Finder Tool. The process to build them takes a long time. There's a lot of approvals to go into it, but the end result could be something that's very user friendly and easily accessible and easy to understand so that people aren't downloading TEM data with numerous codes they may not understand.
- We need to avoid complicated data and provide easy to interpret alternatives where possible to decrease people not understanding and then getting frustrated or quitting or use the data improperly.

1.5 Data sources used by consultants

- iMap BC, the BC Conservation Data Center layers and pull out critical habitat mapping for species at risk from the Federal government,
- The Fisheries Information Summary System (FISS) with the Province for the fish information
- the SARA registry to pull out specific recovery strategies that might apply and look habitat descriptions
- iNaturalist
- For existing consultant reports, so we'll go to EcoCat
- We know that there's data out there, but we just don't know how to access it. So, we have to call other consultants, or call people who might have information. We rely on stewardship groups, and stakeholder groups. Like the Stream keepers are often out there, throwing traps in the streams their data doesn't end up in a place that is publicly accessible. So, we'll often make those phone calls to try and see if there's data out there that exist that is just not easily accessible. And it's more relationship based.
- Same thing with First Nations traditional knowledge. If we're in working on a project that's in their territory, we will often reach out, and get input from them on what they know about the site. Both traditional knowledge, but even like local, just like current day knowledge about a site. They're often on the land and in these areas, fishing and using it in other ways, too.
- I think like we definitely encounter though, even in spite of that there's still lots of data gaps. I think generally anything that is covered by a permit there's just more information. So, there's more information on fish, just because we have the Fisheries Act, and we have DFO. And you know, fish salvage permits that have to be reported fish collection, permits have to be reported, and that data gets submitted back. The province has a similar system for fresh water fish and we have quite good information on things like that. But we have less good information on things that don't have a specific regulation associated with them, like songbirds, for example. We know a lot about where raptor nests are or where heron colonies are. There have been a lot of like focus on that. But there's other bird species like songbirds and migratory birds that we often have to go out and do a survey because we

don't have that information easily available and then sometimes, we can't do a survey just because it's not the time of year, or the project needs to move ahead. So, we rely on collating or relating habitat characteristics to potential species that could be present or likely species.

1.6 Modelling (general)

- In the context of the students, my background is in modeling and I'm interested in modeling what we don't know and what we need to figure out, not building a model that tells us something about what we're modeling. There are two ways of modeling: people who believe their model is telling you this is what it is, and then people who use a model as a construct to explore how much you do and do not know. You can do a power analysis to see how far off you are, whether you're missing something really important, in which case you don't want to rely too much on the output of your model, but you know how it's flawed, so you know what it's bias is. Then you can still use it.
- We don't actually really care about the output, we care about the process, because even if the model isn't 'true' of final, it is the development process that flags the limitations in the data you're using. It will still give you an output, but you better know what the biases and uncertainties are and how they affect the model. We need to culture students who say "I did this and it looks great, but does it mean what we think it means?" To me this is what the interesting conversation is.

1.7 Miscellaneous comments

1.7.1 How much data is needed?

- I do think that these data are important. When you're asking for funding to support a project it is helpful to have these numbers right. The data would be really helpful, but the cynical side of me says we are in a climate crisis, it's pretty obvious were in a biodiversity crisis. How much more data do we need?

1.7.2 Data clipping and metadata

- This project could have outreach that explains about mapping tools and could go even further as a follow up to have information clipped specifically for each local government along with the helpful metadata.

1.7.3 Publishing local government data

- *[DB: Any other kind of policies that you would like to see happen?]* I'd say for policies, there's a lot of options, but it depends what the municipalities have. DPAs, are obvious ones. And see the other one is just publishing data; I think what's kind of new and making a big difference is publishing spatial data. So online. Like, so people, have a better understanding where you know where streams are or setbacks are. Where are these sensitive sites are. In the past, the general public hasn't really got an awareness of that. Or prospective developers purchasing land, they really don't have an understanding of what their restrictions are. So, I think that is making a big difference too, these municipal online mapping tools and publishing information on there is making a big difference.
- I like paper maps. If you're a local government, you can post the map somewhere and people see it. Then it draws awareness.
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2 Land Cover Mapping

2.1 Using remote sensing and AI to generate land cover

- Pre trained land cover, land use classification products that are available through the European Space Agency as well as ESRI, which is the ArcGIS ArcMap provider. Those have been pre-trained on a global data set, so you get near real time land cover, land use classification products. You can determine water, forest, grass, urban in real time, as often every five days. *[LS: Would you think those*

classifications would be relevant at a local level? Or are they more national level?] That would be my worry is that it would be too generalized. It could be good for things like conversion from forest to agriculture. That signal would be reasonably accurate, but anything more detailed than that would require expert local training, establishing relationships between ground-based measurements and the satellite or LIDAR imagery.

- MetroVan have a complete land cover modelling program. They did a land cover map about five or six years ago, through UBC. They're updating that now using a combination of LIDAR, where available, and high spatial resolution satellite imagery, be it Rapid Eye which gives us a 5m spatial resolution or Planet which is now giving us a 3m spatial resolution. So, they've thought a lot about these types of things in terms of the local MetroVan area and I think that they've got a sense of bringing these data sets together to go away and make ecosystem classes. I think that they're aiming for around 10. They are much more urban focused. There might be one wetland class, one shrub class and one forest class
- *[LS: it has been suggested that we should collect all of the available LIDAR data for our area and to use that to develop a land cover layer. In relation to land cover change the suggestion is to use LIDAR to form a land cover layer, and then use other remote sensing technology to monitor change, and basically punch holes through the land cover layer created from LIDAR. You would never go back out to try and collect all the LIDAR, change would be determined by other remote sensing technology. Does that make sense to you?]* Definitely. LIDAR is the highest resolution data set that you could deal with, but it's very costly. It only provides you with one time frame, so you'll never get any changes with LIDAR unless you want to reapply it. But as a starting point, I think that's a fantastic route, because you have the highest resolution dataset. If you match that with some ground samples, you have a really good idea of what's going on, on the ground.
- Local governments often lack expertise in some of these technologies. We work with this technology all the time, that's our job. We can use these amazing new cloud-based technologies like Google Earth Engine and Planetary computer to extract the information that we need and at 10, 20 or 30 metres. We can track harvest; we can track wildfire burn severity. We can even do flooding but I think there's a real challenge there for local governments to be able to take this work and start doing it themselves.
- There's a lot of really cool photo based machine learning software development, even here at UVic. For the Mountain Legacy Project, they're looking at land use classifications, based on AI and machine learning, for 1000s of photos they have in the Rocky Mountains.

2.2 Land cover classifications

- What I don't see are things like cross walks - that's a fancy term that we use for how you go from one classification to another. For example linking a classification that has been done by MetroVan and linking it to the classifications that has been done by Victoria, Nanaimo and Squamish. How do you look at those classes and try and work out if there is any consistency. Can we say anything in common across this area based on these classes? Or can we roll up some classes from Victoria that would more or less match the ones from Vancouver and Nanaimo, giving you a map that would be about ¾ of the area of the same classes. To me a bit of thought is needed around this. If we aren't trying to reinvent the wheel, it is about transferability and cross walking these classifications, to see if you can take the best you can from the different areas and roll them up.
- There are lots of issues: accuracy will be different, the class definitions will be different for each data set. You might be rolling out to such broad classes that it is meaningless, like forest, not forest. It might be the only roll up you can get to. That is of course a challenge. I think that is something thought needs to be put in because we don't want to replicate everything that people are doing.
- I think that one of the main issues that you're dealing with is the fact that you have such a large area. Greater Victoria and Metro Van will be doing similar things with different data, and I'm sure that Nanaimo is also doing something similar. It is really an issue: the area that you cover is so large and covers all these people doing lots of good stuff locally, but how you integrate it into your study area to give you something consistent is really a challenge. I don't really think it's about a lack of data, lack of will, lack of ideas, lack of computing, lack of money – it's more a fact that you are so cross boundary in terms of the different groups you are working with, who all have different skill sets and needs. This will be as much the challenge as anything else.

2.3 Tracking land cover change

- You can do a land cover map at that time [with LIDAR] and either back-project what those land covers are through history over the last five - six years with the Sentinel images or going back 25 years with the Landsat or you can go forward every five days. It is a really powerful tool. You have to have a starting point with the LIDAR, that only provides you with one time frame of the data.
- I would say that for land use change you don't really need LIDAR. However, as long as you're smart about how you're using LIDAR for the ecosystem classification that could be a good baseline, it'll change in the next 20 years, but 20 years is a long time to go between flights. If it's about land cover, often satellite photos can give you land cover, especially land use.
- *[LS: how would you approach mapping land use change at a level that would be useful for decision makers and planners in local government and First Nations?]* I would use something like a Sentinel-2 time series or the longer-term Landsat time series at a pixel size of 10 metres, 20 metres or 30 metres. That's the application that the original Landsat sensors were developed for, to try to grasp land cover and land use change over a long timeframe. They have the best spectral characteristics; they have eight spectral bands which means you can identify different land covers based on those spectral characteristics. The time series aspect of it is just getting better. It used to be every month or so and now we're almost down to every 14 days or finer if you want to look at some small areas.
- *[LS: if we develop a land cover layer for the region, what are the options for automatically updating they layer? How much would need to be manual?]* I think you could get to a point where 95% of the process is automated and 5% is manual quality assurance, quality checking and validation at the end. You have to start with a good foundation of ground sampling
- We're in forestry and our trees do not grow that fast and we don't care about even annual changes to the forest. A Douglas-fir might grow a metre in a couple of years. Ideally for our work on the forest canopy I would expect changes every five or six years that you would actually detect with this technology. A couple of years difference doesn't really bother us at all. Even if we set up ground samples, we would do plus or minus three years. I think most LIDAR acquisition in your study area was in 2019 through the federal government, so we would go back or forward three years for the ground samples.
- *[LS: what we found when speaking with some of the municipalities is they don't have the skill or money for the change analysis, which is why we were looking to automated updates]* With manual interpretation you can hire students to tell you where there's a tree somewhere or not. It doesn't need to be a consultant. It can be someone relatively entry level.
- *[LS: If you have the ortho flown when there are leaves on the trees, would you be better off using that than the satellite information?]* Depending on the area you want to cover. I know that automation is exciting, but I wonder sometimes if for a small enough area and you're interested in knowing where the trees are for urban heating and cooling, I think manual interpretation shouldn't be excluded from the conversation. If you can manually delineate where the trees are I think that should be an option as well. I know Victoria does that.
- *[LS – we are looking to pull together a LIDAR layer for the region and from that produce a landcover layer. Annually this would be reviewed with the ortho data to identify locations where land use change has occurred. Do you think that would be a useful resource for local governments?]* I think you could also do it backwards, by looking at satellite data, you just need someone to classify it and be consistent with the classification. You can see things being logged or converted to developments or farmland. I think you could probably go backwards in time.
- We do produce an annual consolidated cut block layer, so we do track harvest. We use a combination of what's called a results database, where licensees actually report their harvesting activities to us. Then we also include remote sensing based harvest tracking as well. In terms of finer scale land use changes associated with development we don't do that but that could potentially be done through satellites. I guess the question is how large are these areas that are being monitored and how much of it is changing through that specific mechanism. Let's say we know where the new developments are going in. Why use remote sensing if you can just use the planning data? *[LS: permitting would only record a percentage of the land use change in a district as permits are not required for many activities.]*

2.4 Remote sensing tree canopy cover

- Just my team works more to assess canopy cover for which we use LIDAR. I think it's been interesting because we are using essentially a combination of LIDAR and aerial imagery to derive canopy cover.
- Canopy height models are really good if you can get them spaced over time, because then you can see what your vegetation is doing - you can see where it's being cut and how it's growing.
- *[KC: I was looking at the UN Biodiversity Lab data and they have a tree height layer for our area – is that from LIDAR?]* Yes that's canopy height model. With the LIDAR you get reflections from different things from one LIDAR pulse. You get a number of reflections; you can categorize the status them as the top surface of the vegetation, or an intermediate surface or a building or a ground reflection. The reflections can be categorized in all sorts of different ways. So the canopy model, effectively if it's a 1 or 2m pixel it gives you the height of every tree! That's what we have on Salt Spring. It's wonderful –you can pick up pretty much any tree.
- On a tree farm license for instance, they'll acquire LIDAR on their own and then they'll hire a consultant to process the LIDAR and come up with an individual tree inventory. So you get all these points of spruce pine, Douglas-fir etc. so they come up with individual tree inventories and they're really powerful for the operators on the ground to identify where to harvest. They need to identify the best and the tallest lumber to make it worthwhile. They will use the data to identify a hectare of land that has the highest quality lumber based on what they're seeing with the LIDAR. They can do all that work in the office and minimize boots on the ground. I think that's where industry wants to go. That's where BC timber sales wants to go as well because they really like seeing where the biggest and the brightest are available for harvest.
- The two key pieces of LIDAR data are the digital elevation models and the canopy height models. LIDAR BC is releasing all this wonderful 2019 data, but they're not providing canopy height models, sadly. In some areas they are providing a digital surface model, which is the digital elevation model plus the vegetation.You can get canopy height by subtracting the digital elevation model from the digital surface model Canopy height models are really good if you can get them spaced over time, because then you can see what your vegetation is doing - you can see where it's being cut and how it's growing.
- It would help discriminate between deciduous and coniferous trees. You could use very high-resolution satellite imagery.There are sensors like World View, which are pricey, but they have very good spectral resolution. I think you can get 16 bands so you're actually getting pretty detailed spectra and it is high resolution, 30 – 50 cm. *[LS: If we turn the question around what's the best resolution you could get for free?]* Ten metres and that's only in four bands. So red, green, blue, and near infrared. If you're looking for more spectral information, which for vegetation you would need, then you're dropping that resolution to 20 metres to pick up vegetation differences.
- I think it's a stitch thing too for us, usually. It's important to know what year we're talking about, because some municipalities like to be able to say like between 2014 and 2019, we had this much canopy change. You know? Sometimes when the stitched-up images like on Google comes up, it's less easy for us to use it to get the exact times
- *[LS: Local governments have expressed a desire to monitor the loss of urban trees.]* The 10, 20 or 30 metre resolution what we call medium resolution satellites would not work for that application. I've seen some really cool work undertaken by the Capital Regional District, they fly their own airborne imagery, I think almost every year or every second or third year. It's available through their portal. That's very high resolution, 15 or 30 centimetres.

2.5 Leaf cover issues

- I think it's been interesting because we are using essentially a combination of LIDAR and aerial imagery to derive canopy cover and I think one of the biggest challenges that we're running into now that it's becoming more common that we come into a project, where there has been an analysis done in the past, and we're comparing to, and seasonality is actually a huge factor for us. A lot of the LIDAR data, particularly historically, was collected leaf off, and that has led to some significant challenges for us. Because, say like the city of Vancouver, between 2-year periods, just from the fact that the LIDAR and imagery went from leaf off to leaf on, they had instantly met their canopy cover goals actually. Having the ability of accessing LIDAR data and aerial imagery is really important, but I think seasonality

is really something that needs to be better understood. Ideally, we'd have a more consistent way to move forward. Historically, I think, LIDAR data as well as aerial imaging was often collected, specifically, leaf off so that you get a better view of the major human made infrastructure that's underneath it.

- And I think that's proving to be really challenging already. Just from the last couple of years, just as we have been having more frequent opportunities to compare back. Seasonality, I would say, is a big thing.
- And we're also finding even things like, you know, years where the aerial imagery has a lot more shadows; it can lead to like significance issues again in comparison. For our work, comparison is an important part. And where we are using LIDAR or aerial imagery, seasonality becomes a huge driving factor on whether we can actually use it to compare it or any meaningful transect of it.
- *[LS - one of the difficulties they're (Metro Vancouver) saying is that often when they collect the ortho data, they're doing it during leaf fall, because the imagery is taken for buildings and apparently the consultants decided that this result in an inaccurate assessment of landcover change.]* It just might need more human intervention than AI. I think it'd be worth looking at.

3 Ecosystem Mapping

3.1 Data consistency, accuracy, scale and storage

- Ecosystem mapping and maintaining updated information is critical, given how limited the amount of what is red and blue-listed in the CDF now, having refined ecosystem mapping is important. When maps are created, people can then be on the ground arguing about where it is. This makes accurate mapping important.
- *[DB: So, what kind of data would you like to have like in terms of quality or in terms of gaps? That just don't exist at all]* I was just going to say I find it's not always very consistent, even within a municipality which is tricky, but having more consistent data, would be helpful. And more consistently applied.
- Overall, I would say that the existing mapping we are working with is not fantastic. A lot of it, the line work was done quite a while ago, like the Metro Van stuff, and that usually doesn't account for recent development. Or the line work was done manually over ortho photos. It's not super accurate. So, there's a lot of errors, in just the exact location of this line work. And then and there's just varying states of quality in terms of how things are categorized depending on who did the mapping. Some of it is quite good, some of it is not great, depending on who did the mapping, how long ago it was done. Yeah, that's about it.
- *[KC: I guess my concern is when we're talking to local governments or QEPs, they're pulling up the ecosystem explorer data and they're not doing what I did with the TEM, if it's available.]* Exactly.
- *[KC: it seems local governments go to the SEI, they go to the CDC element occurrences and that's it. Perhaps the water atlas.]* That's the big thing that I'm noticing too. That's why I'm trying to highlight the TEI section. That's where the data is actually housed and where you're supposed to go as your first step. It really should be us because we have the current data, we have the most recent and up to date mapping for the area. I know local governments have been doing their own thing as well, which is another reason that this is so important. We need to be more in touch with them and vice versa, but as far as provincial data and what's been happening, we have to be looped in right away so that people know where the most recent data is. Like I said, none of the new stuff for the coast is publicly available, so nobody would even know unless they asked us.
- That's the thing with TEM or any ecosystem mapping, you're always going to have that limitation of scale. I think that's important for the education piece for people to understand that. No matter what scale you map at it's not going to be 100% accurate, even if you're at 1:1000. Like you said [about] infilling of [Garry Oak ecosystems by forests]. That actually became very evident with the last work we did for the Garry Oak work and the CWH_{xm1}. Our consultant mapped all these ecosystems as potentially Garry Oak, and it wasn't until they went out in the field that they were able to say yes or no. We were really having a problem identifying them at the mapping scale, even zooming in 1:1000 because of some of those things you were talking about – infilling and other issues identifying these

small ecosystems. There's always going to be a limitation with mapping. The thing is there are other ways you can use mapping e.g. as a potential identification tool, 'Here's a place you might want to visit to field verify.' There's always an advantage to having it. You're always going to have to go back to the QEP level site assessment. It's always going to be part of it

- I guess the answer to the questions above depends on your purpose. I think there may be opportunities for meeting people who don't want to get into the weeds at those larger scales that resonate around wetlands and old growth forests. Those things are relatively easy to recognize, and working at that scale can still lead to some positive conservation outcomes.
- The drawback in scaling up ecosystems like that is that you can lose some significant variation. That's kind of my world where I deal with ecosystems at risk for the Conservation Data Centre. We split things more and more finely because we're afraid of losing important variations in ecosystems, and then losing biodiversity that we have failed to recognize. I think there may be opportunities to capture those things within coarser ecosystem units but the implications of working at different scales need to be carefully considered. *[KC: Does the SEI already do that?]* That's a good question. I think that is what the SEI attempts to do. I alluded to this earlier, but I'm perhaps not as in touch with the people using that data as I could be, so I don't know whether the SEI really works well for them. From what I've heard, it does in most cases. *[KC: the feedback we've been getting from the planning folks is that the SEI is what they use. That's what the planners understand, that's what the developers understand. That's what they use. But the issue they have is it's often really out of date, but they use it anyway. What we're seeing now is there are forests which are now mature or old but not captured by the SEI. Many local governments are using the SEI as a flagging tool to require development permits. If those mature and old forest aren't even captured because the SEI is outdated the local governments don't indicate the need for a development permits.]*
- *[T.B. Who should hold the mapping data, such as for ecological communities?*] Mapping data belongs where it currently lives with the BC Provincial Terrestrial Ecosystem Information Group. That group maintains all the ecosystem information for the province. It makes a lot of sense, because they know and maintain the standards, review products before being posted, and make them publicly available. The problem is that there isn't a person who is focused on outreach to say which tools exist and where to get them. There used to be the South Coast Mapping network that is still online. And they would put and make maps more accessible, things like wildlife tree information, the WiTS site, wetland mapping and ecosystem mapping and like Frog Watch etc.

3.2 Mapping Buffers

- Is it important to not just have the boundary of the feature included. To be effective, what is needed also is mapped buffers that show what is required around it to protect the feature (whether it be in the form of mapped ESAs and SEIs, and/or red and blue-listed communities). Without mapped buffers, the areas get eroded if you're only focusing on the edges. Buffers should be mandatory.

3.3 Mapping undeveloped areas

- Saanich is very focused on parks and their environmental department has just been moved into their parks department to make it really clear that they think about the environment as being in their parks not outside of their parks and that's the wrong mentality. So how do you use mapping to change that mentality? I think you would have to overcome this idea of private property being sacred, I think you'd have to overcome the idea that that highly degraded areas aren't worth habitat values. I don't know the best way to do it. It might be mapping all of the undeveloped space and trying to use a combination of remote sensing to guess at what habitat values might be offered in each of the different kinds of spaces.

3.4 Biogeoclimatic Ecosystem Classification (BEC) system

- *[Both TEM and PEM use the Biogeoclimatic Ecosystem Classification (BEC) system[2] to identify ecosystems, and field data is collected using Field Manual for Describing Terrestrial Ecosystems – 2nd Edition (PDF).]*
- Another thread I saw in your challenges was that there are challenges with the ecosystem classification system that we use. I'll start by saying that BC is in a really good place compared to other jurisdictions. I see how there are jurisdictions that don't have nearly as strong or robust an ecosystem classification system. We have some incredibly knowledgeable experts who have been working on this for decades and our classification and mapping is always improving, though there are places where it could maybe be better implemented.
- The other thing to be cognizant of is the BEC classification updates that are underway for the coastal BEC units (e.g., CDF, CWH, MH). The old classification is included in the current Red Book or Land Management Handbook #28, which is the base for the BEC classification that describes how you would map things, like an 01 or an 02. That is being updated and they have a draft classification in place but I think it's due to be published at the end of this fiscal year, so next year in March (likely later in 2023). That is going to update the classification for all coastal BEC units, including the CDF as well as the CWH_{XM1}.
- The old mapping that was done through the CDF TEM will be outdated as far as the coding is concerned as well, so it's just another thing to be aware of. They are actually identifying Garry oak specific units. There will be a 103 and a 106 site series that are specific to Garry oak, for instance in the CDF. Just something again, to keep on your radar, that classification is being updated and the line work as well, for those BEC zones. There will be some shifts between the subzone/variant boundaries. That's part of what the CWH_{XM1} TEM was looking at.
- The draft line work and the TEM polygons will follow what the landscape is saying and assign the BEC zone, appropriately. So, yes, it will be incorporated. Cross-walks from old to new BEC classification will be provided in the new guide. For some ecosystems (e.g., site series) it will be a one-to-one cross-walk, while others may be split or lumped into new site series.

3.5 Updating ecosystem mapping

3.5.1 Issues with tracking change

- Another problem is documentation. For instance, the SEM/TEM data provided by the Islands Trust; we've been trying to understand how it is updated. We haven't got to the bottom of it yet. But, as I understand it, the SEM/TEM data exists at the provincial level. The Island Trust decided to take it, and to rename the attributes, as a result, their SEM/TEM data doesn't get updated as the provincial one does. Another place where things get stuck. I think the only way to keep up with the current state of knowledge is to be in contact with the researchers, because the data is always changing, and they're the ones that on the front of the wave. They are also less constrained in sharing data. I would like to point out just how readily this can be done, as an example, we have an Antarctic ice shelf expert living on Salt Spring, and his major work is looking at looking at the disintegration of the ice sheet. *[KC: one the benefits we have on the South Coast is that a lot of subject matter experts live here].*
- *[KC: The other big issue we're hearing about is how rapidly mapping is becoming out of date. We are wondering about automated ways of updating or improving existing ecosystem mapping, such as SEI or TEM. My understanding is that Metro Van has developed new TEM and SEI layers, and are using land cover data to keep the ecosystem mapping up to date and track change].*
- That's right. I think the way the observation community view it is around change. You don't want to map wall to wall every single year or every 5 years or every 10 years. Doing this, you will compare mapping for the two dates and assume that the difference is giving you change. But the trouble is our classifications are still relatively poor. Even if your mapping accuracy is 80% to map 15 land cover classes (which we would regard as a magnificent outcome), when you map again 5 years later, also

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

with 80% accuracy (still a good outcome), you have a problem. With the 20% error at time 1 and 20% error at time 2, and the land cover change that we expect to see over the entire area is much smaller than the error that we have in our maps. So statistically we are unable to say whether the change is real or whether it's a function of error in the two maps we have. Our thinking now is to map the ecosystems well the first time, then focus on mapping the change. So, use your remote sensing to map where you think change is occurring in the landscape and essentially burn it into the landcover map.

- For example, take a high value forests: is there evidence of change, what has happened? If areas have been degraded, you simply re-label those areas on the land cover map. You update your land cover map by burning in the areas of degraded forest, but all your other classes would carry forward. Your urban would still be urban, and your wetland would still be wetland. So its more about looking for change: detecting change, quantifying the change, attributing the change and burning it into the existing land cover map rather, rather than updating the entire land cover map all the time, or the variable all the time.

3.5.2 Provincial disturbance mapping and modelling to update age and structural stage

- *[KC: Did you see the spatial data matrix?]* I did, and that's what I was looking at and seeing, as far as my background, what other layers we would have. There's a disturbance layer for the province for the cumulative effects framework that's current as of 2021. Again, I'm not exactly sure on the state of these and if data sharing agreements would be required for some of these layers, but I just wanted to bring them up as potential sources of information.
- One of the things I caught right away just looking at the first bullet; that mapping becomes rapidly outdated. I'm just curious – is that because of land use change within some of these communities?
- *[KC: Yes, but where it's really outdated, is that it's missing a lot of the mature and old forests. Where there's high development pressures, it rapidly becomes out of date.* Because we are both involved in another project that hopes to address the complaint about the ecosystem mapping becoming out of date due to structural stage and age related factors. To increase the longevity and utility of some of these products, we've been working on modelling the structural stage, incorporating age components and coming up with the best standardized method, in which we could update ecosystem mapping products to give them a longer life. Current work is focused in the Great Bear Rainforest right now; with the goal to have a standardized method for all ecosystems across the province.
- *[KC: So that's just a model predicting how ecosystems will age out over time?]* And incorporating some of those disturbance layers, whether it's harvesting or other disturbances, tracking the age of it to add to the ecosystem map as a base layer the age of those ecosystems and their stage of development beyond age, getting at that structural development.
- It's a big project and we've been working on it for a while and we're making some good progress. That's where we're trying to incorporate land use change. If we have a good layer of where municipalities or rural areas have land use change and development, that could be something that we incorporated into that model. That doesn't help with the scale issue, which I see when I read through all those bullets round 1 interview results, there's a scale issue here which I get depending on what you're managing for, but with the products we have, the ecosystem-specific structural stage model could help with some of those management questions.

3.5.3 Tracking change using LIDAR and automation

- *[KC: We are considering accessing all the LIDAR sheets for our study area, which may involve contacting the holders of the tree farm licenses and the Private Managed Forest Land folks and using the LIDAR data portal. It could be a matter of then getting a student on board to develop some derived layers from that LIDAR sheet, such as forest structure and structural stage which could help update the SEI in terms of identifying where those mature and old forest stands are now, as well as carbon storage.* I think it's worth looking into. I think we still have to be cautious about the potential for updating older products and it would still require some sort of manual check.
- *[KC: one of questions we're exploring is whether models and/or automated methods could be developed using remote sensing technologies and high resolution satellite imagery to improve and/or continuously update ecosystem mapping, track ecosystem conversion, etc. We're hoping to bring the right people together to explore this possibility].* That's what I want to do on Salt Spring. But it's the training issue and getting good groundtruth. Luckily, for the Maxwell Creek Watershed project we have

a partner who is providing various types of multi-sensing, multi-spectral and LIDAR data. It really needs low level drone flights so that you can really start to train your classification plugins. *[KC: And so, if you did the training that for your area on Salt Spring, could it be extrapolated to the whole of the CDF BEC subzone?].* Possibly, it would at least be a good step or starting point.

- *[KC – it has been suggested there could be automated methods of using high resolution satellite imagery to burn out converted areas to do a more rapid automated updating of the different ecosystem mapping layers. I don't know if you've used any of those methods or have any thoughts on them?]* We've talked about that, with the CDF. It would be a good thing to follow up on. That might add to our structural stage modelling project. That general conversation of keeping ecosystem mapping relevant and useful to people, that would be a good avenue to explore.
- *[KC – we were told we would need to verify the data with plots.]* That's something we discussed before, that you can do these updates based on other layers, but because the TEM and SEI are so complicated – especially with TEM you can have multiple deciles of things. A straightforward modelling, an update in that way is going to be tricky, to say the least. It's definitely possible and it would probably do a good job in some areas more than others, but there's stuff to consider as well.
- If you think about Langford, which is under going really rapid development, and rapid population expansion. It's the fastest growing municipality in the region, I think. To be able to say you're losing this much of this ecosystem at this rate from year to year would be really powerful, depending on who's the mayor. It is the numbers that allow that large scale regional planning, the CRD certainly cares. But it does require some method of regular updates like six months as a minimum. In a dreamscape, when you've got lots of money, you could develop somebody to use machine learning algorithms that would be able to do the basic work and then it would have to be checked by a human once every year.

3.5.4 Updating SEI

- *[KC: I have 2 questions for you: it sounds like there's a lot of new technologies with the PEM and the TEM and one of the comments we had was not to get to sucked down too many technology rabbit holes while the kinks are still being worked out. But in terms of possibly an interim step from our perspective one of the things that has been suggested to us by one of our interviewees was if we were able to update the SEI whether it was grounded in the TEM or not to make it more accurately reflect mature and old forest currently, and maybe it could be done with LIDAR maybe with what you're speaking about, if we did that, they we would be capturing most of the relatively good condition ecological communities at risk in the lowland areas. And that maybe, in terms of priorities that's what we should be focusing on while these other things are being worked out. I just wanted to get your thoughts on that.]* I'm always leery of SEI and updating it. I think you miss so much of the context of adjacent ecosystems, and of reporting to baseline conditions for your areas. As things change over time, how much have you lost of a certain ecosystem when you don't even know the full coverage of what you're dealing with. I'm not against the idea of doing it, I just think it's things we need to be cognizant of if you just take a stand alone product like that and update it, are we going to be in the same situation in another 10 years.
- *[KC – I think that it was suggested that potentially with the new LIDAR and satellite technologies, is that you could develop something that could be relatively easily updated in terms of looking at forest canopy structure and converted ecosystems, by combining LIDAR with satellite imagery. Local governments use SEI as a flagging tool when they have development permit requirements. This then triggers the need for a QEP to go out to the site and map what's actually there. What we're seeing now is huge areas of mature and old forests that's not captured in the old SEI, so local governments aren't even necessarily flagging those areas for a QEP to assess for a development permit.]* Exactly, but if you have the seamless coverage with TEM it wouldn't be as much of an issue. You can build those things in. Whereas if you have these stand alone polygons where you said, 'Okay, this is mature', or 'This is a wetland' or whatever, but you're missing everything else, you lose those opportunities and you do have to go back and remap and pull out new polygons. Where if you have a seamless coverage like an ecosystem, like a TEM map you can just update maybe with some of the structural stage modelling work that we mentioned before, or you're starting with something for your whole land base. You're not have patchy polygon coverage. I think the context thing was important too, with the Garry Oak Project, knowing what ecosystems are adjacent to some of these sensitive ecosystems is important, and that's

not captured in SEI. *[KC: I guess it's primarily for areas that don't have the TEM and the CWH_{XM1}]* It's coming. Slowly but surely.

- *[LS: I just wanted to ask in terms of thinking about that information and making it available and thinking about the SEI and the maybe issues it has with it in terms of aging. What we've heard from the local governments is that often they will fall back on the SEI. They generally aren't dialing into TEM if it's available, just because of the complexity of it, and they haven't really understood how to use it, even though it's got the SEI now embedded into it. But the problem that's been highlighted is the fact that forests develop and mature, and with the SEI potentially been 20 years out of date. What's the best approach in terms of catching that up when it's so expensive, and time consuming to collect that information? So how do you influence decision makers?]* Well, it's even more difficult than that within the Coastal Douglas Fir zone, more so than anywhere else in the province. The challenge with any mapping project is that about 93% of the Coastal Douglas Fir zone is privately owned. And it's somewhere between difficult and impossible to obtain access to ground truth any of it. Any other ecological zone in the province, that's not a problem, because there's tons of Crown land. It's almost all Crown land. But in the CDF, it's almost all private land, so it's very difficult to update. And I don't see that as being that much of a problem so long as people understand it. **You know that SEI is 20 years out of date. It would be nice, at the very least, to update it for development, which can be done from air photos or, depending on the nature of the development, even satellite imagery. But as far as just updating the age of the polygons, I don't think that's that important. And you know, so long as it's couched in the appropriate language about how this is 20 years out of date. And if a polygon is identified as such and such, in all likelihood, it's 20 years older than is indicated.** So you should look at some of these mature polygons may actually be showing more attributes of old-growth forests, and so forth. I don't foresee that as being that much of a problem.

3.6 Terrestrial and Sensitive Ecosystem Mapping (TEM and SEI)

3.6.1 Provincial Terrestrial Ecosystem Inventory (TEI) Group data

- I just wanted to mention for the TEI and ecosystem data that's publicly available, it's only current as of 2016. So that's a big limitation and gap to users that are actually downloading our data. We have a process in place, that not a lot of people are aware of, to contact us to get more recent information, because there's a lot of stuff: the Sunshine Coast, the National wildlife area mapping area for Qualicum. Fraser Valley has TEM in some patches and as you know, the CWH_{XM1} TEM that's underway.
- There's a lot of new stuff going on that we have and can provide pieces of or entire data sets as requested. So that's something that I think is important to get out there. We have to do a better job as well on our end and even when I was looking at the website for the CDFCP it mentions the TEM but then links directly to the CDF mapping, but there's no other linkage to the TEI group or provincial government, and we hold all of that data.
- So I think just letting users know that the CDF is here, the SEI is here is important, but letting users know there's also more data and more information that we [Provincial TEI Group] can provide, would be valuable. It keeps coming back to the education outreach thing is huge. And we need to better job of that and I think it's a huge gap that's missing, especially as far as to how to even interpret TEM and the ease of use, and all that. There's a lot of things we need to work on, so I just wanted to mention that right up front. There's a bunch of other layers that we have that I could potentially provide after that could support some of the initiatives as well.

3.6.2 SEI and TEM

- I do think this initiative is excellent to see. The hope to try to figure out what people are needing and what they're missing and gaps and work together. I think that's the whole thing – people look at TEM and think, 'Oh it's too expensive, I can't do it for my area.'
- But it's what you need. You need the seamless coverage that covers all the regions and if it was the same way in a consistent manner that everyone could use and rely on, that's what you want, and the TEM can be used to feed the SEI. That's the issue with the SEI right now. It's patchy and was mapped exactly as that, SEI.

- *[KC: an issue that I have found is that you can download the spatial layers but you need to know how to theme them to show what you want to see. What would be nice to have themed data layers, that local governments can download into either ArcGIS or QGIS already themed.]* That's another thing we're working on and doing a better job of now is using these realm, group and class fields within the TEM data set, which basically will identify things like floodplains or wetlands or forest of any type, avalanche tracks. Basically, it's a higher level classification that you can theme on and do exactly that and flag areas.
- If you have the TEM base you have the ability to extract SEI information and map for wildlife. You could theme it for different wildlife species and do wildlife habitat ratings. There's so many future uses. I think pooling resources and expertise and doing it right and getting good coverage for the entire area is so important.
- *[KC – teasing that out as a separate layer, you can begin to highlight where things are important for biodiversity, for watersheds, for maybe the cultural important ecosystems. We're also looking at wildfire resilience, but we'll talk about that separately. Local governments can begin to stack things and be able to look at the trade offs.]* Exactly. That's why I think having as much information at the beginning as you can and identifying exactly what your end uses are at the beginning is so important because that's why I was leaning to straying away from the SEI because you're so limited. It just shows you that if you have a TEM product with all this additional data within it, you can do various things and produce subsequent layers that provide them with the ability to do analysis on different things, so it just gives you more options for future uses going forward.
- *[KC – what I have heard is that ideally we want wall to wall TEM but the interface that local governments are using in their day to day decision making is primarily the SEI.*] That's probably due to ease of use. The TEM data can give you SEI. The TEM data can give you these realm grouping classes that just tell you, "I'm a wetland," without getting into the nitty, gritty of the TEM codes. It just hasn't been used that way and I don't think local governments are aware of how it could be used. Local governments likely think "Here's the tool I know, it's simple, it's easy to use, shows me what I want to know." I think that's just the education thing, we have to get past that and start to have more forward thinking and long term planning.
- *[KC – not all local governments have the resources to do the TEM mapping or even interpret it, so can we produce some derivative results from the existing TEM?, maybe an updated version of the SEI that they will use.]* Exactly. There's a whole bunch of interim stuff you can do along the way to help local governments prior to that being completed.
- As well, our TEM database has the SEI fields as well. The cross walking thing that kept coming up is a really important thing and can be very useful to do that. I do think that the seamless coverage is important. I think that then you use the realm, group and class fields and SEI fields within the TEM to theme and produce an AGOL [ArcGis Online] map that planners can use. It just makes it really user friendly and it can have all the meta data and information on how to use that product within that application.
- One of the problems with the TEM is that it's a patchwork. They might have someone out in the field collecting additional vegetation data, or refining it. Then they just patch that into the entire data set, so when you look at it you don't know what's from 2017 and what's from 2010.
- I know communities don't use TEM. It is too complex. I agree it's useful for other sorts of analyses, but not the needs of most communities. In a lot of communities, the staff don't have the capabilities to use SEI. I mean your contacts, it sounds like have been largely with some of the Greater Vancouver governments where the staff complement runs to the hundreds. We have 5 staff in our community. And so, you know, we have one person who does GIS, some of the building inspections and a bit of by law enforcement. So a lot of communities won't have a dedicated GIS person, so things have to be relatively simple and straightforward to use.
- *[DB: So, you mentioned the CDF is unique because there's so many private land owners. And even for something as simple as ground truthing data can prove difficult]* Yeah, I think that's good argument. Again, I think that's not possible. I mean it was a problem even with the initial SEI, I remember, being able to ground check some of the mapping that they did, and as a consequence the SEI is much better, is actually pretty good in some areas, and really crappy in others. And part of that has to do with the ability to ground check but that's a that's a particular problem in the CDF.

3.7 Mapping small ecosystems and point features

- Some examples challenges to ecosystem classification are because of scale. You can have mapping with mixed polygons that have various types of wetlands or wetlands that are lumped in with non wetland and that's not particularly useful for planning or decision-making at certain scales. I do think that we could do a better job of mapping smaller features. Things like vernal pools are of interest to me, but I guess circling back to your original question on that, I've thought a lot about the scale at which the ecosystems really matter to the people who are making decisions or resonate, you might say.
- I've been working a lot with Garry oak ecosystems recently and sometimes ask: do we need to know what *type* of Garry oak ecosystem it is, or do we just need to know that it's a Garry oak ecosystem? Do we need to know what type of wetland it is?, or do we just need to know that it's a marsh, or a wetland?, to take appropriate conservation action.
- There are other things that we've been incorporating recently too as far as point features in our mapping and that's directly linked within our mapping. Like with the polygon feature, you can have these point features as well that you can use to identify things that maybe aren't mappable, like that are less than 10% of a polygon, for instance. We used that in the Garry Oak project, and if it was a really small feature, they would use this point feature and say, 'This is a Garry Oak patch', or 'This is a sensitive ecosystem' or 'This is a wetland.'
- There are other ways you can go about it in our current TEM mapping structure that you can use to identify these things, and it would be a really easy way for local governments and planners to see areas that might be of interest or might be of concern as they develop these plans.*[KC: Is that something that's available now?*] It's available now. It's just something that we haven't been using as readily, but I think going forward, that's the plan, is that we can use these types of point features and other things to identify these areas, and if it's something that's important across the board for local governments, it's something we could implement more and more as we go on.
- It's a relatively new thing we've been trying to use to capture some of those smaller areas, but like I said, it's still embedded within our spatial geodatabase format. So, users can use it. Considering the user friendly aspect and potentially AGOL ArcGIS Online type maps as opposed to the TEM data that people don't understand is also important.
- *[KC: So there's the resolution issue, it was mentioned that in the TEM they're starting to develop a point feature layer for Garry oak trees or maybe it could be vernal pools.]* That's something I've talked to the province about, too. Karst was another feature type.
- Karst potential layer (though I have heard from experts that it's pretty coarse, and notably a POTENTIAL layer rather than actual): https://catalogue.data.gov.bc.ca/dataset/reconnaissance-karst-potential-mapping
- Also see **Section 4.2.1** on Garry Oak point feature mapping.

3.8 Wetlands and riparian mapping

- It is the same for the wetland inventory, which was a national initiative so they used nationally available data like Landsat and radar, which gives them very good maps at a provincial scale showing where the wetlands are. But on a point-to-point basis of is it a fen or is it a bog, it is going to be much poorer, as the data is good regionally, but not locally.
- For the wetlands and riparian, there's also the Nature Trust Riparian Modelling. I just learned about it the other day and I know it's raster based right now and there's some limitations with it, but it looks like it could be useful for some purposes. It looks like it has provincial coverage as well.
- If you want an example of that, we have our Williston Wetland Explorer Tool Willaston Wetland Explorer – it's a good one. Check that out and it will give you an idea of a basic way of how you could view the data that way and it could be easier for others to use.

3.9 LIDAR for mapping forest characteristics

- That LIDAR data would be incredibly useful for lots of things. One is going to be the prediction of biomass, but it will also give you vegetation corridors, structure of the vegetation, how complex it is, do

we think it is old or do we think it is young, do we think it has been harvested or disturbed in some way, what is the fuel? We can use the LIDAR to give us an estimate of the vertical structure, we can use it to build a DM [digital model] that shows streams. It is an incredibly valuable data set that is going to feed into many of the questions you have.

- *[KC: one the concerns raised is that old and mature and 'big-tree' forest is not being captured by the ecosystem mapping, and the VRI is often out of date or inaccurate. This also relates to the Old Growth Strategic Review, especially when they get to the consultation stage with big tree old growth identified as a priority. It seems LIDAR could cover off a lot data gaps in these areas].* That's right, it's a highly accurate map that can inform many of those things. You might want extra data, you might need species information for some things and you might need other pieces of information to support it, but LIDAR is going to underpin a lot of those things.
- See also **Section 2.3** on using remote sensing to map tree canopy cover.

3.10 Predictive Ecosystem Mapping (PEM)

- Pamela Dykstra is the lady at the Ministry of Forests who is doing the PEM work. She is the head of the working group. She is based in Victoria. The person leading the MetroVan mapping is Laurie Bates. She is excellent. It was Josephine Clark, but she has stepped aside in relation to the remapping. Pamela would give you a good sense from a provincial perspective of the challenges when moving from an interpreter based to automatic based mapping approaches. Her interest is PEM, but it is equally relevant.
- There is also an initiative – it's in the research phase right now provincially – looking at trying to PEM the province, so doing Predictive Ecosystem Mapping, which has been used more in the interior, whereas here on the coast there's been some issues resulting in varying success with PEM on the coast. Now working with new methods and new data available such as LIDAR and other layers. There is a desire to have full coverage of the province with ecosystem mapping, but the scale of that and the methodology is still being explored. It might not respond to the full list of the challenges round 1 interview results, but it could be something that gives us a better base layer with more coverage, and updateable, is the idea. If you have a good method that works then you could update it, ideally, a little more readily and have that full coverage.
- *[KC: I looked at the coverage of the PEM project and it looked like it was missing the Georgia Basin lowlands?]* We're just talking about it right now. We're doing some pilot studies throughout different ecosystems across the province, seeing where the methods work and updating them. We're still in the research stage, the beginning phases at this point and we were just discussing some coast areas to trial their methods. We're going to try next year to get out and pick study areas with a mix of some dry ecosystems, some more disturbed ecosystems, some of our wetter, steeper, mid coast ecosystems and then go from there. It's still in that research, beginning stage.
- *[KC: that would be adjacent to the TEM mapping?, or augment the TEM mapping?* They are thinking it might replace it. They're really trying to get it so that we can use it provincially and that's our big question on the coast. Can we do these new layers and methods that improve on TEM? Do they do a better job? Or is TEM still going to be the best product?
- We've done this before, on the coast. There was a big initiative, and it didn't really work very well for the coast which is why the TEM came back into play. There was a huge push to TEM map the coast. It will be interesting to see how this plays out and if it will be a feasible option going forward. For now we are planning to continue with the TEM, especially in the CWH_{XM1} and our plan is to continue with that and keep mapping away as funding becomes available.
- I think that's one thing, an afterthought of the PEM project, it might not replace TEM completely on the coast but perhaps it can pick up some of the ecosystems that TEM isn't picking up because of the scale issues. It might be able to be used in conjunction with the TEM depending on the values one is trying to manage for.
- The non-forest ecosystems are in question as far as the methods and how it will work for that, because it wasn't designed for those ecosystems specifically; it's more of a forestry based approach. So that's the other thing, some of these non forested wetlands and maybe even Garry Oak patches, who knows how the PEM will do at picking them out. And that's part of what we're looking into more this year; how these non forested units work within the PEM and the province's approach.

3.11 Interpretive mapping (PEM and TEM) challenges

- *[KC: one of the things that I'm hearing from ecologists is that they really like the Terrestrial Ecosystem Mapping because of its depth of ecological data. Do you think there is any capacity for LIDAR to identify ecological communities, potentially at a higher resolution than current mapping – some way to merge or integrate those two types of data (TEM and LIDAR) to come up with a better product?]* The Ministry has a pilot project to try to redo PEM - Predictive Ecosystem Mapping. Its like TEM but model-based – it gives you similar classes to TEM but they are predicted rather than observed by an interpreter. The methods they are exploring include climate and land cover data and satellite imagery, which they use to make predictions on a 5x5m grid, I think.
- The Province is running the working group that are looking at the feasibility of doing this. They have a few pilot areas including the Boundary area in the interior and Deception Lake in the north. They are looking at automating the process rather relying on interpreters, and LIDAR data is part of that prediction, but not LIDAR data on its own because there are too many other things.
- PEM also uses an understanding of how you think the site will progress; it has a trajectory component. Even today, all of those TEM and PEM approaches incorporate water regime, moisture regime, and everything from understorey herbs through to the overstorey structure. It's incredibly complicated. It's a worldview, a philosophy of how you view that site and all the things that are going to be occurring there, that is captured and mapped by ecologists. Ecologists use their experience and knowledge, plots and their understanding of the system, to come back and say this polygon is CDFxm05. So LIDAR is only really measuring the dominant overstorey structure, and it is much better in trees than tiny shrubs. It is not going to give you the whole picture and there is not going to be a direct relationship between the two. It can be part of the ecosystem interpretation, but never going to be all of it, even if you are using satellite data as well. You will only get part of it with LIDAR, because so much of those mapping systems are about the worldview of the ecologists. *[KC: their interpretation needs to come into it?]* That's right. We have invested massively in a highly interpretive based mapping methodology which makes it incredibly difficult for an automated system to replace it.
- *[KC: Do you have an opinion on that interpretive mapping system?]* I think people love it because they find it very useful and they think it works. I don't doubt that its very useful approach, but it means we have invested in something that is incredibly expensive, incredibly manual, incredibly interpreter-based and unrepeatable. *[KC: And that's not changeable? Isn't PEM trying to get around that?]* Yes it is, as is, perhaps, this idea of change rather than trying to redo / remodel a lot of the stuff that we already have. Maybe we are better accepting that we have it and then we think about how LIDAR can augment it as a change layer or a biomass layer. Maybe we accept that there is no technology that can come up with anything like TEM attributes, like species assemblages that we can predict - no technology can do it. And instead, allow remote sensing to come through to do things that its good at. Accept that we will end up with a Frankenstein mosaic of different data to give us different things, rather than one panacea of remote sensing that gives us everything we want wall to wall, because that's not going to happen.
- *[KC: In your opinion are there ways to train data, whether it is satellite imagery or LIDAR, maybe using TEM, to develop predictive mapping showing where certain ecosystem types might occur. If you had the TEM and high resolution LIDAR + satellite and ground plots, could you develop a layer that was higher resolution TEM? Could you get things more automated?]* Potentially, I don't know how accurate it would be and it would depend on all the layers you put in and what you are trying to predict. It is what the PEM project is trying to do. Can we completely automate this novel interpreter-based approach to ecosystem mapping? We can use the PEM plots that are collected and use all the geospatial layers we can find and then produce a model and do it all automatically at 5m rather than relying on interpreters. Because interpreters cost $500,000, but we might be able to do it automatically for $50,000. This is what the PEM project is trying to look at. If the ecological mapping is a whole suite of things that we are predicting, some will be predicted well and some will be predicted very poorly. For example, the presence of a particular fireweed, or a graminoid which ecologist use as an indicator but makes up only 5% of the ground coverage. It is going to be very hard to predict these kinds of things. Some aspects might predict well while others are doing to be more variable, but I think it is possible.

3.12 Soils, terrain and karst

- *[KC – any other suggestions about who we should talk to or what our next step should be with this?]* No, as suggested I recommend you talk with my colleague about the Terrain mapping. Otherwise,, it seems like your are reaching out to everybody and all the local governments and the workshops are a great thing and important to that.
- Yes that's why a lot of the time on our side we've been pushing for this what we're calling a TEM SIL 4, which requires a certain amount of field verification, but also includes bioterrain as well. Because the bioterrain is a really important component for things like delineating those alluvial fans or riparian areas. It really will help with your carbon stuff as well. If you build your TEM based on foundational soils and terrain information, you can be a lot more comfortable in your ecosystems that are on it and how things will change in the future. I think starting with a solid base as best as you can with the information that's available at the time, all of the data, to use it for all of those purposes is hopefully the way that these things will go. *Yes*, maybe later this summer we can talk about what the terrain data can be used for.
- Karst potential layer (though I have heard from experts that it's pretty coarse, and notably a POTENTIAL layer rather than actual): https://catalogue.data.gov.bc.ca/dataset/reconnaissance-karst-potential-mapping
- Our SIFT tool[3] for soils is kind of a similar format. It's a Soil Information Finder Tool. The process to build them takes a long time. There's a lot of approvals to go into it, but the end result could be something that's very user friendly and easily accessible and easy to understand so that people aren't downloading TEM data with numerous codes they may not understand.
- We can follow up on this at the workshop, and/or let me know if there are any specific types of features you'd be interested in. You've probably seen the SBOT and SIFT[1] tools? I'm not overly familiar with them, but they seem pretty good.

3.13 Vegetation Resource Inventory

- *[KC: One the suggestions that has come out of my interviews so far is that it might be worth investing in updating the VRI, which appears to be particularly out of date for private lands. There is a lot of information that could be mined from the VRI.]* Actually the VRI data for Salt Spring is quite good.

3.14 Ecosystem mapping decision trees, guidance and best practices

3.14.1 Decision trees on how to use mapping

- *[KC: I'm getting feedback that the SEI works as a flagging tool for local governments and the development community, despite its problems (e.g. not picking small ecological communities or many ecosystems at risk, being out of date, etc.). So maybe there's a framework where you say the SEI is appropriate as a flagging tool (to say there could be sensitive ecosystems or biodiversity features in a particular area (without necessarily necessarily delineating them), knowing that If development is proposed in that area, then a ground level assessment by a QEP (Qualified Environmental Professional) is needed to determine if sensitive features (e.g. hydrologically sensitive areas or ecological communities at risk) are actually on the site, and to identify and map them if they are. And you could create a list of sensitive ecosystem features of concern that could potentially occur within a each SEI category, such as ecological communities at risk, hydrologically sensitive areas, etc., and best practices for protecting them, so the QEP know what they're expected to identify and the standard of expected site-level management measures. Or maybe you go the route of developing more detailed mapping that tries to actually delineate all those features as well as possible. In either case, you need to show how different types of mapping at different scales and levels of detail are appropriate for different planning levels, and how they are nested (e.g. 1:20,000 SEI mapping for deciding where to direct or avoid development in a Regional Growth Strategy or for identifying regional level biodiversity corridors; vs. 1:5,000 site level mapping for identifying where actual sensitive features are on the ground, and should be avoided or managed during the development process, as part of the*

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

development permit conditions). However, I guess the more detailed the mapping and the finer its resolution, the less local governments have to rely on QEPs hired by developers to tell them what's important on the site, which can sometimes lead to disagreements.] If you created a decision tree like that, and there were some standards of best practice, even if they did the RFP process, then they would be required to follow the same framework and you would at least get some standardization.

- We were working with Kootenay Boundary Regions specifically, trying to develop a Strategic Plan for Ecosystem Mapping. We have developed flow charts and tools as part of that process.Hopefully that can be useful for people when they're trying to decide what type of ecosystem mapping they might need and some of the benefits and pros and cons of each. High level approach but it could be useful for local government to understand the difference between TEM and SEI. We do have that information available as part of that project.

3.14.2 Best practice guidance for mapping

- *[KC: I don't know that we would even be looking to do a regional roll-up of ecosystem mapping. We're likely going to be more focused on exploring whether its worth providing some guidance on best practices for ecosystem mapping on the south coast, and identifying opportunities for pooling resources to develop improved/updated products. MetroVan's work is cutting edge and they could serve as a great example, but we have these lower resourced local governments who don't have the resources and in-house knowledge to do this sort of mapping. So perhaps there could be opportunities to share resources and skills between local governments, if agreement could be built on what's being mapped and how.]*Yes that's right. As MetroVan employs consultants to do the work there, they could also encourage them to write up best practices, which could be shared with other local governments. That's half the battle. Rather than starting with a blank bit of paper, local governments would have guidance explaining: you'll need this imagery and this many points, these are the ecosystem classes your going after, you'll need a computer that is this powerful and you'll need $15,000. Best practice guidance and commonality in an ideal classification: ideally this is what we would like for future work, we want 15 classes, we want vegetation described this way, we want structure described this way, we want wetlands described this way, and some justification for doing so. That would be an excellent outcome because people can work towards that rather than being very myopic. Metro Van has never said how useful their mapping is to other local governments in the region, but if you had a document that said that if you use three wetland classes in your mapping rather than one it would help all of us, then that would be a great stimulus for them to go away and do it.
- I am happy to help facilitate this process. I've been involved from the start of mapping the CDF. I would love to see seamless mapping coverage that all local governments on the island and lower mainland can use.
- *[KC – That's where we thought if we could get some agreement in terms of the ideal gold standard set of mapping for biodiversity, for ecosystem mapping, for element occurrences, for carbon, for watershed resilience, and then some sort of decision tree that if you have this data, you do this. If you don't, you do that. Maybe an action item list where we can come together and say, "Here's the big gaps that we'd like to get filled. Can we pool resources?, can we pool expertise?, and can we start applying for funding at a regional scale?"]*

3.14.3 Checklists and best practices for QEPs

- *[KC – Do you think there's an opportunity to get a working group together to develop a list of criteria that could be used for development permit classifications and checklists for QEPS?]* Definitely. It was mentioned earlier about data we should be submitting data to CDC, there is a form, a conservation evaluation form that can be filled out that the CDC already has. It was often done as part of TEM projects and was done as part of the CDF mapping originally in 2006, 2007, 2008 that kind of flags those things and ranks the condition and ranks the fragmentation and leads into how CDC actually develops these element occurrences. There's standard forms that QEPs could be filling in. We could look at that aspect as well.
- *[KC – It could also be an opportunity at that stage if we develop a best practice guidance for local governments and QEPs.]* Yes, and that's exactly what this form is already. It's an older form, But it's worth revisiting. *[KC – Do you know how widespread its use is?]* Probably not very. But I don't know for sure.

- I'm hoping that the coming changes to the College of Applied Biologists, will lead to things like that becoming more common. *[KC – I think that's part of the problem. If we could provide best practice guidelines for this region, I think it would be helpful until that is resolved.]*
- And just in terms of the checklist you were talking about, I know Port Moody does one. They have an environmental checklist, which kind of gave them all those environmental values and things to look for. Then they call it Sustainability Checklist, they also brought in kind of more economic and social side as well, to help them evaluate, at a municipal level, you know, this might damage a few more, like require a bit more tree removal, but they're going to get all these social benefits from it in terms of day care and things like that. Or if they take a look and there's none of those benefits then maybe they'll tell them, they need to protect more of the natural areas. That helps them not just evaluate the environmental side but compare it to the other aspects as well to help them with their decision making.

4 Species and Ecosystems at Risk (SEAR) Mapping

4.1 SEAR mapping constraints and suggestions (general)

- Provide extracted red and blue-listed ecosystem information with only the fields that they require, along with the suggested buffers to make the information more accessible and helpful. But you have to provide warnings as well, such as for things that do not always show up on the maps (like little wetlands, which can be captured through RAPR instead).
- Mapping is a nice concept to the people with good intentions, such as landowners (like on Salt Spring Island) quite often are good with wanting to protect areas through a covenant etc., but we need the bigger picture to consider others, such as forestry.
- Is it important to not just have the boundary of the feature included. To be effective, what is needed also is mapped buffers that show what is required around it to protect the feature (whether it be in the form of mapped ESAs and SEIs, and/or red and blue-listed communities). Without mapped buffers, the areas get eroded if you're only focusing on the edges. Buffers should be mandatory.
- Mapping of hotspot biodiversity is beneficial, which is typically where you have the connectivity and some of those older features.
- *[DB: And in your experience, do you feel like there's something that would really help the staff?]* Sure yes, there are lots of tools really help the staff. **I would say they're largely GIS layers that identify species and ecosystems at risk.** So that if a council or a regional district is considering something on a particular piece of land, that when they look at that particular piece of land, it will pop up that that piece of land contains or is adjacent to species or ecosystems at risk. And if it is some kind of simple and straightforward tool that they can use, then with any luck at all when any proposals affecting a piece of land are brought to that council, they will be accompanied by a note, that that piece of land or adjacent to it, contains species or ecosystems at risk.
- yeah, I agree with that. And I think there's often, you know, a different level of quality in some of these environmental reports that come in as well. And they're not always consistent across sites, or providing the same type of information to the same level of detail. And sometimes I think some QEPs might put a little bit more of their values-based judgment whether or not a site counts as a sensitive ecosystem, for example. I've seen some that, you know, think presence of invasive species might make it not, and others might disagree. There are not always some clarity rules around that as well.
- *[DB: And do they also have to lay out any consequences? Or is it just a note that this contains species at risk?]* Well, I mean to the extent that you can talk about the factors that are putting a species or ecosystem at risk, then that would be useful information. So that not only are the decision makers presented with the fact that yes, there is a species of risk here, and if you know if the trees are removed, the species will disappear say.
- I'd want to make sure that the municipalities are aware of the resources that are out there; the provincial observation database "SPI", the CDC; are they checking the Element Occurrences? Are they checking the federal critical habitat, are they checking iNaturalist? They should be aware about what's

already out there. For something like the CDF, look at the CRD atlas; that's a great resource. There's great imagery in the Atlas. Then they need to think about building capacity and think about what values are important to them. Can you get people together to gather those data?

- I did see that as a challenge as well, that people keep finding red listed ecological communities that are not mapped by the CDC. There is this perception that it's not red listed if it's not mapped, and I constantly disabuse people of this notion because we are aware that there are lots of red listed ecosystems that we just haven't mapped.
- I think we have a bias in the province because of access to data. We tend to use vascular plants and vertebrate animals as proxies for everything. We don't think so much of invertebrates, nonvascular plants, bryophytes, lichens and fungi. We just always look at those two groups and I wonder what's lost with that approach. At the same time that's what a lot of people care about. They're the charismatic species and we do have the most knowledge about those species.
- *[LS: we have seen that local governments understand and protect habitat identified as SEI, but they struggle to deal with valuing habitat outside the SEI boundaries. Do you think that it is valid for us to try to find an additional layer that could express the need for a range of habitats across the landscape to support species e.g. bats, amphibians, ungulates etc?]* I think it is valid, one of the issues with that is habitat for what species. For example, tree cover and connected tree cover might be a good indicator for something that uses the canopy, but if there's a road underneath it, maybe it's not so great for a mammal. I think understanding how to incorporate some of those constraints and the way that you're presenting it would make sense to me. I might think about protection of undeveloped land. As long as it's not paved over, it's probably offering some potential habitat, so having that as part of the conversation is important. In Saanich, has something like 67% tree cover, yet I wouldn't say we're doing a great job of thinking outside the box.
- There are three key points of contention around being able to create a map like that *[of ecosystems and species at risk].*
    1. The availability of information from private properties. I think biodiversity at this point, is often in private properties where there is space that hasn't really been disturbed or changed and the issue is that people want to leave open their options so that they could eventually develop it or change it in some way. They don't want the constraints that come with public knowledge of what's on that space. So, mapping on private property is almost impossible.
    2. First Nations communities don't really want publicly available maps of their reserves for very obvious reasons. I feel like I know, there are internal maps that have been developed to some capacity for camas harvesting sites, those are not publicly available and partially because of that they're not particularly well developed, I think there's a lot of gaps, there hasn't been a lot of capacity to be able to go towards building those kinds of resources, because they need to be private.
    3. The third major issue is that there's not a lot of consensus on what exactly we would be mapping. Quality of habitat, when you're thinking about connectivity, it a real bone of contention. Does it count as habitat if it's highly degraded? and a lot of the spaces that are left are highly degraded. So how do you make sure that you're mapping in a way that actually does capture connectivity? what does that mean? how does it depend on things like habitat quality?

4.2 Mapping Garry Oak systems

4.2.1 Using TEM

- No matter what scale you map at it's not going to be 100% accurate, even if you're at 1:1000. Like you said [about] infilling of [Garry Oak ecosystems by forests]. That actually became very evident with the last work we did for the Garry Oak work and the CWH_{xm1}. Our consultant mapped all these ecosystems as potentially Garry Oak, and it wasn't until they went out in the field that they were able to say yes or no. We were really having a problem identifying them at the mapping scale, even zooming in 1:1000 because of some of those things you were talking about – infilling and other issues identifying these small ecosystems. There's always going to be a limitation with mapping.
- For the CWH_{XM1}, we have refined Garry oak mapping, so Garry oak mapping polygons are embedded within the seamless TEM and as a stand alone product that was field verified. So that does exist. A similar thing hasn't been done for the CDF yet; that would still be the old mapping. I believe it is using

the new classification that will be coming out. And like I said as part of that, point features were used for identifying areas for Garry oak trees or stands.

- There's a bunch of work that's been done already that could be basically incorporated right now to help identify some of those areas, but like I said, it did come up as a limitation with the mapping alone. It's very hard to identify these sites just based on imagery. Field verification is going to be needed to nail down where some of those sites are. Even with recent digital imagery and zooming in to 1:1000, it's still hard to tell if it's a Garry oak stand or a sensitive ecosystem.
- *[KC – was looking at the TEM with the Garry oak polygons and they seem to be quite a bit more expansive than the actual element occurrences from the CDC. Then speaking to the comment that Garry oak systems would have been more widespread than they are because they were actively managed by First Nations, to produce a predictive layer that identifies where Garry oak ecosystems used to be? Back in the 90s in the Okanagan we looked at mapping of habitat suitability versus. Habitat capability. That was for specifically for species at risk but I was thinking about habitat capability for Garry oak systems if there was prescribed fire, if those stands were thinned. Because there may not be Garry oak elements now, but there could be if the management regime changed.]* Exactly. That's why I keep going back to the need for seamless coverage, instead of just pulling out SEI. You need to know the context of these areas. Right now, the Garry oak mapping shows you where it currently is, but what's directly adjacent? Is that something that could develop in Garry oak in the future, all these pieces that are interconnected.
- *[KC – So that is a product that could be derived from the TEM mapping; a Garry oak capability layer. If we had that, and we had a specific set of criteria for QEPs who work in the Garry oak zone, that if there's a development application in the Garry Oak capability zone, that the QEPs would need to have a checklist specifically for these pieces to be identified and maybe even a suggestion that if the parcel was suitably large a condition of development would be management activities e.g. thinning, or prescribed burning to try and bring that back.]* Yeah, that was the first step of a project for the CWH_{xm1} was identifying Garry oak potential. So they actually went through and ranked the entire area as High/Moderate/Low based on a whole bunch of different features and pulled out areas that they thought were going to be most important, and those were the areas they visited and field verified and then refined the mapping according to that. We already have a Garry oak ranking for the CWH_{XM1} for the whole area. *[KC – So that could be done for the CDF when the TEM is updated?]* Yes, 100%
- *[KC – that would resolve the concerns raised about the Garry oak not being picked up; the small patches and under canopy.]* Yeah, at least it will give you those areas where you should think about visiting. Like you said, just like a habitat suitability map or capability map. You'd say, "It's moderate, we think there's a chance it might be here, maybe it's not but at least it's worth checking out."*[KC – that could inform checklists for permit applications issued by local governments?]* Exactly, then you could cycle back into some of those forms that would get submitted to CDC and say, "Yes/no, it is a listed ecosystem, but it's been logged", or "There's this many invasive species presence and 5% fragmented," and that's where you start getting that level of detail.

4.2.2 Garry Oak classification

- *[LS: has someone developed a classification system for Garry oak ecosystems?].* Dan Leithinger and his colleagues put together a classification system for each individual type of Garry oak and associated ecosystems. That's a fairly extensive, very detailed classification system, I think there's 13 different kinds of Gary oak associated ecosystems and then there's also a suite of coastal bluff systems that are associated with arbutus more than oak trees. That's not really contested, although it's quite hard to implement for someone who doesn't have a high-level understanding of plants and plant communities and it is quite a western science perspective of looking at these ecosystems.
- Another thing that came up when I was working on Garry Oak ecosystem issues were, like the trees don't make the ecosystem. Just because you protect the trees, but you, clear all the understory around it and plant a lawn doesn't mean you still have a Garry oak ecosystem. It just means you have a few Garry Oak trees and a lawn. So there's a need to differentiate that.
- And I think for a lot of the public, they don't understand that. When you name the ecosystem after the tree, they think it's about the tree. And it's not about the tree, it's about all the other plant and animal species that utilize the collective ecosystem. So I think again, that's probably a forestry based lens. Historically, we were a forestry economy, and BC was forest oriented. So we've named all our

ecosystem communities after trees, you know, Coastal Douglas Fir. For Garry Oak, there was actually debate among some of the biologists what we should call it? We should call it something else, like coastal grassland ecosystems, or like, coastal savannah ecosystems, oak savannah ecosystems to recognize that it's not just the tree, it's everything that the tree is a part of - the natural system that tree is a part of.

4.2.3 Condition, stewardship and restoration

- *[LS: mapping of habitat connectivity appears to be an area that local governments and First Nations are struggling to map. I was just wondering what your thoughts might be as to how we could approach this?]* It is a big question, and it's definitely important. I work in Garry oak meadows a lot and it's a naturally fragmented ecosystem at this point. It probably wasn't in pre-colonial times, but now it's patches that are scattered across the landscape. I think one of the obvious weaknesses is that we don't have a map of where they are.
- I would say the contention that I was talking about is more about habitat quality. There was a gentleman called Ted Lee, who produced a historical map of oak meadows, which is mostly just a guess. His current map, from 2000 is the only one that is cited in the literature. So, when you hear that number 5% remains, that comes from Ted Lee's historical map. Ted Lee was also one of the RP Bio's who was looking at habitat quality, particularly on private property and determining if it doesn't count as an oak meadow because it's too degraded, therefore, it shouldn't be covered under the bylaw for needing permits for development.
- I'm just thinking of CDF ecosystems in Saanich, North Cowichan, there's always a debate on what qualifies as a Garry Oak ecosystem or a sensitive plant community some more sensitive plan community, how far departed it is from a natural system. So, do you still map that as a sensitive plant community, or you identify as a potential restoration site. I think definitely the mapping, understanding spatially where things are is the biggest gap to manage these areas.
- You get these remnant Garry oak patches that are not in good condition. They're impacted by grazing deer and invasive species but we encounter this question which is at what point do you not call it a Garry oak ecosystem anymore? But then if it's not a Garry oak ecosystem, what is it? It's still something that is very at risk and has value….If we're vetting and only mapping the best intact Garry oak ecosystems that remain, we shouldn't map it but at the same time it's something that is very at risk and valuable, even if it's novel.
- Particularly, we haven't touched on cultural ecosystems yet, where the long-term integrity of an ecosystem is directly reliant on stewardship from humans. There's a strong link to be made there.

4.2.4 Bird models/analogs

- *[KC – one of the things we had suggested is that you could use bird models to predict where Garry oak systems are.]* That's interesting. I have not seen it done. I've heard about people doing it. I haven't seen the results of it, but it sounds very interesting. *[KC – if we were going to do this workshop in the fall would that be of interest?]* I think that would be great. Not just for Garry oak but for other ecosystems or culturally sensitive plants, things like that. You could use it for anything if you can start relating species use to a specific plant or ecosystem community. Definitely.
- *[KC: I have a question for you about bird models being used to identify at risk ecosystems based on crowd sourcing iBird data. If you can pick out certain groups of birds that indicate where Garry oak systems would have been found. One of our interviewees said they could be a better predictor of where Garry oak systems are or used to be.]* Maybe. You might even think of some invertebrates, butterflies even, if you're looking for a proxy that is directly connected to specific host plants. *[KC: I think the reason this person was suggesting birds was because there's a lot of data.]* Yeah. That's a thought. *[KC: We're trying to see if we can source someone who can talk to this opportunity.]* Yeah. It's not something I know a whole lot about, but I've encountered the idea.
- *[LS - Have you heard of anybody trying to use bird data specifically to predict certain habitat types in the landscape e.g. Garry oak?]* I'm not a bird person but I think in relation to Garry oak there are not many habitat-specific bird species aside from blue birds/
- A really strong association that I'm aware of is between Clark's nutcracker and whitebark pine, a federally listed species. Clark's nutcracker spreads the seed so usually we're you find nutcrackers, you find whitebark pine. That's a really nice relationship that you can easily map.

- What you're talking about is using a species as a proxy. I think you can do that but be transparent about what you did. What are the drawbacks of that, and what are the advantages? I think the utility of it depends on what you are trying to do; are you trying to map forest types? Are you trying to map ecosystem types? How are you classifying your forest types? How are you classifying your ecosystem types? It's a little tricky. There's a lot of people birding but are there people in the northwest of the province birding? Probably not. It could be a valuable approach, but you would need to be transparent about the limitations of the mapping.

4.3 Mapping restoration sites

- Particularly, we haven't touched on cultural ecosystems yet, where the long-term integrity of an ecosy Nancy Shackleford at UVic and some of her lab members also recently created a cool Garry oak restoration map: https://www.restorationscience.net/map-of-restoration-projects.html
- For the CDF, Madrone in the early 2000s, did a mapping project with Helen Reeve(?) before she retired, and mapped sites for restoration and recruitment for CDF. It would be interesting to revisit that, even though a lot of the areas are probably gone at this point. Mapping efforts and products have been there, but the policy and frameworks just don't seem to work.

4.4 Conservation Data Centre (CDC) Element Occurrence Mapping

4.4.1 Activities and tools

- The Conservation Data Centre is part of the NatureServe Network. The NatureServe Network is a not for profit that used to be the sister organization of The Nature Conservancy. The Nature Conservancy does land stewardship, and we focus on data. There's a Conservation Data Centre in each province and territory in Canada and in the US. We all use the same database, mapping methodology and ranking methodology. The BC CDC's core activities are to identify the species and ecological communities that exist in BC, assess the conservation status of species and ecological communities in BC, we map known and potential locations of species and ecological communities at risk, and we make these data and information publicly available.
- By default the CDC have an open data policy. We try to make everything open and out there. We do serve a lot of local government, academia, industry, consultants, First Nations, federal government. We answered over 800 custom client request every year. We have a number of tools folks can use to interact with their data and to do their own analysis; CDC iMap and we're also just about to release for a new tool called EcoAtlas, which is combining the BC CDC Conservation Data Centre's data along with the provinces inventory data.
- The CDC do a lot of outreach too. We'll talk to local governments, the College of Apply Biology, regional staff etc. I also volunteer in my community. We talk a lot about the CDF and the CWH_{xm1} and the challenges with a lot of it being privately owned.

4.4.2 CDC Element Occurrence mapping

- At the moment the CDC map Element Occurrences (EOs). We use the word "element" to mean a species or ecological community. We map occurrences (which are polygons) and they are an area of known conservation significance.
- *[KC: So when it goes on your database, is there a site level confirmation requirement for you to upload it into your mapping?*] Yes, at the very least, we check the imagery. But you will see when you browse with our tools, there are always notes on whether or not it's been confirmed on the ground. We try to do so as much verification as possible but at the scale of the province, that's not always feasible. We do make a note about whether a specific mapped occurrence is based on TEM and it's not been visited on the ground, or when it has been confirmed with five field plots, etc. Then the other thing about the latest updates is that we have eliminated some of those big circles and made them into more precise spatial polygons.
- The Conservation Data Centre publicly releases element occurrences but we're looking to also release a suite of spatial data for people to use. Element occurrences are a good product - they're precise and they're accurate. When I use the word 'precise' we're referring to decimal places. How coarse or fine

something is. Generally speaking, 'Accurate' refers to whether something is correct or incorrect. That's why element occurrences are great because they are precise and accurate.

- There's sampling bias in the province. The CDC build element occurrences from point data - you see a bird you take a latitude and longitude. That's a point/observation/inventory data. We build element occurrences from data and these occurrences can represent a population of something depending on the species. The problem is that for some species, the points and occurrences are accurate and we have good coverage, but we have so many species at risk in BC and we often don't sample in many places across the province. The province is crazy in terms of topography and there are a lot of inaccessible places. Sometimes our occurrences are limited to where people are doing development projects. As a result, we have major sampling bias in the province.
- There are also lots of areas that just don't have quality ecosystems on them anymore and that's one of the things the CDC does when mapping occurrences of ecological communities at risk. When we mine the TEM data if it looks like ecosystems have been obliterated in the time since the mapping was done, it's no longer considered to have as much conservation value. *[KC: So there's a condition threshold to meet the ecological community at risk criteria?]*
- The Provincial Terrestrial Ecosystem Information Group is the main source that the BC CDC then goes and takes to use for their element occurrence records. The BC CDC high grades the occurrences of interest, has an ecologist confirm the conditions and that it meets that element occurrence. And then it goes into their system so that anyone who's searching for rare keys of any kind, through an environmental impact assessment, or just out of curiosity, knows it exists.
- We are behind on our Element Occurrences, but we're pretty good for CDFs, but they probably need to be revisited because who knows how those have changed since they were originally mapped. We do work with the Islands Trust often to update their mapping to show the change over time. Can be depressing work, but sometimes there's still a lot looking healthy.

4.4.3 Using TEM to identify element occurrences

- *[KC – that statement I made about most of the ecosystems within the CDF and the CWH_{XM1} are ecological communities at risk, is that something we can safely say?]* I believe so. I think pretty much everything is listed.
- *[KC: My understanding is that the CDF and the CWH_{XM1} are almost wall to wall red and blue listed ecosystems at risk. Is it correct to say that?]* Almost. *[KC: When I pull up the CDC ecological communities at risk mapping, it's not wall to wall. Am I correct there hasn't been comprehensive mapping on all 35 ecological communities at risk in the CDF area?]* It's complicated but I can unpack it. There are tons of gaps in raw data that we get. Mostly we mine products like the CDF TEM, the one that Madrone did in 2008. If there's a polygon in a TEM product of one of those red or blue listed ecosystems and we feel good about that polygon (meaning that there is good evidence to support the presence of that ecological community, such as plot data, and the accuracy of the delineation of the polygon or proportion of the polygon that contains that ecosystem), then we'll map it. We've made pretty good progress on that.
- But then for the CWH_{xm1} there isn't a TEM. It's not necessarily covered, so we actually don't know what is there. So that's our main source of data. We mine TEM projects and SEIs, or we can, if we have a chance, go out and do our own field data collection, but there's a really powerful point there which is that there's tons of ecosystem mapping done on private lands which is not shared with the province, not accessible, and not mapped or made public, so I think if that could be done then we would definitely move closer to that wall to wall mapping.
- *[KC: It seems to be that there could be an opportunity for a contract for someone to go through and theme the available to highlight important ecological communities at risk and develop pre themed layers that local governments could use. Maybe we could house it on the CDFCP website and spread it through our networks that this information is available.]* Exactly, that was the whole point of the CWH_{XM1} project, was to get full coverage for the entire area and then you'd be able to do that and you'd have those layers. It's there, we have so much underway and compiled already, it's just not completed because of lack of funding.
- *[KC: What I wanted to highlight is the difference in occurrences of Garry oak between the TEM and CDC. Can TEM be used to develop predictive mapping for ecological communities at risk ?]* Yes, that's exactly what I would do, is theme it that way and pull out the Garry oak ecosystem.

- I know that the CDC do pull in the TEM when it's available and review that to consider for their elemental occurrences. But again, we're also out of date on what we're publishing as far as TEM. The Garry Oak stuff isn't available for what we recently did for CDC to even use to go through this process. We're always a step behind.
- *[KC: with the other ecological communities at risk in this CDF. Can you use the TEM to predict the likelihood of each of those occurring? Is there a crosswalk table? I've seen one and I've started trying to work through it and pick out some of the TEM polygons that were cross walked with the different ecological communities at risk, but some of them didn't crosswalk well.]* Some of it is pretty tricky and that is essentially the work that we do and why it's so time consuming, is cross walking those. The other complicating factor is that the province is updating the field guides for the west coast. There's going to be the added complication of having to crosswalk old ecosystems that we've ranked as red listed to the new field guide. It's pretty into the weeds, but I guess you put your finger on one of the issues and why it takes so long, that's our main source of data. We need to go out there and mine that data and crosswalk them, sometimes from older mapping or classification systems, and sometimes verify them through field visits or aerial imagery. But that's also the strength of those CDC layers. If it's mapped by the CDC, it's probably there.
- *[KC: When I look at the TEM data for Garry oak ecosystems and I compare it to the mapping of the ecosystems at risk layer held by the CDC, the CDC mapping doesn't highlight all the Garry oak recorded in the TEM?]* When is your CDC data from? *[KC: It would have been downloaded last year.]* If you go to our website right now and check those out, there is probably going to be better correspondence. In the last few months we released new Garry oak element occurrences, based on that CDF TEM.
- *[KC: I would assume that you would cross check an occurrence of Garry oak in the TEM with satellite imagery to determine if it was still present?]* Yes, or field plots if we went there, or if someone went there. If it's a condo now or a gravel pit we wouldn't include it.
- Legal protection of red and blue ecological communities would be helpful, as well if there was a clearer direct link between the site series and the ecological communities. That has really led to a lot of confusion as it is not always a one-to-one relationship. Need clarity that just because it is that ecosystem, doesn't mean it is considered red or blue listed.

4.5 Condition, structural stage and at risk status

4.5.1 Defining which ecosystems are sensitive

- Anything that is basically a floodplain, a wetland, a grassland, Garry oak system should be protected and sensitive, no matter what. But it's more those forested ecosystems with the structured piece that I think are probably being missed and it's a big issue obviously. You know in the CDF and CWH_{XM1} because everything is listed.
- *[LS: we have been hearing that ecological communities at risk are not well defined, do you think that this is an issue?]*I'm the wrong person to ask because I don't really like arguing about definitions. I feel like letting people decide for themselves is in some ways best. If I was putting together legislation on something like that, instead of saying it counts or doesn't count as habitat, give some specifics on a scale of quality.
- So, how do you come up with something that's fairly objective about what quality this particular example of oak meadow is, and then allowing people to use that to inform whatever decision making they are going through at the time, so if there was a way instead to map out the status of it in terms of forest, it might be standard age, it might be something about the forest structure that allows there to be an overarching map that captures the range, but allows people to make decisions within that range in a clear and informed manner. I think that to me makes the most sense.

4.5.2 At risk status of harvested upland/forested ecosystems

- A lot of what we do as far as the TEM projects and ranking of considering things red or blue listed, we're basically using climax condition things, so old forests. A lot of what I was reading in reports was concerns around ecosystems that were logged but not listed as sensitive. And I'm not sure what the CDC does for that, but a lot of what I've been reading, and some of the advice coming from the Great

Bear Rainforest, which leads to old forests, wetlands and flood plains of any state being red or blue listed. It sounds like it's not clear, based on the report, what actually qualifies as an ecosystem at risk.

- *[KC: that's what we're hearing. There's not a recognition that uplands systems, if they're not in a pristine state, are at risk.]* But that's the thing, I'm not sure if that's how it's defined.
- *[KC – it was pointed out that there's forestry on agricultural land that was harvested back in the 30s, when they logged out all the timber licenses. So now all that forestry is getting to the 100 yrs. Old stage but it's not identified by the SEI. Even if the SEI is updated, there could be pushback from the QEPs saying it's been logged, so it's not an ecological community at risk.]* Yes, that's kind of what the standard practice is. If it's been logged, it wouldn't be considered an ecosystem at risk.
- I think that one thing the CDF struggles with too, and I this is less probably relevant to the lower mainland, and more relevant to like Vancouver Island is the rare plant communities or ecological communities that we map in the CDF, it's based on a climax community concept. And so a lot of the CDF has been logged historically, and there are very few areas that remain as old growth CDF. And so there's a question that should be considered a rare ecological community if it's been logged? And where does it then become that rare ecological community, even though it probably has the potential to one day become that rare, ecological community? I've seen a lot of confusion around that concept. When we're mapping, rare ecological communities, is it based on the potential of the area to become that community again over time? Given the amount of time for the forest to regrow and succeed into an older, more mature stage? Or is it just based on whether that's present now, in that mature stage? I think that comes out of our ecological community mapping in BC being based on a forestry template where it was focused on like, how do we manage these things in the forestry context? But in an urban development or a land development local government, context, there are different questions that are asked for different things. So that that system is not necessarily working. Doesn't work great in a developed landscape concept.
- Madrone (2022[4]) suggested adding categories for forest ecosystems at risk as per GBRF, including 250 plus yo stands, flood plain ecosystems of any age, and:
  - Stands ≥140 years with Veteran Overstorey Trees (VOTs)≥ 15 stems per hectare (sph), and
  - Stands ≥80 but ≤140 years with VOTs ≥ 20 sph.

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

4.5.3 Guidance for QEPs and local government

- *[KC – We're starting to think that maybe we need two levels of decision support, firstly trying to improve what ecosystem mapping there is and update it, but secondly recognizing that we're never going to get things to the scale everyone wants and maybe we need to provide some decision support for site level assessments. We're imagining providing boilerplate policy guidance about ecosystems at risk and other nature-base services that local governments can cut and paste it into their OCP, into their environmental development permit language. Then maybe also a comprehensive checklist of things for QEP to look for when they're doing the site level assessment as part of a development permit application. To try and get past the problem of the gray areas where a QEP says, "That's not an ecological ecosystem at risk," but maybe someone is saying there is.]* That's something that's really important that we have to clarify and define what meets that criteria. Because I do think that most QEPs right now would report a red or blue list community for a forested ecosystem only if it was greater than 250 years old.
- That's sort of the guidance that's been put out there, especially with the red and blue list. Then there's been this additional notion of sufficiently established stands which have a whole bunch of requirements

[4] From CWHXm1 draft TEM report.

as far as veteran trees and things like that (see Banner et al., 2019 – Guidelines to support implementation of the Great Bear Rainforest Order with respect to old forest and listed plan communities). There are younger stands that could potentially be included, but the general practice right now is that it would be mostly mature to old stands for forested units that would get pulled out as actually sensitive or at risk. Mature, is around the 80 year cut off.

- *[KC – I guess one of the things that local governments have highlighted is that when they try and bring these criteria in, then they often get pushback from the developers who don't necessarily trust their expertise, because their QEPs might be telling them something different. One of the things that we've been asking for is guidance from the province stating that these are features that are considered sensitive.]* That's where we need that legislation piece that we don't have.
- *[KC – in absence of that, local governments can through the Local Government Act set their own criteria, if they can say that, "This is sensitive," and if they can have some guidance that doesn't necessarily have to be regulatory from the province saying that these are considered ecological communities at risk whether there's provincial legislation protecting them or not, local governments can potentially require that they be addressed at the site level during development planning.]* I guess that's where the structural stage of the forest comes into play. Really nailing down what the actual official requirement is.
- *[KC: the challenge I've found is that consultants or the local governments go to the Sensitive Ecosystem Inventory, then they go to the ecosystem explorer and that's it. There seems to be this perception or practice among consultants or QEPs in that if you have consulted the sources above and a forest has been logged, it's no longer an ecological community at risk. One of the things I wanted to run past you as an idea, can we have something which at least flags the possibility of ecological communities at risk? That could be an updated SEI. One of our interviewees suggested that if the existing SEI was updated to capture mature and old forest that would pretty much capture all the high-quality CDF ecosystems left. If you just had that and then the best practice guidance to local government was to use that as a flagging tool to say if you have an area that falls within this and it's mature to old forest, there's a good probability there's ecological communities at risk. They're not all going to be on the CDC ecosystem explorer website. We could have written guidance for QEPs detailing the ecological communities that they should be looking for and here's the criteria for inclusion as an at risk community; condition criteria. These could be developed by a provincial working group with other representatives, and we could produce a package of guidelines for local governments to use.]*Yeah, I like the idea. My first thought is that any QEP worth their salt will get there anyway. They should know enough to recognize, as you have, that most ecosystems are going to be red or blue listed and so if they're working in the CDF and they see an ecosystem that looks relatively intact, and it's not already a parking lot, they should be doing their due diligence recognizing it's there and making recommendations accordingly. But I also recognize that we do constantly get that question: "It's already been harvested, it's kind of young now, so we're not sure whether it is that red listed ecosystem. It's a wetland, it's degraded, it's just wet ground now, is it really a wetland?". I do think we encounter those questions and that confusion enough that some clarity would be warranted in the form of a tool like you've described.
- *[KC: Do you think there would be an interest in the appropriate people in the province getting together in a working group to develop a guidance document. Something that could be a companion to the Green Bylaws Tool Kit in the CDF area.]* Yeah, I think there would be value in that. I might speak to Katrina Steinbeck who deals with direct questions from municipalities to get her opinion. She helps them produce the list of what's there or interpret what they've found. She has a good sense of how frequent these things are asked. I see the requests when they become complicated enough to need an answer from an ecologist

4.6 Species range maps and habitat suitability models

4.6.1 CDC species range maps

- *[KC: The other thing we talked about is the possibility of using the TEM for predictive mapping for ecological communities at risk and habitat for species at risk and that would provide an even finer flagging tool than SEI that local governments could use.]* The province and the CDC have been working on habitat suitability models and range mapping for species. When you first started talking

about the value of broad scale flagging tool for ecosystems, I thought of the range maps. We're working a lot on better range maps for ecosystems and species.

- We are looking to build data products that can help mitigate some of the sampling bias. We've been working on a product called Species and Ecological Community Range Maps *[see method here, for completed amphibian and reptile range maps]* These are provincial scale maps that are based on Ecosection line work. There are 139 Ecosections in the province which are big polygons. If a species exists in a Ecosection polygon it's considered to be "present". We assign the category "presence expected" during the expert review process and an expert identifies that no one's surveyed there, but that habitat looks good for that species or if it historically would have been. We're hoping to release the range maps soon. Then we're moving into wanting to produce species habitat models. The Conservation Data Centres perspective is that we are looking to make more spatial data to serve our clients.

4.6.2 Species range maps and habitat models

- *[LS: Do the CDC range maps reflect species habitat preferences within their range?]* That's a really good question. Why do we want to produce species range maps and species habitat models? Going back to what I was saying in terms of accuracy and precision, I view the species range maps that we're making as accurate, but not precise. Whereas the species habitat model is going to be more precise, but accuracy is going to vary. One important part of species habitat models is how to be transparent about that accuracy. We are often asked why we are bothering with the species range maps. Firstly, the species range maps, the methods are fairly simple for folks to understand and they're simple for us to produce. For a species habitat model, the outputs are great, they look great but the devil is in the details. You have probably heard the phrase 'garbage in garbage out' with models. If you don't input the right variables, or if you only have highly biased input data for the species, your model accuracy can be low.
- *[KC – I looked at some CDC species range maps because I was thinking back to the habitat suitability models that were developed in the Okanagan, which were different to the range maps, because they actually picked out the ecosystem elements that those species required within in their range.]* Exactly. I think they're looking at kind of both fronts on that. There are two products that are coming out of it. I think the range maps are one and the more ecosystem based is another. I do know they're looking at compiling some of the wildlife focus information e.g. breeding bird atlas.
- With the range maps, we produced them at a provincial scale. I also see the need for them at a national scale. I'm part of the national working group called Ecosystem Based Automated Range Maps (EBAR), and we scaled this up nationally. We're trying to do the same thing with species habitat modeling. We're trying to get something going in BC, building a provincial standard. I'm also thinking nationally and internationally.
- *[KC: I did look at some of the range map work but it doesn't take into account habitat requirements of the species and I thought of the work undertaken in the Okanagan around habitat suitability and capability models for species at risk. I kind of had an idea of "Why aren't we doing something similar in the CDF?"]* Yeah, it's a good idea. Hitting it at the right scale that really matters to the people who are using it. That would be useful.
- A colleague of mine was working on a product through CDC where they were looking at species habitat modelling and updating some range maps. They've got an ongoing project that's just starting at looking at some of those different sources of data that you could use to do these sorts of things.
- The NatureServe Network has a mapping standard for making element occurrences, and as a network we're trying to make a habitat modeling standard. The US is ahead of us. They did a big project that was co-funded by Esri. The folks who make ArcGIS and Microsoft AI for Earth, and they've done biodiversity mapping for continental US, the resolution isn't amazing, but there's some neat papers coming out. As a network, we're trying to look at making a modeling standard, and it will be less about what algorithm you should use to model, and instead about consistency on how you report out on your model.
- We don't want to be prescriptive about modeling algorithm or other aspects. You can't be prescriptive if you haven't seen the data that people are dealing with. We do want consistency and transparency with the models being produced.

- There are other people in the province that are ahead of us doing modeling, but there's no consistent guidelines, or one consistent place in the province like the BC Data Catalog where you can access models. I'm not looking to reinvent the wheel, we are just looking for people to be consistent about the inputs e.g. what input data were put into it? What validation techniques? That's what we're trying to do with that project which is unfunded.
- We hired some contractors last year and we assembled a library of environmental predictor layers; soil type, geology, water, climate etc. to get a sense of what was available in the province. Where are the holes? We did this a little bit for a national level, too. Then can we start building decision trees. We also looked into whether we are able to group species in terms of environmental predictor data? - For example, for all the herps [reptiles and amphibians] can we use a particular suite of environmental predictors? We did a deep dive with plants. How would we model plants versus animals? What are some of the considerations that we need to think about? Year one of the species habitat modelling project was a research year, and we produced one model for elk as a proof of concept.
- Meanwhile, I'm feeding into the draft NatureServe Modeling Standard and I'm trying to connect people that are doing this work together. I think that the end product that we would like is a provincial standard, and we would like to produce some models but it'll be down to capacity.

4.6.3 Habitat data quality and gaps

- The problem with models is that they can look great, but they could be garbage. The real challenge is communicating clearly about what the model is and isn't and being transparent about the quality of the data that formed the model.
- Inventory data is so important, going out in the landscape collecting data, doing it in a non-biased systematic way that makes sense for the species life history is so important, but the reality is that not enough inventory is happening. I don't want people using garbage models and thinking that's the truth. How do we find the middle ground with the data we have? We have to start somewhere so let's be really transparent about the limitations of the model, and let's give guidance to decision makers about what the model should or shouldn't be used. We can't control who or how someone uses our data. My job is to be as clear and communicative as possible, so that we're hoping we can help people make the right decisions.
- I've been criticized for the range mapping project and species habitat modelling- some people think that we shouldn't do it as there's not enough information. My view is that we have to start somewhere so we are going to start with data that are available and be transparent about the short comings and we will document the short comings for future funding opportunities. These projects can show people what we can do and where we want to go. Hopefully we will get some momentum, show a product, and then tell how we can iterate through time and improve the products.
- After doing a year of research into the species habitat modeling I think one of the most valuable things that's going to come out of this is a document on gaps on baseline data. I think we need to start collectively documenting the need for data and tools.

4.7 Climate effects on species and ecosystems at risk

4.7.1 Climate vs human impact

- One thing I will say is that in the world in which I work, which is mapping those vetted ecosystems, I have this perception that what actually matters is what humans decide will be on a certain area almost more than climate as a determining factor of the type of ecosystem. Or more often, the current ecological communities are an incidental result of the impacts of people in the past not having made clear and informed decisions about the type of ecosystems they wanted to be there in the future.
- I know ecosystems will change in the long term as a result of climate, and climate change is a huge concern because it is so pervasive in extent, but I think probably the most important determining factor to the province's most at-risk ecosystems is direct human impact. Climate almost becomes a less important factor and this is something I encounter with degrading Garry oak ecosystems a lot.
- I think for my job, which is to map those occurrences of the province's most at-risk ecosystems, that the main thing we probably look at is human impact, more than climate. Things like roads, mines, agriculture, grazing, recreation, invasive species, urban development, fire suppression, and pollution.

And it's concerning that we don't even have very good comprehensive and up-to-date spatial data sets on the various types of human impact across the landscape, even before considering the impacts of climate change.

4.7.2 Range shifts for species and ecosystems at risk

- *[LS: we are trying to find a way to make changes in the range / distribution of species and ecosystems at risk meaningful for local governments and First Nations. Do you have any thoughts on how this could be expressed?]* That's a very good question. You're asking me to solve all the conservation problems? I think there are some well developed tools in Europe that look at species range distributions, based on shifting climate projections. I think they use a few different models. I think it can be applied to any species, although this particular colleague uses it mostly for trees.
- One of the examples that I have for their work is they looked at all the forests that have undergone restoration in South America, and they looked at the projected future range, and they looked to see whether or not what we were restoring is actually the stuff that will be able to survive there in X number of years. I think there are some scientific tools that can at least look at range shifts, but the issues with species at risk is, first of all, they're not really able to move usually so even if their range shifts they can't respond. I would guess that they might rely on things like climate refugees, which aren't really incorporated into those big distribution models.
- *[KC: My other question is on shifting habitats for species and ecological communities at risk with climate change, what are your thoughts in relation to mapping and this topic?]* It's not really my area of expertise. Colin Mahoney has done some work with Will MacKenzie and others on flying BEC Zones / predicted changes in BEC Zones or sub zone variants that might remain stable or be predicted to change in distribution with climate change. (see **Section 5.1** for more information).
- *[LS: we are also considering how genetic material could be protected as climate change occurs and ecosystems contract to small pockets through their original range.]* There's a forest SEED Centre in Vancouver that has very sophisticated tools for thinking about some of those things and for doing seed propagation. The idea that the climate determines the presence of certain ecosystem types is true, however, for many 1000 years, Garry oak ecosystems are present because of human management. I do think that we have a role to play in supporting certain ecosystem types. So, it is a combination of climate refuge on the landscape and climate refugia that human management can offer.

4.8 SEAR data collection, storage and sharing

4.8.1 Trend data

- It's hard, baseline data collection is expensive and it's not widely available. We don't have the data to say biodiversity is declining in our municipality through time.
- What I would really like to see at a provincial scale is more work on trends. We talk about the status of a species it's red or blue listed. We're not really seeing the changes through time.

4.8.2 Standardizing and centralizing SEAR data collection and storage

- If you need to do an ecosystem inventory or a stream inventory or a bird survey, you use the RISC [Resources Information Standards Committee] standards[5] or the RISC methodology but that, again, is very forestry focused. It's not always applicable to an urban or urban rural landscape. And so I think we need more standardized system, so that we're getting the same data from each project that can be fed into a larger database, and then we can look at more landscape level issues using that data. Now it tends to be like everybody does it slightly differently.
- …but for more elements of biodiversity it would be really helpful or more standardized ways of doing that inventory that are relevant to an urban context**.** We have the RISC standards in BC that a lot of people fall back on to do biodiversity work.

[5] https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/laws-policies-standards-guidance/inventory-standards

- There's no secret pile of data that the municipalities should be tapping into, but I think what it says is that they need to invest a little bit more into gathering that data. That can be really hard, because everyone's running on a shoestring.
- In my community, one of the things we've been doing is to have an ongoing database of species, we do bio blitz's every year, and we have an iNaturalist project to try to get people to submit observations. We have actual set days where we will get experts out, and we blitz certain properties in the municipality and we try to keep an eye out for areas and properties that we think are great opportunities for conservation that may be coming up for sale or have some changes coming.
- I think if there were more requirements under some of the permits to have to feed your data back into some system. Even if the local government land development permits required that of the consultants that are doing the environmental assessments. If they did a bird survey or a fish survey. Some of that does go back because we have fish permits that the Province requires that information goes back to them.
- That data often just stays in the consultant's hands, or in the consultants report. It's never put into some centralized data clearing house. And if a municipality want to look at the local scale or at a landscape scale or a regional scale, where are the values. There's a lot of useful data out there, it would take a lot of effort to pull that out.
- If there were more requirements to collect data in a standardized way and push that data into some centralized database, as part of a requirement so that maybe that's part of a land development checklist requirement is that this data gets submitted and mapped in a GIS system.

4.8.3 CDC data submission, sharing and reporting

- *[KC: I keep hearing that 97% of the ecological communities in the CDF and the CWH_{XM1} are at risk, but when you pull up the CDC ecological community at risk mapping only half or less of the area is identified as red or blue listed. When I pulled up the Garry Oak occurrences from the CDC and I overlaid that with the TEM and highlighted the TEM polygons that have Garry Oak in them, the TEM polygons show a lot more areas than the CDC element occurrence mapping. I just wanted to get your thoughts on that discrepancy.]* I've become more aware as we work more with the CDC is they rely on people giving them that information. So now when I'm out and speaking with folks they tell me this is a community at risk, but it's not mapped in the CDC. I say map it, particularly if in an area without ecosystem mapping, give CDC a polygon or a point feature, send it to them and let them know it's there. Then they will add that to their system. There might be a bit of a time lag but they will get that in there.
- There is partially just a capacity issue I think with the CDC and updating and maintaining the location of a lot of these communities. That would be my first thought, and it's again an education piece. I've had them come and speak in our offices with other groups that we've worked with. They're trying to get it out there that they can use help. Anybody who finds or can locate some of these ecosystems that are not within their current mapping then they're happy to receive that information and add it to their inventory.
- Something I have encountered is a desire from municipal governments and contractors or professionals to share data with us, which is really encouraging. I've heard people say "we've got this ecosystem at risk mapped but half the occurrence has now been developed, here's the new polygon that removes the impacted area." Or "we found this wetland, you haven't mapped it, can you add this to your ecosystem at risk maps?" The issue is they email it to me and then I have these shape files in my inbox until I have time to deal with them. You can imagine this happening at the scale of the province. It just isn't feasible to take in fine-scale spatial data from thousands of individual users around the province at this time, though we do have some pretty robust standards and guidance for ecosystem mapping. There isn't currently a clear and easy pipeline for these people to provide us with high quality data that can be fed into our layers in a timely fashion. *[KC: Almost like a crowd sourcing tool for spatial data.]* Exactly, with species the potential of this sort of approach has become really apparent as the turnaround time for tools like iNaturalist on occurrences of rare species has dwarfed anything that the government has the capacity to produce. It certainly can be very useful for helping to fill the many gaps in our data. As I've said, CDC layers are very useful because they're vetted and experts have looked at them. You know that if it's mapped by the CDC it's probably there and that's the approach we take. Its worth communicating that. But I would like to see some opportunities explored to expand what we're

able to do with those other input sources while still maintaining high standards for the quality of our data.

- Citizen science species identification can be quite helpful. An example is the protesters at Fairy Creek were using eBird to upload information about Western Screech-owls that led to further monitoring that confirmed seven owls. It is important for accuracy to have supporting photo documentation and recordings. The BC CDC and the Nature Trust of BC both mine their data from those sources.
- [*T.B. Thoughts on iNaturalist?*] There are too many options for where to submit your data between eBird, iNaturalist, eFlora and Species Inventory (SPI) database. There's just a lot of different data sources that can be used. When mining that information, you must be aware about how accurate the identification is.
- *[KC: Like a citizen science platform?]* Yeah, or even if municipalities do assessments and have the QEP who has mapped something, it is vetted by a QEP, we could improve the pipeline for getting that into our mapping more quickly.
- *[KC: Do you have any ideas on how one might do that, if you had a magic wand?]* We are working on a few ideas. I think that the data systems that support and feed into what's served out in the BC Species and Ecosystems Explorer need to be looked at. I think it'll take some time. Developing and maintaining a strong Community of Practice of trained ecologists who are speaking the same language and mapping to a common set of standards is also important, and is no small task.
- As far as tools go, members of the public may not be aware that they can report any rare red-listed ecological plant community they might have. They just need to have the knowledge on what to look for and how to do submit the info. Could be good to test how easy is it to find that form and to undertake the process. There have been huge improvements but because there is such a demand for the BC CDC data, there is no easy face to face access anymore.
- Even to request BC CDC data, you have to go through a training program to get approved. There are these kind of hurdles that didn't use to exist in the past, when you could just call someone and ask for a shapefile etc.

4.8.4 Centralizing invasive species inventory

- …mapping for biodiversity values for invasive species, because there's not one central clearing house for that information.I remember when we started the Surrey job we just wanted to pull together all the information for Surrey. And we had to pull it from all these different places. So, like the invasive species mapping. There's the provincial invasive species database. A lot of local governments maintain their own GIS layers because they're just focused on managing their invasive species. So they've got layers of where the knot weed populations are, where they've treated, knot weed. But again, it's not all together in one place

4.9 Biodiversity Galliano Project

4.9.1 Aggregating and visualizing biodiversity data

- Our projects began with the Biodiversity Galliano Project. We founded this project on Galliano about seven years ago, with the intention of consolidating everything we knew about the biodiversity of the island. https://biogaliano.org
- I started by aggregating all of the existing historical data, and creating a database and then using iNat as a tool, and organizing all kinds of local community events to engage the community and sharing their observations. It's been a little while since I've updated this, but here is the stats page which shows the progress we've made so far.
- Over the last seven years we've so far aggregated records representing about 3000 species, of which we've confirmed 50% and we've added over 1200 new species, which totals to about 4000 species documented on Galliano. Behind this is a database which was really accessible only to me. So, I was really interested in trying to create some tools for making that information more readily accessible or available to people. This has gone through quite a few different versions or iterations and it's quite simple, because it is just a summary, but it actually began with this presentation. A web of life / sunburst visualization of all the different groups of species that we've found.

- We had this goal of creating visualizations to make the biodiversity data for Galliano accessible so that people could track the historical metadata e.g. it was first reported in 1975. There's prior knowledge of the species on the island before that, but there is at least one collection at the Royal BC Museum, that goes to 1975 and it has since been observed.
- They came up with a system for tracking continued presence. Slender popcorn flower, has not been seen since 1980 so the species is red instead of blue (colour-coding of the visualization), which tells me it's historically known, but it's not been observed since.
- One of the projects we're working on right now is using the historical data, in conjunction with contemporary data and observations being made by the community to narrow down a list of species that have been reported historically but haven't been seen in several years so, monitoring potential changes that are taking place by comparing observations being made to his historical baseline.
- Part of the purpose of the tool is to visualize the historical and community metadata and give credit to community members who are contributing to it.
- So where did it go from there? The goal now is to formalize this work by publishing these data to the Global Biodiversity Information Facility. What began as a project to formalise the baseline record of the biodiversity of Galliano has turned into a broader initiative, using Galliano as a model that other communities within the region can use to create an atlas.
- You asked me about visualizations, but a lot of the coding and what we've been working on here was actually a process of developing a workflow that communities can use to curate biodiversity dataset to a standard that could be publishable for global biodiversity research. The vision is to have an atlas where we can synthesize existing information that's out there; in research collections and in different silos, but also with the information that communities can generate.
- There is a significant amount of data out there, a lot of which has been generated by community scientists / naturalists that has been largely overlooked in the scientific community, and there's an increasing trend toward acknowledging that and trying to make use of it. But there are a lot of gaps and a lot of these data don't reach the peer reviewed scientific literature.
- We recently completed a contract for the Valdes Island Conservancy to aggregate their historic and contemporary biodiversity data. They basically provided me with all the raw data that they had and I did some additional ferreting out of records from museums etc. Then we built up the data repository of all of these different catalogs of information. We have included Hul'q'umi'num names.
- One other thing we were always bearing in mind when developing these tools is, rather than reinventing the wheel, how much can we pull from existing resources as much as possible? A simple example of that is a Wikipedia summary for something. Obviously, it's clipped. This gives something brief, but we can start scraping the internet, other repositories of information to include more details as well. That's a recently completed project.

4.9.2 Extending project to network other communities

- I mentioned the long-term vision of working with different communities it to eventually network the projects.
- When Biodiversity Galliano began, I presented on it and a representative from Squamish was present: Judith Holm. It turns out she was inspired about what we were doing so she started the Squamish Biodiversity Project, which has been running in tandem with Bio Galliano for the last six or seven years. She's been using the same framework for tracking and integrating the information. She initially started for Squamish and then when she thought further about how to designate the project boundaries, she decided the appropriate boundary would be the watershed. Since then, the Howe Sound UNESCO World biosphere has emerged and the two projects have merged.

4.9.3 Predictive ecosystem modelling

- For my PhD, I want to go further and do predictive modeling of ecological communities and validating models etc. I want to go further with analyzing and making the data useful in different contexts for both research and conservation.

4.9.4 Community curated atlas

- We're really interested in the idea of a community curated Atlas, that people can contribute to almost like a Wikipedia. The tools that we developed in this project allows us to aggregate catalogs of occurrences, which was a really important step for us.
- There are tools that ESRI ArcGIS have produced for online story mapping tool. But of course, you need an ESRI license to use it. And so, again, everything we're doing is really in that spirit of open source, software development.
- We're working on not just the products (maps), but the community of practice, and the protocols around how to share or communicate information, how different communities use information, mapping that all out as well. We came up with a workflow to facilitate the community curation process. That process guided people with research backgrounds but it was also something that communities could support or being engaged in.

5 Climate Data and Modelling

5.1 Climate and ecosystem shifting

5.1.1 Climate BC Tool

- On the climate front, ClimateBC[6] or ClimateNA is a very easy to use tool. It covers a very large area beyond the Georgia Basin. This work is supported by the BC Ministry of Forests. We have an organisation called the Forest Conservation Council and its a Conservation Technical Advisory Committee. It's part of the Forest Genetics Council of BC. So, only concerned with trees.
- For the climate data layers we have a spatial layer in the data portal, but as mentioned it covers either the entire BC or the whole North America, but for this project I believe it is necessary to generate climate layers for some important climate variables at higher resolution. The layer we have for BC is at a resolution of 1km. For your project I think maybe a resolution of 200 m or something around that would make it more accurate. It would not be difficult to do.
- *[KC Local governments are interested in regional green infrastructure networks or biodiversity corridor mapping. However, it seems that the analyses they're doing don't take into consideration climate shifts.]* I think that climate shifting is very relevant in terms of species and ecosystems like the BEC Zones and the BEC variants. We have the models but we have the same problem - our projection is available at a 1km resolution. For this specific area we need to have a 200 m resolution. There's a lot of this spatial data that needs to have a higher resolution specific to this project. It's worth having the support for a student; otherwise, it's too much work.
- *[KC - the climate projections you're doing, you're also looking at US?]* Climate NA covers the entire of North America. For the US part of the Georgia Basin, you can use Climate NA. *[KC - I spoke to somebody who didn't have a lot of faith in Forestry's projected BEC units for the BC coast, because the models they used didn't include BEC equivalents south of the border – they only used existing BC BEC units.]* Do you know Will McKenzie? Two-three years ago, we developed together extended BEC zones. With the same principal but extended them into the US and Alberta. He said that it was almost finalized, but that it needs more ground truthing. If that was released, I would do the projections on that. Then we can have projections from the US to BC. That has not been released yet. Colin Mahoney and Will McKenzie wrote a paper on this, but it's not very detailed.
- People are looking from different angles, different aspects. My expertise is looking at the mismatch and providing the essential climate data that models the mismatch. So, higher levels of modelling are beyond my scope.
- I'm impressed that so many people are talking about climate impact from different angles, but in most cases they miss the mismatch part. The mismatch is the key thing.

[6] See: https://climatebc.ca/mapVersion

- You mentioned many times the climate shift is the key. People are talking about impact of climate change and prolonged fire season and many, many other things, but I think climate shift is the key to many other issues. Different parts of the world have different climates, so why does climate change matters? What matters is the *shift* [caused by climate change].

5.1.2 CDF zone will shift to a novel climate

- *[KC - when I saw the Climate BC's maps of projected BEC zones, it identified the CDF as an area likely to become a novel system, but not what that would be. Does that assume that in future there will be no CDF zone in BC?]*
- If you look at the map that I just sent you, the green/grey almost dark areas are the novel climates. If you click a future period such as 2071-2100, you can see a lot of black areas. Those will be from the US. After the extended system is released, then I can predict what the black areas will be.
- In my new projection the CDF zone will have a novel climate. However, the coastal douglas- fir [as a species] will still be there. *[KC: So are we going to be getting new species from further south when we're talking novel climate?]* Only if we move them. They're not getting near fast enough. Assisted migration is needed.
- *[KC - I'm trying to get a picture of what that looks like assuming that plant species can't move here fast enough or at least within our time frame. Does that mean the CDF is going to be losing ecosystem elements?]* There's a different level of novelty. My projection is community based; many species together. The climate may not be suitable for a given community anymore, but for the individual species, many will be okay, while some others may not be okay.
- But in general with the shifts what you expect is that you have what they call a colonization credit and extirpation debt, which basically means that you lose things [species] faster than you can gain things because they just can't move. You have to go a long ways south before you get many new tree species. But you get down to Oregon and you start getting Port Orford cedar and things like that. Go farther south you get the redwoods, but that's not going to be relevant in the Georgia Basin. It's not foggy enough. It's a complex situation.

5.1.3 Climate shifts and cedar

- *[KC: I agree. I've worked a little bit with First Nations here and heard interest in things like, where is cedar going to be in the future, for example?]* That's a great question. I would say it's good to know if there are areas that are becoming favourable and it's worrisome if there are areas that are less favourable, but I would say that doesn't mean you shouldn't be protecting those areas. I would say hang onto the old growth in those areas because you don't know if you're going to get regeneration there, so I would use those projected changes very cautiously. There's also huge uncertainty. So they're important if you're deciding what trees to plant, but if you're deciding what to protect, I would not be calling the winners and the losers for your protected areas based on those projections.
- The cedar is a great example. We've all seen a lot of cedar die back, but in fact the models show cedar persisting in a lot of areas. But for microsites on shallow soils, steep slopes, east side of Vancouver Island, under those conditions it's not a great outlook. I think you want to spread protection across all these BEC units as they are now and you know they're going to change in the future but you've still got those protected units.
- I didn't expect cedar would be a problem on Vancouver Island, but in some areas it's really suffering.
- Cedar is an interesting species to talk about. Cedar province-wide has a large growing area (in the interior there is a huge area suitable for cedar) but on Vancouver Island the climate suitability for cedar is declining dramatically. I didn't take a look at the east side particularly, but overall Vancouver Island suitability is declining. Two years ago, somebody called me and said, "The young cedar trees are even dying, what's going on there?" So, I checked my projections and I found that for the 1990s reference period, the suitability was 80%. Now it's about 35%-40%. It's a dramatic drop.
- *[KC: So I think First Nations might be interested in this information].* Yes, I think to have a high resolution layer and to look at the difference between them, to look at the information about the microclimate conditions could be valuable.

5.1.4 Ecosystem Forecast Centre

- *[LS – the BC Climate Preparedness and Adaptation Strategy indicated that the Ministry of Forest was going to set up an Ecosystem Forecast Centre. Will you be involved in that**?**]* It's brand spanking new and I don't know a lot about it yet, but I think one of the things they're going to be doing is look at how Biogeoclimatic Zones will shift with climate change through time. I think they are also talking about better resolution climate data for the province.

5.1.5 Local climate refugia

- *[KC: right now local governments are often using the Sensitive Ecosystem Inventory mapping and the CDCs, Ecosystem Explorer which shows where the ecological communities and species at risk are and it sounds like ecological communities at risk might not even look like they look now in the future. Do they need to know about this for their decision making? Do they need to be thinking about climate shifts? What would you be wanting them to know?]*
- Retaining more trees is a nature-based solution of course to some extent, although not when all your trees die. But I would say for those sensitive ecosystems or those under represented ecosystems, often what makes those special is local topography, local geomorphology combined with whatever ecological unit they're in. That element of topography and its effects are enduring features. Those don't change. The species that are there might change but it still might be a relatively rare set of environmental conditions because of those that will support a different host of species.
- One of the things that some of the folks in the Kootenays have espoused that I didn't appreciate until later was that idea of enduring features and the fact that your geography isn't shifting and you're still going to have the effects of that. And also you may have the effects of that which create a kind of local climate refugia. Because you get local conditions that are maybe a little cooler or a little wetter in that spot than they are in the surrounding area because of the topography and because of the water courses. Those areas might not sustain species you're hoping for, but they might still be important for biodiversity.
- Again, microclimate is important. The topography features eventually are linked to microclimate so the topography feature may create a microclimate that can serve as refugia. You know that's critically important. For that reason, we really need a high resolution map to reflect these microclimate conditions. With our climate model - ClimateBC or ClimateNA - can generate climate data at any resolution. We need to get the data elevation at a higher resolution, maybe 25m will be the best, but the volume of date would then be huge. I would say a 100m – 200m resolution will be sufficient *[to identify those climate refuge areas].* We can predict our ecosystem by this high-resolution data. Then we can say that CDF is moving away but part of their species still remain in those microclimate conditions.

5.1.6 Next steps with Climate BC

- *[KC - one of our interviewees is looking to develop protocols for undertaking ecological restoration for wildfire resilience and watershed resilience. They have downscaled validated climate projections, but they have not been able to find hourly data. Are they just not looking at the right place?]* That's not what we can provide. Our data is at a monthly level so for the process-based models for the fire, they need daily data or even hourly data, which is beyond our scope. For the climate data, I can generate it but my schedule is very tight and it could be delayed. If you have funds to support summer student to do it, that would be easier.
- For the CDF, we have some issues because the protected areas are generally small and often do not meet our criteria. Do you have the information about private and other levels of protected areas? *[KC: I think there's been some past mapping that would probably have to be updated. We could work with the land trusts to confirm what the private protected land coverage is].* Do you think, we could use of that? It would be an improvement, certainly. I've thought this for years. The Nature Trust alone has a lot of properties in key places. *[KC: If we can identify data gaps that would assist with your analysis, the CDFCP through its network and our membership could try to chase that data for you].*
- I think I can help with the climate layers and ecosystem projections, the BEC zone variants. Those are important information. Particularly the shift of the BEC variants. Climate, I think we can produce a historical reference layer and then some future layers. We have developed ensembles to represent the average of many GCMs [General Circulation Models] together. *[KC: so historically what the climate was and then where its heading?]* Yes, that's a reference point and then see what change will happen

in the future. Then also the ecosystem; what is current, what it will be the future. *[KC - Would that look like a detailed BEC map? Past and present?]* Yes.

- *[KC – thinking of those climate layers, could we potentially get it to a resolution to show the climate refugia?]* Not refugia, just the climate. Higher resolution will show the local variation. If we make the projections for the BEC variants using this high resolution climate data, we may find some potential refugia. *[KC: But you would need some support, to get a student. What would make that happen?]* I think so because the two together it is quite a lot of work, and I'm very busy. Fully committed. *[KC + DB - Maybe we could try and find some resources for that, how long would it take a student to do this work?]* A month maybe. *[DB - we have a forestry undergrad student who might be able to help]. Sure, he could do the climate part if he has knowledge of GIS. For the ecosystem projections my model is not available, so I would need to generate the projections for the BEC zones. That's a complicated process.]*
- *[KC – is there any possibility of having a demonstration product for the workshop in October?]* The projections I will show you are zone level projections. On the top there's climate maps overlays and the second column are the BEC zones we have currently mapped. If we click the future, you will see the future BEC zones, but this is for the whole province. We can zoom into Vancouver Island, however, the resolution is not that high. You can download this. We could generate this at a higher resolution.
- Let a student generate a shape file for the coverage, then I can talk to him about how to generate a DEM [digital elevation model], which can be used by Climate BC and then he can run Climate BC to generate spatial climate data. After the spatial climate data are generated, I think I can run the projections.
- *[DB - we are also looking at cumulative effects, and I was wondering if the projections take into account any other factors?]* No, the idea of the projection is that we associate the current BEC system with climate variables. After the association is built, that's our model. Then we plug in the future climate data to see the future. So, no cumulative effects can be taken into consideration.

5.2 NOAA tools

- I've dreamed of a partnership with NOAA (National Oceanic and Atmospheric Administration). NOAA has everything, and they update it. Their sea level rise map tool ends just south of White Rock, but you can be sure their data doesn't end there. It's an example of a useful tool for planners. It covers the whole of the USA. So my point is, there are many tools that have been already developed, we don't necessarily need to build new ones. It's just a matter of populating them with the correct data for our area. I believe in collaboration and I think NOAA would be an awesome partner in this regard.
- When I look at what NOAA has done, that's what a government should do – process and validate the data. There were people who used to work in Ottawa for Environment Canada doing exactly this. But the office was cut by Stephen Harper and they all got fired. They've started a little company out of Toronto, and they're trying to carry on there: doing Canada-wide downscaled climate data, and developing interfaces that allow people to ask questions about weather data and events. But now you have pay for it because they had to go corporate in order to pay themselves. I think the next question is, who are the people who have already done this kind of work? And can we bring them in to fast track something, to start getting stuff into people's hands right away.

6 Corridors and Connectivity Analysis

6.1 Corridor/connectivity analysis and inputs

- It is important for maps to show landscape connectivity and how fragmented most landscapes are, and at a scale that people relate to.
- *[KC: we're potentially in the position to advocate for or attempt to wrangle the funds and the resources to do some sort of regional analysis. That's where the local governments were saying it would be nice if somebody did a regional corridor analysis to identify ideal places for corridors. And we've been talking about trying to get a unified sheet of LIDAR that we can use to derive some products that identify where*

the remaining relatively contiguous intact forest cover is. I'm wondering whether there would be value as part of that analysis to use some of the modelling you're talking about, to highlight where the likely climate refuge areas are to make sure they are highlighted or captured as important within a regional corridor analysis.] Yes, I think that's a good way.

- The baseline information for most of these projects, like the canopy work and the tree work, which relies largely on LIDAR, existing mapping like TEM mapping and LIDAR is a big part of that, looking at the state of trees. We figure out how to do a pretty accurate analysis of urban trees based on that when it comes to biology planning and looking at sensitive ecosystems. It totally depends on the municipality I think we're with, and what kind of information they have… And so, we usually pull together all the mapping, as best we can, overlay that with LIDAR, which gives us a better idea of the edges of these natural areas, and then we do field work to kind of spot check as much as we can like 10-20%, of the polygons and collect detailed information on what's there, and that's sort of our process. And then, for all the projects we try to kind of summarize that at the beginning as a State of report, which is what exists and what condition it's in. And that, of course, leads to recommendations for policy and planning and procedures.
- *[DB: I'm just wondering, coming back to the data gaps and also the whole concept of ecological connectivity…Since you've done this kind of analysis for quite a few of the cities, does the methodology differ, depending on the city's priorities, or depending on the location? Or are you adopting on more or less uniform approach to it?]* I'll quickly say I think it tends to depend on existing assets within somewhere like New West or City of North Van are so built up that we [Diamondhead] just start by protecting existing connectivity, and trying to improve connectivity through those kind of urban corridors greenways that I was talking about earlier, where you're really constrained already. But then somewhere, like Surrey, it can be a bit more detailed. But because there is so much undeveloped land, it was really trying to identify those and strategize for which of those areas to protect, and there can be a different emphasis between existing connectivity and creating new ones…It totally depends on the municipality I think we're with, and what kind of information they have…Saanich actually has a fair amount of information and North Cowichan too, I guess they have TEM, which is great. There's the Metro Vancouver SEI Mapping, and it sounds they have their own mapping, like Saanich has identified many sensitive areas.
- Yeah, I think a lot of the connectivity work that we [Diamondhead] are trying to do is species focused. But then there's still a values piece to bring into that, because with those connectivity corridors it's just not just about protection, but also maybe equitable park access, or things like that as well. And so there can be that value-based piece as well around where the municipality wants to protect and to what degree, and things like that, so that's definitely something that we've encountered along the way. *[DB: Okay, that's yeah, that's a good point. I didn't think of the human element in that.]*
- Mapping of hotspot biodiversity is beneficial, which is typically where you have the connectivity and some of those older features.

6.2 Wildlife habitat connectivity

- *[KC - Do you think that the corridor analysis would be worth pursuing?]* If you're thinking about animals in terms of the corridors that's something where I would think that Nicholas Coops would have a role. You'd really want remote sensing and you might want to pull in someone like Cole Burton and on the wildlife side of things to know what their requirements are, what works optimally for different sorts of creatures. His lab is called The Wildlife Coexistence Lab[7]. They do a lot of camera trap work. He'd be a great person to communicate with on that front. But with the amount of development happening in the Georgia Basin, it's too bad that wasn't thought about 20 years ago.
- *[LS – I'm interested in habitat connectivity mapping at a resolution that can be used by local governments. Have you heard of any group within the province that has done it?]* I really struggle with how people are defining habitat. At times, people use the term "habitat" interchangeably with the word "ecosystems". I see them as different, but there is some cross-over between the two terms. When we talk about habitat mapping, we talk about habitat corridors, are we talking about bears and cougars or insects? I think it's an important question to ask.

[7] https://wildlife.forestry.ubc.ca

- *[LS: do you know if anyone has been working on habitat connectivity in the province?]* I know in our office, there are a few biologists doing different projects relating to ungulate winter range, and moose habitat. I don't know if it's really specific to the coastal Douglas-fir area.
- *[LS: we are currently working with two GIS students to see if we can use a proxy species to map habitat connectivity based on their habitat requirements.]* I just think it's hard to think about how to scale that. How could you get every municipality to do it? I would be curious to see how much of it overlaps with existing parks, and how much is outside of park boundaries? and what does that mean for the way that planning happens?
- In forest ecosystems, you might be able to use things like LIDAR to understand canopy density, and maybe use that combined with age of the stand to point at whether or not it would hit certain targets, but the thing is it accounts as habitat for what species? Each species has different requirements. So, trying to give it one definition, doesn't really function well in my mind, and instead trying to provide fairly clear, well defined information that then allows users to make decisions makes more sense to me. But of course, it puts the onus on the person pulling the information together and again resources are constrained.
- *[DB: And in terms of the kind of connectivity analysis that you're doing, have you worked on different projects for different governments and used different methodologies? Because we are also grappling with the issue of like, what do you use as a proxy. Do you use big ungulate? Do you use smaller manuals? Do so we are also trying to look at what might be the most appropriate methodology. And I was wondering how you approach that question.]* I don't know. That's a tough question, as we find what with all the connectivity studies, there's tons, of questions about why you chose certain species to represent.You know certain groups, and how the model works and what the inputs are. I find it's pretty challenging. I think people's expectations of connectivity modeling is too high. I think the simpler approach is almost the better, so it's clear what the constraints are, what the assumptions are. It's so complicated you can't account for everything. With modeling in general, you know, wildfire modelling or biodiversity modeling, the more aspects you try to incorporate in, the more washed out the results, you know.
- So, if you include too many species, and too many factors to analyze, when you put them all together it doesn't really make sense. You know what I mean. The output doesn't really make sense. You got to, I think, you choose fewer, very clear inputs, and then use the results – a bit more logical when it comes out. Does that make sense?
- Well, the quality of the outputs depends on how many species you look at. We've [Diamondhead] done up to 8 for Metro Vancouver. And then it's tricky because you need to find metrics on that species like dispersal patterns and home ranges and patch size. And then, it also depends on the data you have on the ground as well. If you're looking for specific habitat quality for certain species that's needed you need to have that spatial information on the ground to be able to find it. So, it totally depends on the municipality and what their baseline information is like. And how many species they want to look at.
- *[DB: Yeah. It gets hard for people to understand also what's going into the model.]* Yeah, it gets too complicated. We've done a few that worked pretty well. But somehow, I think, at the end, the final result in the end is something professionals could, probably just do based on professional judgment. You know what I mean. Or sometimes this professional judgment might be better. Just state your assumptions, and usually that can work as well. I don't know.

6.3 Climate Considerations: genetics, migration and fire

- For any given species I don't know that we [Climate BC] can identify climate refuges but looking for those local anomalies; the slightly cooler, slightly wetter areas, could be helpful. But the corridor thing seems to me to be tremendously important and it's important for lots of reasons. I guess some people might not like it because it will give a corridor full of cougars to show up in town. But so be it.
- So far our [Climate BC] model cannot predict the location of corridors [due to scale], but after the projection we may identify corridors from our maps.
- Of course we're going to have increased fires and those fires are going to take out some of those corridors, so thinking about redundancy. We did the analysis of tree populations in protected areas around the province. We build in redundancy in that we expect to have three or more protected areas that meet the requirements. In a perfect world where you knew those populations would all persist, one

would do the job, but we know that doesn't happen. So, in the event of catastrophic events, we're thinking about how to overbuild the system.

- It's a tough one. I think the model we use works well, like it's a spatial prioritization model. It works well, but again, it just depends on what your inputs are and what the data is like. So yeah, the better the baseline data, the better the results.
- My analysis is pixel-based. After you map it, you can identify, "Here is the corridor." We can see they have a similar pattern. When I model the Lodgepole pine moving from US to BC, it has a narrow corridor at the bottoms of the valleys. It clearly shows that. Later on, after the Lodgepole pine spreads over the entire province, then when I compare the performance of all the different populations, I found that the population from this early corridor has the best performance. They are established earlier they possess a higher genetic variation, so they are more resilient and grow faster. From our mapping predictions, we can see the corridors that have the potential.
- *[KC: Would that suggest that coastal douglas-fir trees from the dry CDF would do better as the climate heats up. A better pioneer genetically than those in wetter CWH forest?]* Yes, they could be. In the future, the climate will become dryer, although the precipitation doesn't change much. The rise of temperature makes the evaporation higher. The water deficit will be higher. The drier area will be more resilient and will have a higher chance to persist. [KC - Thinking in terms of arguments for conserving CDF ecosystems, they will be those genetically predisposed specimens that survive climate change?] At this moment we are guessing. After we look at the map projections, we will have a better idea.

6.4 Municipal vs. regional scale

- *[LS: The other thing that we're looking at is habitat connectivity, and I suppose we were looking at what was the appropriate level to deliver that and in my mind that seems to be at a regional district level. But it would have to be at a resolution that was meaningful to municipalities. What are you thoughts around that?]* Well, regional district level is appropriate, but meaningless, is how I would describe it. If you're interested in in large carnivores, which is generally what people use in talking about habitat connectivity, then regional district is the appropriate scale to look at it. But I suggested it's meaningless to a certain extent, because the all decisions about everything that happens on that land base will be taken at the municipal level. So you can map it out with the regional district level but they have no control whatsoever over anything that happens in that area, and at best they can suggest to the municipalities that they think that this might be a good thing to do.
- *[LS: I think we were also trying to think about, almost not stepping away from the carnivores, because obviously they are important, but thinking about a lot of the municipalities, often with the habitats they are talking about, it's not necessarily the carnivores that they're talking about. If you thought about the Saanich Peninsula, you know, it becomes more about birds, and amphibians, and other sort of species. So were just trying to figure out how to approach that?]* Sure, and absolutely most of the big land use decisions, you know, involving big parcels of land in CRD are still premised around large carnivores, which is fine. But of course, as you say, that's more to do with the Sooke Hills, and the western communities and some of the more northerly communities within CRD. And not necessarily within most of the communities on the Saanich peninsula. So to the extent where decisions around say 10 hectares is important, then the municipalities are the level where the decisions are made. And they can look within a municipality.
- I think the scale is going to be an issue.

6.5 Crossing local government boundaries

- The problem is that you can make decisions in one municipality, for example, I am a municipal counselor in Metchosin. So we can make decisions about Metchosin but our two adjoining municipalities, Langford and Colwood, are the fastest growing municipalities in British Columbia, and they are particularly aggressive in their development. And they're doing what they can to address the housing crisis by developing as densely as they possibly can. So, for example, you can now see the boundaries of Metchosin in air photos because of the dense development right up to the municipal boundary. So Metchosin can make decisions about what happens, let's say, along the length of Billston Creek in Metchosin, in order to protect habitat along Bilston Creek and protect Billston Creek.

But Butston Creek, upstream of the Metchosin in Langford, we have no ability to make any decisions or even influence decisions about what Langford decides to do along Billston creek. And they generally decide to develop densely up to it.

- *[LS: In that situation do you think the province does need to step in?]* Well, municipal politicians generally won't say so. I think you'll find municipal politicians are rather protective of their ability to make decisions about their own municipality. So let's say you went to Burnaby and said, All right, Burnaby, we want the provincial government to make the land use decisions in this part of Burnaby, how do you think that would go over? Not so well, So I mean, there are problems with that sort of thing. Sometimes municipalities will work together and ideally, you know, municipalities recognize that the world doesn't end at their borders. But in the end, Burnaby will make decisions in the best interests of Burnaby. And you know what you do about that aside from amalgamating municipalities, or building new municipal boundaries, that follow watershed boundaries, I mean, there's lots of different approaches that would make more sense biologically but none of them is going to happen.
- A lot of municipalities want us to look at adjacency, so connectivity to adjacent areas. You can't really analyze those areas because you don't want to implicate the other municipality. It's something that they haven't really signed up for. So that's where regional initiatives seem to work pretty well because everyone is on board with it already.
- I would like to see the Regional District take this on. *[LS – I have heard that the Regional District staff do not feel they have the authority to undertake connectivity mapping without clear direction from the municipalities].* Agreed, that is a challenge. Did you speak to Joel Ussery from the Regional District I think his group is looking at a climate change report?

6.6 Application by local government

- *[DB: I'm just wondering from the work that you've been doing on biodiversity and connectivity in cities, how easy has it been for them to implement this?]* You know Surrey has done a pretty good job. They are probably the oldest one, and they've done a good job following up on it. They spun off a bunch of new environmental policy. And they've also got funding place now for acquisitions of priority lands. They've done really good job, but they are the biggest city with the biggest tax base. So, I would say, they're a pretty good model to follow. Other cities we've worked on, it's relatively new. And I say, there's whole range of recommendations. Some of them are easy like procedures and updates to the policies. But then things that require resources or money are tougher for municipalities. They have to go to counsel and get approvals which can be more tricky. So, I think it's a whole range.
- They tend to work really well for watercourses. I think because there's so much Provincial legislation and that's been around for longer. Connectivity by following like water course corridors tends to be the easiest for municipalities to implement. I think it can be a bit trickier for some of the natural area ones on private land. How you pick which site and how you protect them, and how much how you restrict development, and how you support development while protecting these natural areas. It's a bit of an interesting question.
- *[DB: I wonder about this a lot, because you know, in cities so much is already developed that is almost like, if you want to keep establish connectivity you shouldn't be developing much more. So how do you balance that whole dilemma? And there's so much pressure to create housing because of the housing crisis. I just wonder how it actually plays out in practice.]* We [Diamondhead] did some work for New Westminster and the City of North Vancouver, which is very built out, and all their natural areas are parks, you know, and so it's very established. Both very established cities and compact and most of the connectivity recommendations follow greenways that have been enhanced. So, we got larger corridors or naturalized corridors enhancing urban green ways, focusing mostly on birds and flying insects. Looking to move flying species through the city.
- Yeah, and in terms of protecting existing natural areas from development. So, allowing development and stuff like that, with density bonusing and stuff like that they can concentrate development away from more sensitive habitat. We worked on a few projects that have protected up to 50 % of the site by concentrating development on smaller lot sizes and higher density residential building.
- Part of the implementation strategy was a development permit area process for the [Surrey] green infrastructure network. It's actually one of the few development permit areas I know out there that's focused more on biodiversity. A lot of the development permit areas that local governments have in

Metro Vancouver focused on specific things like steep slopes or flood hazard or stream corridors, because those are regulated through the riparian areas protection regulation, but Surrey has one that's more focused on this green infrastructure network and biodiversity, which really you unique when it came in about 5 or 6 years ago. It was the first municipality to have more of a biodiversity focus. Pamela Zevit - Her role is to implement the biodiversity conservation strategy on a landscape level.

6.7 Other connectivity projects

6.7.1 Montreal corridor project and others

- That seems like a really important area and I know they've done some really good work in Quebec along those lines. I can't direct you to anyone in particular but the city of Montreal was really focused on finding corridors through the municipal area. I think there's a scientist named Andrew Gonzalez at McGill who was involved in that. I heard a talk about it a long time ago. That just seems a really high value activity.
- *[DB: Are there any kind of international guidelines or methodologies that are recommended by, say, the I use? I was just looking up. IUCN has some report, but it doesn't go much more into the details of it. So, I just wonder if you have come across anything that's considered like a gold standard in this kind of work?]* I think some of our [Diamondhead] methods were originally based off of a paper that came out of Montreal, I think. I can look up what that paper was, but that's some of the more detailed model-type work that we did for Metro Van, for example. Yeah, probably Andrew Gonzalez from McGill, I think.
- The Resilient Waters project too where we are restoring connectivity too. Part of that is understanding that in a changing climate, connectivity and access to diverse microhabitats becomes really important.
- There was someone doing corridor mapping work with HAT.

6.7.2 Diamondhead corridor analyses for Courtenay and Metro Vancouver

- For the Courtenay report, for the urban forest strategy, we also included this section on wildlife connectivity. So, we did that corridor analysis in Courtenay. That's probably what you found in there that is most relevant to your project. And then we did a similar analysis in Metro Vancouver looking at connectivity corridors.
- *[DB: And in terms of the kind of connectivity analysis that you're doing, have you worked on different projects for different governments and used different methodologies? Because we are also grappling with the issue of like, what do you use as a proxy. Do you use big ungulate? Do you use smaller manuals? Do so we are also trying to look at what might be the most appropriate methodology. And I was wondering how you approach that question.]* It is a tough one, and is always debated a lot. Most recently, we did work for Bellingham. But before that we were doing work for Metro Van, which we ended up looking at a few different types of species trying to understand their minimum patch size, their connectivity needs, edge effect, and try to incorporate all of those for 8 different species. And each species was meant to represent a variety of types of species that would be similar. So, we had a few different small birds, few different big birds, some migratory. Some smaller animals, reptiles and mammals and things to try and get different kinds of needs, habitat needs and connectivity, and then did kind of a simple overlay of the different habitat needs, and then also kind of the critical keys of the habitat as well, and then try to identify those key corridors that serve the most critical habitat, the greatest number of species. That was kind of a big part of our analysis for Metro Van.

6.7.3 City of Surrey Biodiversity Strategy and Green Infrastructure Network

- In terms of shifting ecosystems and migration corridors, that's part of what the Surrey Biodiversity Conservation Strategy was trying to address. This idea that we need migration and connectivity.
- I was actually involved with coming up with that concept of the Green Infrastructure Network, that actually came out of a largely out of a book called Green Infrastructure, and has a number of different case studies from around the US, and that concept was what was the initial basis for some of the work in in Surrey. The initial work in Surrey then led to their biodiversity conservation strategy.
- Biodiversity conservation strategy in the city of Surrey - I was involved in the early conception, but then, other consultants took it on. The idea of this green infrastructure network and preserving core areas of habitat and connectivity between them. First time in our region that I have seen a project take that

approach in terms of biodiversity conservation. Until that time, there'd been a lot of focus identifying environmentally sensitive areas and trying to protect those areas as part of local governments jurisdiction over land use.

- The biodiversity conservation strategy was more like looking at the functions of the landscape and trying to incorporate biodiversity information, and mapping this idea of preserving ecological function over specific parcels of land. There is a focus on identifying key areas of habitat but also built into it is more flexibility in terms of the way that things are protected. And how connectivity and that function is preserved over just like let's delineate certain areas and then try and protect them, which I think reflects the reality of local government Land Use planning is they can't always get preservation, but they can work to protect things on a on a larger landscape scale. So that's really where that's a good example of where that's a different approach.
- Initially, we did a really detailed mapping of habitat types, more detailed than most municipalities have data for. That was mostly GIS-based, but we did go out and ground truth some of that mapping. So, it was more detailed than TEM mapping terrestrial ecosystem mapping for forestry like the 1:20,000 scale. We were doing it like more on a 1:500 to 1:1,000 scale.
- Then, we used some GIS tools to determine where the connectivity corridors just were based on the existing habitat types on the ground, so I don't know if you've ever heard of something called Least Cost Path Analysis. It's a spatial analysis tool to be able to determine what is the most connected part of the existing landscape. To generate the initial corridor, hub in corridor map, that we called it, for this Surrey project, we used that exercise of doing Least Cost Path Analysis, and that then determines a base case that we modified, based on known development patterns in the landscape that were coming. So, we looked at like the city had already approved development in these areas, but they haven't approved development in these areas. So there's an opportunity to still preserve a corridor. In some cases, we shifted the corridors to accommodate or to recognize that there was development that had already been approved, that we couldn't go back on. And we also looked at could there even be opportunities to improve connectivity in developed areas. In the Surrey biodiversity strategy, there's this whole idea of like backyard connectivity that you know even trees and gardens and vegetation habitat in people's private properties has value and can increase connectivity for certain species. Not for all species, but for species like pollinators and songbirds and those sorts of species, that's really relevant.
- Part of the implementation strategy was a development permit area process for the green infrastructure network. It's actually one of the few development permit areas I know out there that's focused more on biodiversity. A lot of the development permit areas that local governments have in Metro Vancouver focused on specific things like steep slopes or flood hazard or stream corridors, because those are regulated through the riparian areas protection regulation, but Surrey has one that's more focused on this green infrastructure network and biodiversity, which really you unique when it came in about 5 or 6 years ago. It was the first municipality to have more of a biodiversity focus. Pamela Zevit - Her role is to implement the biodiversity conservation strategy on a landscape level.
- There's been a lot of complaints, both in the development community and the consulting community, that the Surrey process is too onerous. It makes sense, maybe for big developers who are developing large sites. But for a single family lot, where a person wants to tear down their house and build a new house, they have all these requirements, around biodiversity protection. The biodiversity DPAs process that because quite costly and onerous for them to pursue. They have to hire consultants. And they don't have a streamlined or a simpler process for those types of situations. They are subject to the same requirements that a developer developing a larger site would be.

6.7.4 Connectivity and Nature Conservancy of Canada prioritization tool

- *[DB: What tools and methodology are out there? What does it look like on the ground? It may be that we build more connectivity between habitat? that's another question I had in terms of habitat connectivity. What methods are you using for connectivity?]* There are two levels we have. One is really at the more regional or local level which is not my group. In our group, from a national perspective, we are again looking at things that can be used across the country. And that's why I was mentioning the Environment Canada work because they are producing data across the country. And if I think about the more local example, I wouldn't even know what has happened since I've left. I have stopped working in the CDF.

- For the CDF region, which is spanning quite a bit of area, there's a lot of ocean between that, it is really more about the local connectivity for certain species, which we usually don't have data for. That's really the main thing. We don't have data that's useful, from a countrywide level that can be applied to.
- That's also why in our Where To Work tools, in the web release, we always stress the need to add local data to the national data we can provide because we know with local information, you just are way better at fine tuning the results of those tools to what's really important. But we can't curate local data sets at a national scale. That's really where the local planners come into play because they have the best knowledge of the area. They can combine what we know from a national perspective with what we know from a regional one. And then, in combination, do you get stronger results? And that's the same approach to great technical connectivity. Because we don't have anything at that scale.
- *[DB: This national level data set – Is it published?]* It's in review. there's at least a map. Peter from Environment Canada has been really good at sharing those data too. And I don't know if you and your group are connected with Angela Brennan from UBC. But that's also a person that would be useful to reach out to, if you're not because she is working on connectivity, and especially the functional connectivity for species. That's the paper that you see in the link[8].
- *[DB: Who has developed this national layer?]* it's Richard Pitta who is from Environment Canada. He's leading that, and there are a number of others involved, and Angela is one of the people from UBC.
- *[DB: I guess connectivity depends on which species you're looking at. How have they defined connectivity?]* It's what kind of landscape features do you have that would be conducive to connectivity? What's the human pressures on the land? It's really fairly broad component points that give us a broad stroke picture about connectivity across the country. Again, not good for local planning or local species. But it's the first attempt. And it's just helping us get more on the way of having connectivity data for the country. Because we don't have any.

7 Cultural Ecosystems Mapping

7.1 Indigenous stewardship of ecosystems at risk

- I think there's a huge opportunity to integrate the process of collecting knowledge well, knowing what needs to be done and taking action to restore or conserve that ecosystem. Doing stewardship while doing the assessment is an opportunity because I do feel like under the framework that we operate under now we have somebody who goes out there and they map the ecosystem and then somebody looks up those data and analyzes the data and says, "Okay we have this ecosystem there. We need to decide what to do with this ecosystem." And somebody else makes the decision about what to do with that ecosystem, and then somebody else goes there and does the restoration. In between there, somebody else needs to apply for funding to get the money from somebody else to do the thing that the other person said to do because another person found the ecosystem there because someone else said to look for it. And probably few of those people involved in all of those steps have lived there for generations and have a deep connection to that land.
- As you go through all those steps ideally it should be an adaptive management cycle that happens very quickly. As you know, and as you've spoken to, often we don't even get to that first step of initially having an ecosystem map there, so how are we going to be responsible stewards of that land?
- Indigenous people know which ecosystems are there. They often know the condition of the ecosystems. They know what action needs to be taken for proper stewardship of that ecosystem. They really just need to be given the resources to do that work and so I think recognizing that is what my project is focused on right now.
- *[KC: So when you say resources, are you talking about the proper guidance about how you do the restoration, or the actual dollars to do the work?]* I think at least with some of the Nations I've worked with, I'm talking about the dollars to do that work, or frankly, and this is a bit of a fraught area, the

[8] https://www.science.org/doi/10.1126/science.abl8974

recognition of their right to do so. Depending on the status or ownership of that area of land that we're talking about.

- So, resourcing may go from funding or resources to getting guardians or knowledge holders out on the land to do those assessments. Garry oak is a great example because people could go to a Garry oak meadow digging camas bulbs while noting that their camas bulbs are in a field of invasive grasses that weren't there 10 years ago. They could dig camas bulbs while removing those invasive grasses rather than going and doing a status assessment that says there are invasive grasses and then two years later somebody comes along to control the grasses.
- I feel like there's an opportunity for a bit of an iterative process there. I think that circles back to our initial conversation about the scale that resonates with people. There are 100 different ways to slice up Garry oak ecosystems but maybe what really matters is what resonates with the people who are going there and digging camas bulbs and doing that active restoration.
- I think there has been a bit of a disconnect between ecosystems classified as those unimpacted, pristine, unaffected ecosystems and culturally affected ecosystems or seral ecosystems as they're sometimes called in the BEC system.
- There's a disconnect between those, which often corresponds with ecosystems that are highly at risk. We imagine that when ecosystems are unaffected by humans they're in great condition, but often ecosystems that are not maintained actively by knowledgeable Indigenous stewards are the ones that are not in good condition. I think we can do a better job of formally recognizing that.

7.2 iNaturalist data

- A colleague did a query on iNaturalist data for three species. I think there was camas, yampah and maybe Garry oak. The iNaturalist data had amazing correspondence with what I would say are probably culturally significant sites.

7.3 Provincial projects

7.3.1 TEI –Sechelt Nation predictive mapping project

- *[KC: We have an idea that, if there was interest, the TEM could be used to develop a predictive map of where culturally important species might occur. I went through the TEM and picked out the polygons that that had camus recorded in them, and the province said they are actually working on a project with Sechelt Nation doing exactly that. I don't know if you're familiar with it.]* No, I will follow that up. It seems like there's lots of potential here, if the work is done in a true partnership with nations.
- *[KC: Two obvious things I thought we could potentially offer First Nations through the CDFCP project are: 1) working to provide them with any kind of biodiversity and ecosystem service related mapping that's compiled or generated through this project, in a format that's useful for their referrals and their own land use planning; and 2) exploring whether its possible to crosswalk culturally important plant and animal habitat with the TEM data, to develop predictive mapping flagging the ecosystems that potentially support culturally important plants (and animals), such as camas meadows, devil's club, monumental cedars, etc. If this is something of interest to First Nations, we could potentially explore it as a pilot or in partnership with another project.]* That makes sense.
- *[KC – what we are hearing is that First Nations need the same layers as local governments for their own land use planning and referrals, but we were wondering if you could use TEM to predict where culturally significant plant species could be e.g. camas devil's club or monumental cedar. I want understand if this is a product that could be developed that First Nations might find useful for their referral processes.]* We have a research project doing exactly that.
- These are all great questions. A lot of people are asking them, so we have been working on these questions in the Great Bear Rainforest (Nanwakolas) and on the Sunshine Coast with Sechelt FN. We are working in both of those areas and one of the objective's of the project is whether TEM can be used as a tool to predict where some of these culturally significant species are on the ground, and starting with presence/absence but ideally predicting probability of finding various sized patches or amount of cover of each species. You don't want to just find one salmonberry plant, you want to find a whole patch. The specifics that would be more useful for the Nations.

- We're working with UBC on the modelling components and to include some of those layers previously discussed (LIDAR, disturbance, etc). What we're exploring right now is some of the more generalist species versus some species with very high site fidelity, preliminary results suggest that each requires different criteria to model it out. We've made good headway and we're hoping that we will learn more soon from UBC about what they have been able to do with some of the LIDAR and other layers that he's incorporated. For example, using LIDAR or VRI to identify gaps in the forest canopy, as we expect to find more salmonberry growing with bigger gap(s) in the canopy.
- A really cool project and it would speak to some of your question, but we're not totally at the phase of, 'Yes it works really well' or not. We continue to determine the modelling method appropriate for each group of species that are of importance to them.

7.3.2 FLNROD – Sechelt modelling for Land Use Planning

- There are also projects with Sechelt through the Land Use Planning Table with FLNROD. Our project is longer term and will take some time to develop the modelling techniques that we're doing, much more data, driven. Whereas there was a more expert, driven modelling that was created by consultants (Strategic Natural Resource Consultants created the model; Ecora did some of the ground plot/verification) for the Nation, in cooperation with Land Use Planning Table.
- They used TEM and some other criteria and then some more expert opinion incorporated into it. It was a simplified model. To confirm the outcome of that I'd have to look back at some of the reports, but they were using that as a first step. If you're looking at something "quick and dirty" for lack of a better word, using certain layers, putting in certain criteria and coming up with an answer to, 'Is that species going to be there or not?', as a guide to target areas that people might want to go and explore that exists. I don't know what stage the project is at or if the report is available for circulation.

7.3.3 CDC - Syilx culturally sensitive ecosystems project

- *[KC: Getting back to the cultural values, what are your thoughts on that?]* I've actually been doing quite a lot of thinking about that. Searching for resources to initiate projects. I do have some projects I've started and they're not in CDF. One of them is working with the Syilx Nation around identifying culturally sensitive ecosystems.

7.4 IMERSS project

- Andrew Simon with IMERSS is working on a pilot eco-cultural mapping project on Galiano Island. https://imerss.org/2019/01/01/ecocultural-mapping-pilot/. They're looking to expand their process to create ecocultural maps of significant sites throughout the Salish Sea. They're working in partnership with Whiteswan Environmental, an indigenous led institute working on natural, cultural and historical restoration to the Salish Sea. I'll send you the link from the IMERSS-White Swan project. They've got something started. Its very local scale but if you're thinking about a pilot there could be linkages. I think they've got connections with the Penelakut and with a matriarch body that is forming across communities, and they're affiliated with White Swan Environmental, which is a First Nation organization.
- The last one I'll dive into is this Eco-cultural Mapping Pilot. This is the splash page through IMERSS. It's really important to emphasize that it's something that was initiated by Whiteswan Environmental.
- They were intrigued by the mapping and data visualization we were doing and they engaged us with the idea of creating an Ecocultural Mapping Framework. They had a vision of restoring ancestral lifeways within the Salish Sea, connecting Lummi First Nation with Saanich Nations. So, mapping out sites of cultural and ecological significance in their ancestral territories. It began with developing a kind of coalition and a Memorandum of Agreement, such that, if we were to participate in this or support this process, we would do so in a way that protects their concerns. If we pursued grants, it would primarily benefit indigenous community members.
- We've had funding from the southern Gulf Island Community Resource Centre, and more recently through the BC Healthy Watersheds Initiative/Indigenous Watershed Initiative. We're going into the third phase of developing this and it's been focusing on this area here on Galliano: Retreat Cove (Xetthecum), which is interesting, because it's outside of Strait Salish territories, technically, it's more

within Hul'q'umi'num territories. The coalition is starting to include many nations outside of Strait Salish territories as we go through the initial work of just developing the framework.

- We're creating project documentation with the idea it will be an open-source framework. There will be cultural content that's sensitive to this place that will be protected and respected as content, but the framework itself can be adapted as open-source, so that's the goal.
- We started by mapping out the different ecological communities and getting input from the community, the public, on the values associated with this. We conducted some semi-structured interviews with Indigenous community members and elders who have strong ties to this place. We did these interviews with indigenous community members about not just this place, but also the ecological communities represented here. The next phase is deepening that outreach and continuing that process of collecting that information.
- This is where we started leading into the need for the development of a story-mapping framework, because of course, there's a narrative emerging now. And we didn't have that at that time. It basically gets scrunched into the template we had before. The idea is to be able to embed video. We also had community members going out and create soundscapes, like recording sounds from the different communities. When you click on or the marine environment, you would get sounds from that environment. We started going out with a community member connecting with this place to learn the Hul'q'umi'num names for some of the species. We have some video and some audio.
- Respecting the sources, we didn't present the detailed cultural values of different species.
- Putting into perspective how you move slowly and carefully in this kind of area, it has probably taken four or five years in development by the time it's nearing completion.
- *[LS: So when you started this journey, what was the main outcome that the First Nation actually was looking for?]* We're not anywhere near that close to the vision. Their vision would be seven long houses in the southern Gulf on the Canadian side, and then seven long houses on the US side, representing sites of safety for cultural practices, basically restoring their practices and their presence on the landscape. What they want to do is map out culturally significant sites, within their traditional territories, and use that as a framework for communicating the importance of these places to them with the long-term vision of having long houses built in the region. That's really the vision, restoring the reef net fisheries etc. There is a full holistic vision. The mapping framework is a way of communicating their vision, which is very holistic and broad and ambitious, long term.
- *[LS: Do you think the communication is internal or external? Is it a tool that the First Nation themselves would be using, or is it to communicate to externally to local governments and the wider community?]* I think both is the goal. We haven't hosted anything sensitive so far, which is why it's online. How do we honor this place? the significance of this place is not something that the First Nation necessarily wants to openly communicate in great detail. We're looking at how do we represent this for numerous audiences? So right now, I think the Islands Trust is interested in developing cultural overlay mapping.
- Potentially it would allow the people making decisions to understand the presence of something sensitive. I think they're developing mapping that would highlight things that are a little bit more subtle, or about the cultural significance of places to integrate that into land-use planning. We worked on this prototype with a mind for its implications for that.
- There are currently areas of high cultural significance that are significantly impacted by recreational visitors to the area. There is a motivation to create public awareness for the ecological significance of this place, which is another external use of the information.
- *[LS: we're looking to try and develop tools that would be useful to First Nations, but it's trying to find a way to engage that is also useful to them. Do you have any recommendations as to how we could engage with First Nations when we're talking about climate adaptation?]* In the Howe Sound biosphere region, they have been working for a long time to build relationships with First Nations. So they already have a lot of strong relationships.
- For the work that we've been doing, we gained traction by working on a grassroots level with people, starting with the relationships we had with those immediate to us in our community.

7.5 University projects

- *[KC: Do you know of anyone who's doing that who we should talk to?]* I'm not sure. I would say there's probably tons of knowledge held by Nations that I am just not aware of or don't have access to. Some

of that data is also guarded very carefully for good reasons. I know Pamela Spalding at UVic is doing some good work with T'Sou-ke Nation. There are plenty of researchers working directly with nations, but I don't know of many within the provincial government who are working with TEM. There's also a well-developed set of principles out there for Use-and-Occupancy Map Surveys, but that might be something slightly different.

8 Carbon Mapping

8.1 General considerations

- For mapping, would be good to highlight where carbon sequestration is most beneficial and could be helpful even as a local government planning tool.

8.2 Mapping forest carbon storage with LIDAR

- Also see **Section 1.3**
- *[KC: with respect to carbon mapping, if we were to identify key action items for the region, what exactly should we be recommending?]* We should try and find all the LIDAR data we possibly can, because LIDAR is the best technology to predict biomass by far, by an extraordinary amount. Any other prediction of biomass will be poorer than what LIDAR can provide, including predictions based on Landsat data, VRI, optical imagery like Planet, or aerial photography. Nothing is going to beat LIDAR. There are issues with LIDAR and people are picking up on that: it wont give you species, its expensive, its difficult to process. But they are minor things compared to an above ground biomass map you'll get, with 70-80% accuracy. You're going to get very accurate estimates of biomass.
- *[LS: We're also interested in carbon so its been suggested that LIDAR is needed to quantify land-based carbon. Am I correct that the only way or the best way to calculate carbon is by using LIDAR in combination with ground plots?].* Yes. I just wanted to mention that we had a conversation with another branch in our ministry (MoF), and they are called the Forest Carbon Branch. They came to us and said we have a million and a half dollars to do a Forest Carbon Forest Inventory somewhere, and asked if we had any ideas on where we wanted to do that or what that would look like? They want LIDAR so that would be the first piece, acquire the LIDAR and then transform that LIDAR into a forest inventory. That could be used to monitor carbon. There's a lot of people thinking about forest carbon, in BC. You might want to reach out to this branch too.
- *[LS: do you know what the driver was for that piece of work?]* It is to determine carbon offsets, and trying to manage those through time. It was a high-level discussion, and they really just wanted to know where we thought it would be a good idea to acquire LIDAR and do these types of projects.
- Finding out who has the data, working out under what agreement its being collected, looking at the age ranges of the data, making a map of the holding, and starting to negotiate with all the people own is really where your best bang for you buck will be.
- *[KC: is there a commonly agreed upon methodology for using LIDAR to map carbon storage, or is that something that needs to be defined as well?]* I think it's pretty well known how to process the LIDAR for carbon mapping, so methodologically there's no issue, but there's always the need for ground data. LIDAR is only giving us a beautiful point cloud: how do you relate that to the biomass? You need plots to tell you what the biomass is. That's the second big project, to gather ground samples / plots that tell you what the above ground biomass is. Its not as impossible as it sounds because you can convert forestry plot data to calculate biomass. The province has plots across this area that we would could use. There would be fuel plots and researcher's plots all through the gulf islands. Again it would take some work to find the plots and figure out if they were appropriate. Ideally you would have 200-300 plots to serve as ground references of the biomass. Then you would build a model that relates the plots to the LIDAR model, and make a broad scale prediction.
- *[KC - what are we talking about in relation to scale and cost for a project like that?]* Scale: normally you would make a map with a pixel size the same as the plot size so you would probably end up with a pixel that is 20x20m grid, over the entire area that would be a prediction of above ground biomass.

- We would need to burn through water, urban and things that don't have any biomass. We would use a land cover map to burn through areas that are not forested or vegetated and then….*[KC: we need the landcover map first. CWS has their landcover 'Frankenmap' for BC, have you seen it?].* I haven't, but if the LIDAR says there is no height then its either concrete, bare ground or water.
- So there are some things that you can do at a very coarse level. If you don't care about the land cover and you just need a mask then it's very easy to get rid of a pixel that is not forested, because you can just say height is zero. But if you want to use the LIDAR data in the non-forested area, to use the land cover map to interrogate the LIDAR, e.g. to calculate the average height of buildings, then it needs to be better than a mask. But I agree there is probably enough layers around that you could do that pretty easily. *[KC: if we were to contract someone to do the carbon mapping, how long for the plot data? How much money are you talking about?]* That's hard to know.

8.3 Tracking change in forest carbon

- Even if we had a continuous layer of above ground carbon, we still would not want to map that as a variable year after year. We are better off mapping it as accurately as we can the first time, then looking for change in carbon over time. It is actually the change we care about.
- If we decide the best way to do this is using LIDAR (and the whole area has probably been flown with LIDAR at least once), the LIDAR data is held by lots of different organisations, different people, and some of it will be public some of it won't. A lot of effort will be needed to get all this data and make really good maps. We can't afford repeatedly map the current state of the biomass every one, two or three years - it is an enormous undertaking. So lets map it well once, then focus on the change.
- Of course, the forest might grow, the wetlands might absorb more carbon so they might change on an annual period, but it is not really the increase in carbon associated with forest growth that we really care about - it is probably only 1-2 %.
- What we really care about is their clearing, their expansion, their degradation, those sorts of things. There the things you're better off mapping. Can you map the degradation, the pressure or the threat of something. Can you map the expansion of urbanisation. The better questions to ask are very specific to understanding the influence on above ground biomass, rather than mapping above ground biomass every year. Especially if the methodology relies on LIDAR and Planet.
- You can pay Planet to provide you with change products in terms of biomass and carbon. That would likely require LIDAR, which is fairly high cost and also requires a fair amount of expert work. That would require some cooperation with experts such as the federal or provincial government.

8.4 Canadian Forest Service carbon mapping

- *[LS: when I look at the amount of mapping that is currently available, why do you think that they haven't been as successful as they were intended to be?]* The Canadian Forest Service (CFS), for example, are charged with national carbon reporting so they need to use data and techniques that are consistent across their purview, in this case national. So they are not able to go away and use LIDAR across all of Canada, because we don't have LIDAR across all of Canada - only around 5% of Canada that has been mapped with LIDAR. So if they need to build a carbon model and develop it across the country, they have to use data that is consistent across the country. This means they are reliant on the provinces to give them forest information, like the VRI, which is what they use as their base in BC. They do the same thing across the country and all of their carbon projections are based on polygons that are as consistent as possible across the entire country. This results in a product that is actually quite poor at a local scale but reasonable enough at a national scale to do national level reporting. They don't really care if the prediction is correct outside the window, they care that statistically on average the prediction is correct for the lower mainland, so the maps that you get from CFS are nationally excellent but locally poor, because of that assumption.

9 Watershed Resilience Mapping

9.1 Defining watercourses with LIDAR

- And then I was just going to add that we use LIDAR to help identify water course location. So, either ones that have been missed historically, that they didn't know about or to refine their location. So, we find LIDAR really helpful for a lot of that stuff. So that tends to be how we come up with a lot of our mapping or refine a lot of our mapping work, it's through that LIDAR. In an ideal the world you'd want, like a province-wide LIDAR based assessment of all that stuff. But it's not really realistic to do it at that scale, maybe. But that would be helpful.

9.2 Wetlands and riparian mapping

- Refer to **Section 3.6**

9.3 Hydrologically sensitive areas

- *[KC – Local governments are concerns about the effects of development / forestry on the ecosystems services provided by water. I have been looking at how we can use the layers we have to identify hydrologically sensitive ecosystems that could enable local governments to determine where forests should be retained to protect their hydrological systems].*
- *[KC – if you overlaid the riparian mapping, wetland mapping, the Nature Trust riparian mapping, could that give us a useful layer for identifying hydrologically sensitive areas?]* Yes, I think so. My colleague developed the layers for the Williston Wetland Mapping.]
- *[KC – looking back to the hydrologically sensitive ecosystem mapping. There are two aspects that are missing. One is groundwater recharge and discharge areas. I've seen some mapping that was done by a consultant for Salt Spring Island, but the detailed methodology wasn't in report. I was wondering, does existing terrain or TEM mapping allow you to tease that out? Is that something that could be added to a layer for hydrologically sensitive areas, to your knowledge?]* I don't know if it would be directly within the TEM. I know that there's a whole bunch of water retention and climate based layers. I think my colleague would be the best to answer that question, but yes, there is information like that available that can be used and incorporated into the TEM or as a stand alone layer to get you that information.
- *[KC – The other piece with that hydrological sensitivity is identifying forest structural stages and element contributing to watershed hydrology, which currently the models that local governments seem to be using for their hydrological modelling doesn't seem to incorporate forest structural stage. It seems that getting agreement amongst hydrologists in the province as to how forest structural stage impacts watershed hydrology seems to be a contentious issue. We're probably going to go through a process with some hydrologists to identify whether we include old forest or old growth forest in watershed headwaters into a hydrologically sensitive areas layer. The way the criteria are set out for deferrals, they don't address hydrological watershed issues or carbon storage. I was wondering if we could get ahead of that with local governments so that when they are consulted they look at hydrologically sensitive forest stands on private and crown land above them.]* Yes, I think that's a good point and definitely a missed piece, for sure. *[KC – Okay, so we're not on the wrong track there.]* No, no. *[KC – That's good to know that I wasn't off on the wrong tangent with the terrain mapping.]* Yeah, definitely, and the soils layer as well. There's a SIFT tool. That has useful information as well as far as the soils within the province.
- [KC: What about coming up with an additional attribute column for the SEI mapping, which indicates or ranks the relative hydrological sensitivity of each of the ecosystem categories?]. I don't really like indices, and I think its better to keep it to the smaller watershed, so you can say to people, 'this area here is the most important area for shallow water groundwater recharge in the entire watershed.' I think that if you start to extrapolate and rank and use indices extend across a large geographic area, it

waters everything down. It needs to stay localized, so people realize they could have important watershed features on their properties.

- I've talked to William Shulba about groundwater and he makes a very good point. Yes they have mapping that shows areas of importance for deep aquifer recharge, and areas which are important for shallow water aquifer recharge. There are high and low rankings given to recharge areas, but William says 'low' doesn't mean an area's not important, and low recharge areas shouldn't be talked about as not being important.
- *[Added by KC: Islands Trust has done mapping of groundwater recharge potential, based on precipitation, land/vegetation cover, soil, geology, slope, faults etc. https://islandstrust.bc.ca/wp-content/uploads/2021/02/2019-17-gws-ssi_groundwater-recharge_final.pdf*
- *They also have a regulatory toolkit outlining what kind of planning tools can be applied by local governments to protect groundwater https://islandstrust.bc.ca/wp-content/uploads/2020/05/groundwater-toolkit.pdf]*
- *[KC: Do you have any thoughts on the maps that were produced last year by Tara Martin's lab for the Islands Trust Salt Spring Island CDF project?]* Tara's model can be used to ask certain questions around big trees, which probably capture areas with good moisture and high water table.

9.4 Water quality

- *[LS: where do you think the gaps are in terms of spatial mapping around the Georgia strait?]* Coming from an aquatic perspective. I think the big one that we've recognized is the impact of anthropogenic activity on aquatic life. We've identified a big gap in relation to water quality and toxicants so there's a lot of work going on in that we are trying to identify different datasets and assess impact. Another good one that ties in with the terrestrial is understanding how streams in urban settings have been impacted by development e.g. culverting of streams, riprap etc. I think that would be a really good way to get people to understand how they impact on streams and also how they can change and work alongside nature.

9.5 Hydrological/stream flow modelling

- [KC: We're also looking at trying to figure out a way to identify hydrologically sensitive areas on the landscape so we can map them. But apparently there is some division in the hydrological community about this, in terms of the relative impact of forest cover/age and forest harvesting on watershed hydrology.] North Salt Spring has a watershed that supplies potable water through delivery of North Salt Spring Water Works district to about 40% of the island. So they are managing the water resource, and a large amount of the surrounding area is covenanted. It has a history of silviculture, mostly just clear cutting, and agriculture with some wetland draining. When we look at the reports from the hydrological engineering consultants that were brought in to build a water model, and I don't know that they ever set foot on the island. So they're making some assumptions about groundwater supply versus rainfall, and the wetland and forest cover of the watershed does not get modeled into it. Its a box type approach, focused on the movement of water but not on the system itself. Then the next issue is who is doing the hydrological modeling, because if it's a hydrological engineering firm who is hired to address supply, then they're using a very different model with a very different objective. The other thing that's been very surprising for me in North Salt Spring is they don't seem to have water monitoring for the lake or the creeks.
- We know that climate is going to change like stream flows, for example, in the future. So, we need to build things in a different way that recognize that there might be higher stream discharge events, and then lower during drought events with less water. So, base flows might go down, and peak flows might go up in stream ecosystems. And so, we need to account for that. So, we definitely we account for it those sorts of ways, I think.

10 Wildfire Resilience Mapping

10.1 Risk and fuel mapping

- Identify fire risk zones, but also provide guidance on how to reduce fire risk and not impact the ecosystems
- *[KC: would LIDAR would be useful for wildfire risk mapping?]* It is useful for fuel; its not going to be incredibly accurate, but it will give you attributes like overstorey cover and midstorey cover, understorey cover. Obviously the DEM (digital elevation model) gives you good information on where you are in the landscape. With the very accurate DEM you can get information around local micro climates, fine scale mapping of wetter and drier parts of the environment. You can also do this using the provincial DMs, but the finer resolution topography you get from LIDAR-derived DEMs gives you much more information: small streams, ephemeral streams, where they start as they come down the landscape, where they're going to be more wet or dry. These things help point out where the fire risk is going to be. LIDAR has no weather component (e.g. how dry it is from a day to day point of view); it is more about structural fuels: where do we have lots of fuel structure, where do we have little structure, where do we have more open areas that might be resilient, where do we have these very dense fuel locked areas. LIDAR will give you that level of information. *[KC: basically if we got that wall to wall LIDAR for our study area, that would be a great starting point for all sorts of things?]* I would say so.
- *[LS: Would Natural Resources Canada hold the LIDAR for the area?]* Canadian Forest Service don't collect the LIDAR themselves, they might have little pockets here and there. It is going to be held by the province, local governments or private landholders.

10.2 Maxwell Creek Project

10.2.1 Reducing wildfire risk and biodiversity

- The focus for our Maxwell project is on reducing fire risk in the in the forest while demonstrating the values of our local forests in reducing the spread of fire. I think that's a really important storyline for the people who don't care about biodiversity.
- You mentioned perhaps needing to trade off biodiversity for other values – in my project I can't think of a single trade-off that would not result in improved biodiversity. My goal isn't biodiversity, its to reduce risk. But the best fire risk reduction happens to be native vegetation, green waxy leaved plants, high moisture in the soils, higher structural complexity, all of which equal biodiversity. So I don't need to talk about biodiversity. It's encapsulated in reducing fire risk. [*KC: When ecosystems are in good condition they create or maintain conditions that help ensure their longevity. So it only makes sense that healthy ecosystems maintain moisture/water on the landscape.]*
- And also to introduce the idea of how riparian areas are a natural fire break – due to the moisture and low flammability index of the leaves of many of our understorey plants. You don't need bare earth - you need native vegetation and riparian areas. So it's a different conversation.

10.2.2 Mapping wildfire fuels and risk

- Our project at Maxwell Creek is fantastic. I can send you the proposal, but the project is still emerging. We had a landowner step up and start providing us with processed LIDAR data, which is incredible. So we're mapping fuels, we're trying to map stumps and coarse woody debris, and to determine the historical tree density in the area and how its changed. We have all kinds of data on silviculture, when trees were cut. So in this watershed, we're able to identify areas where we have high fuel loads and potential for ignition to help us prioritize where we need to do something first. Then on another level, we've got highly stressed, overly dense forests, never thinned, that are contributing to fuel loads and fire risk, with low biodiversity and early seral habitat.
- We're also looking at the interface of between hydrology, the landscape, the forest canopy with fire risk, to come up with an analytic way of looking at the landscape and prioritizing where we can do an

interruption, like a break in the canopy or restoring riparian systems, to stop the spread of fire. We can do interventions on the ground and thinning that would enhance the ability of trees to mature while also allowing understory to be restored and increasing fire resilience in these forest, while also increasing wildlife habitat (overall biodiversity).

- Right now we're looking at what data do we have? What's going on this landscape? And then how do we measure canopy? This is the technical side – how do we collect information on canopy closure, coarse wood debris and tree density, without requiring volunteers (who have high variability in how they measure these things). Can we use a technical tool instead, such as a drone or photographic images that can be processed through an app.
- We're starting with what we have in terms of the LIDAR data, and then we're then we're to try to validate our assumptions and develop and test methodologies for doing some form of technical evaluation and quantification that could be repeated without a huge cost. Then we can see how large the disparity is between remotely sensed data and locally collected data. These techniques could then be transferred and applied to different parts of Salt Spring and other Gulf islands.
- So you can start off with a coarse LIDAR lens, and use these same layers in the same way to identify particular areas with very high potential for canopy spreading fires, and high potential for ignition starts for ground fuels, ground fires and laddering. Then we can look at the landscape and start identifying areas where could be problems, and look at the potential for fire to affect other values, such as wetlands and lakes, which we don't want to be contaminated.
- We're looking at developing a toolkit of methodologies for Maxwell Lake that can then be applied elsewhere, starting with the remote sensing, and then working down to these modified techniques that don't require as many human beings to go out on the ground. You start off by identifying hotspots, then use defined methodologies, such as taking pictures in a particular way, which can then be inserted into an app which analyzes the photo and tells you what the tree density and canopy closure is. That way you don't have to rely on highly variable estimated by humans.
- You can use historical and climate projection numbers about relative humidity, the maximum overnight temperature, etc. to calculate fire hazard and how it's going to change. That kind of information can be used to demonstrate risk to people and get them to understand.

10.2.3 Restoring wildfire resilience

- So we're trying find ways of using the data we have to assess these things remotely, and then do some ground-truthing to validate our assumptions and the locations of priority areas. Then we layer it all together to determine how we can best restore local hydrology and reduce fuel loads and fire risk while optimizing biological and structural diversity, at a landscape level.
- These systems can benefit from thinning, the first question is what should thinning look like? This is why we're looking at historic tree density. IF we have blowdown, how much can we thin at any given time, how do we do the patch thinning so its more natural, and where are we most likely to have success with natural regeneration of the understorey with thinning?
- At the same time we're going to demonstrate the types of restoration activities that would be appropriate to thin the trees to reduce the fire risk, to increase the organic matter, to deal with the issue of organic debris on the ground, and then actually implement them on the landscape.
- Fortunately we have Gulf Islands National Park, who are doing some fire work and tree thinning in the National Park, which will help us in our thinking. Our study area on Salt Spring also has an Eco-gift covenant, which is the most strict in limiting what you can do on the property. So I'm going to have to go through the process of collecting data to make the case for restoration activities, where we need them and why, and the approaches/thinning methods to be applied in each location. Then we'll have a dossier to give to the land conservancy, who will then submit it to Environment Canada, to see if they will give us a variance and a time window to go in and actually do the work. If they create an impediment to restoration by saying no, it will open up an interesting conversation, because this project has Environment Canada funding.

10.3 Burn severity mapping

- *[LS: Do you think there's anything that you're working on at the moment that could be interesting in terms of what we're doing? That would be worth sharing with us?]* I can mention the burn severity

mapping that we do. It's annual mapping so there's no delay. The harvest tracking and that we do, would also be of interest. That's just the projects that I've been involved in.

11 Marine and Coastal Ecosystems Mapping

11.1 Strait of Georgia Data Centre and Marine Reference Guide

- *[LS: Can you tell me about the mapping portal development that you've been working on in terms of the Strait of Georgia Data Centre [9]and the Marine Data BC?]* The Data Centre has the Strait of Georgia as its area of interest. A lot of the time we're out there trying to find data that might not be widely distributed. It might be available through someone's email or maybe they have these data in a portal but the portal is hard to access. We want to make these data more accessible, we want to streamline that accessibility. We will look at data related to the Strait of Georgia marine environment and this can be from various sources; it can be from local government, other levels of government, NGOs, etc. and we acquire these data by contacting folks and putting it in the portal. In that way, we are slowly expanding the amount of data that is now shareable to the general public and ultimately we believe that accessibility leads to increased scientific research and increased conservation efforts.
- Though we're specific to the Strait of Georgia, we don't clip data. We understand the relationship between terrestrial and marine environments as well and we don't want to focus strictly on datasets that are just in the water. We do have some freshwater data but ultimately, this means we have datasets that expand beyond the Strait of Georgia. You mentioned the Marine Data BC Portal[10], that covers all BC, though you will find a prevalence of data for the Strait of Georgia.
- The mapping is taking specific data sets that someone either on our team or on an external team has said, we think these data are really important, and then we will create educational resources in the forms of story maps, interactive maps or non interactive maps, where you can easily digest these data by looking at that map, and maybe do more advanced things like filter over time. That would be some of the more obvious data related to the ecosystem like forage fish spawn locations and locations of nearshore habitat, things that we believe at the Pacific Salmon Foundation are ultimately most important to salmon. The mapping is focused on those low-hanging fruit, easy to showcase the important datasets.
- Then the Marine Reference Guide[11] is taking all of these data and puts them in one map. We can speak to that a little more as I think it's probably quite relevant to the development of a Biodiversity Atlas. It's a centralised map for 400 plus datasets that allows you to visualize and compare a lot of the spatial data that's available through our portal.
- *[LS: Do you think in terms of the Georgia Strait, there could be an opportunity to bring in our layers or do you think that's too much of a stretch in terms of coming away from the marine environment?]* I think there's opportunity for sure, we never want to dismiss data. We would probably want to look at the layers and if they are related to the aquatic habitat, that would probably be our mandate. In terms of posting data it wouldn't really be an issue.
- Just to add to that, the inland and ocean environment are not separated at the coastline. Things that happen in the catchment will affect the estuaries and rivers and ultimately the marine environment. So, I don't think there is a distinct cut off.
- A big aim of the mapping is to look and see what you can find, find the gaps and work out ways to fill them. One of our other programs is Resilient Coasts for Salmon[12] which delivers nature-based solutions along the coastline, a facet of their project is mapping hard armoring along the shoreline because that's not well documented. There's obviously a lot in urban areas, but also coastal properties, maybe officially or unofficially adding armoring to their properties. So, we are filling that gap by undertaking boat-based monitoring and identifying all the locations along the coast where those things

[9] See: https://sogdatacentre.ca
[10] See: https://soggy2.zoology.ubc.ca/geonetwork/srv/eng/catalog.search#/home
[11] See: https://maps.sogdatacentre.ca/apps/765d1442158048e8a94482b3429585b0/explore
[12] See: https://resilientcoasts.ca/community-mapping/

are. I guess a part of the project is we can look at all these things, find as much as we can sleuth and there's always going to be more out there than we can possibly discover, but using the mapping tool/imagery we can see areas where we would like to focus and collect more information.

- *[LS: How have you involved First Nations in the project and its development?]* We like to take a respectful approach. We understand as an open data portal that a lot of First Nations prefer to keep data internally. We will reach out to First Nations and collaborate with First Nations on maybe making metadata available where it's okay to say the data exists, but that you should contact the First Nation. In that case, we won't actually make data available. We've been conducting workshops where we are showcasing the marine portal and the marine reference guide and we've invited a number of First Nations to come and have the opportunity to learn about how they might be able to use this map for their coastal efforts. Again, we take the respectful approach of saying, we're open to collaboration, though there's no pressure to feel that you should be obligated to make your data collection efforts available to the public.
- *[LS: are the Guardians providing data for the portal?]* I think that you are correct, though that work was delivered by another colleague of mine.

11.2 Citizen science data

- *[LS: what do you think about using citizen science data sets?]* I would say our use has been fairly limited over the years, but that it can be quite successful. The Island of Mayne has a conservancy group that has collected detailed eelgrass habitat distribution information. If you have a detailed methodology it can be effective in producing quality data. If you have a more ad hoc approach to collecting data, then the data might still be useful, but it just might have limitations. It's something that you might have to dig into and have to filter through the data to find the particular layers you're looking for.
- One thing that we didn't bring up in regards to Citizen Science is where we (or partners) have organized citizen science programs that help fill gaps but are overseen by PSF/University/WWF/ONC/DFO other organizations to collect data at low cost (due to volunteer nature) but at a high standard (due to oversight, processing or analysis by specialized organisations). We have multiple examples of these data in our Data Centre/MRG and they are highly valuable (Citizen Science Oceanography, Green Crab Sightings, Forage fish beach monitoring etc.)
- *[LS: from a political perspective can you think of someone who is currently influential in this field?]* From our Resilient Coast Team Perspective, they're putting a lot of energy into education and outreach directed at councils. Those are the ones that are going to be doing city planning and that sort of work, and then, more specifically, landowners along the shoreline. I think you'd want to direct your energy at the level of people who are doing the city planning and making adaptation plans, so regional districts.
- Have you spoken to the Átl'ka7tsem/Howe Sound Marine Stewardship Initiative? I would highly

11.3 Other projects and organizations

- *[LS: who do you think we should be speaking to, to learn more?]* Coming from a salmon mindset, maybe you've already spoken to some of these organizations, but there are a few organizations that I can think of where they are looking at stream environments, which would probably be quite tied to terrestrial based ecosystems. There's the British Columbia Conservation Foundation (BCCF) and Raincoast Conservation Foundation. There also a plentitude of smaller NGOs that would probably be interested.
- There's a map we actually have in our map catalogue, if you go to the data centre under maps and products, it's the aquatic conservation NGO map, where we have created a map showing over 300 NGOs working on aquatic related initiatives in British Columbia. It would have contact information for them. Returning to the citizen science question from earlier, they might be able to provide you with data or help promote your initiative by sharing information about it on social media.
- Have you spoken to the Átl'ka7tsem/Howe Sound Marine Stewardship Initiative? I would highly recommend it. We partnered with them and they have a very similar project to us. Their map is actually the same front end as our map. They gave us their map, though they're a couple years ahead of us and they've really taken their project to the next level where they are, getting engagement from local

governments and First Nations. I believe they have worked with First Nations for herring spawning. Their approach is getting a refined layers list specifically tailored towards working with First Nations and Local Governments.

12 Additional Related Initiatives

12.1 Stolo and Squamish Connect

- With the Stolo Connect referral system. That's another example of where First Nations have created the system, that they can run their referral applications through, and understand how the project might spatially impact things that they've mapped like archaeological sites or significant cultural and spiritual sites. It is fairly sophisticated. We have used it for restoration projects. We upload a polygon and a report, and then they have access to that information. They can review it in the context of all the information that they already have, internally. I think that's a great system.
- Squamish now has a system called Squamish connect that is actually based on the Stolo connect platform, And I've used that to get input from Squamish on projects. So, it's actually like having project tracking and management integrated with the data. I think is also really useful.

12.2 Provincial spatial tool (Monica Pearson)

- Another example data and decision making, and specifically spatial data is what the province has been building. Monica Pearson has been working on a spatial mapping tool that tries to collate a lot of different information around natural resource management and conservation, to be used internally by the province for decisions that they're making about applications that they receive for various types of natural resource projects.
- There's a public version of that, and that is an example of where I think you are probably headed, and where you probably want to head as well. This idea of like a one stop GIS based tool for helping to people to be able to get information quickly, to help spatially understand how their project that they're reviewing or involved with fit within a landscape of biodiversity values. A tool, collating existing information into the database, and making sure that information then is available to people who are doing those sorts of decision-making or involved in land use, planning processes or and making that available not just to provincial staff but also to local government staff for reviewing land development applications.
- you can put down a project location on a map and understand what are all the environmental constraints related to this site related to biodiversity, and previous projects in the area. All these sorts of information sources that the province has, generally in a GIS system, but doesn't have a tool that gives people the power to use the data in the way that they might want.

12.3 Local Government mapping projects

- I know there are a few municipalities that are more sophisticated on the GIS side, and have been doing more biodiversity mapping. City of Maple Ridge is one of them. They did a lot of work in the nineties, and early 2000s on trying to map out their ecological values. And then the District in North Vancouver also has been a little bit more sophisticated on GIS and mapping, and trying to take information from individual projects, and use it to create a management picture that that local government staff can use to review other future projects, as well. People to contact: For the city of Maple Ridge, it's their environmental planner. District of North Vancouver, Richard Bose and also Caroline Jackson, Climate, Biodiversity and Ecosystem Services.
- Comox Valley Land Trust was also involved in some recent local mapping for a Natural Asset Management framework, which pulled in many useful layers.

12.4 Nature Conservancy and WWF

- I find that some of the work that the Nature Conservancy and WWF does at the higher level planning scale, and they do a lot of complicated spatial analysis at the national level, I find them useful, for furthering the discussion at the provincial and national levels, but I found them a little bit detached from the local level decision making and the ability to apply that work at the local scale. If you can get some connection between those two, it would be great.

13 Project Questions and Comments

- In terms of how I would run the workshop. I think that your plan is a good one. I think the concern is that you end up with a wish list, like you have in your doc points, a wish list that is impossible. *[KC: I would like to see some things picked up from the wish list that are deliverable.]* You want to refine the conversation down to vignettes of success, where are there groups that have used the technologies that have been useful and they a discussion around how we do it. Not a discussion that comes back that says that we can't, we don't have the data. You want to avoid that.
- I did have a chance to flip through the report [Round 1 Interview Results] this morning, and it was good to see these are basically the same things we are aware of. We know there are issues from our end as well and it was interesting to see the same sorts of things coming up over and over again.
- *[KC: What decision support tools e.g. mapping would help local governments and First Nations in relation to the management of biodiversity? What do you think of the key challenges that were highlighted during the first round of interviews?]* I will say that the list of challenges resonates. I can think of work being done to address a bunch of them already, but when I looked at the challenges, I could see that you had spoken to some very knowledgeable people who have identified some very real challenges.
- The forest land base [of your study area] just seems too big. *[KC - we're focusing on where do they need better decision support. The focus could be providing SEI and / or identifying sensitive hydrological features. Maybe a predictive mapping layer showing where culturally significant species are and a lot of this work is already going along, it's not like we're not going to invent it. It's about just trying to align these things. When we're thinking of the crown base, we're mostly thinking about the spatial tools the province is developing and whether the analysis can extend up to the tops of the watersheds, particularly in relation to watershed and wildfire resilience.]* That makes sense. What you're trying to do is consolidate existing data.
- *[KC: Yes, and then if there's some glaring gaps try to get some collaborations going to fill them.]* That does seem really important. Do you have support from the provincial government? [KC - Yes. They're partners with us on this.] They're giving you money? *[KC: Yes, they're giving us some money, most is from the federal government at the moment, but yes, we do have provincial money. The idea is trying to align things rather than everyone running off in different directions and to avoid the possibility of people doing the same things when they don't have to, or running at cross purposes.]*
- It sounds really worthwhile and very challenging to narrow down what you're going to do, so best of luck with it. I'm glad you're working on it. I'm sorry if I sounded skeptical on the old growth. I'm not skeptical that there's going to be more permanent protection; I think that is going to happen. I just think that now that those deferrals have been identified, which of them are protected permanently is going to involve more politics and economics and First Nations than anything else. The other challenge is that within the Georgia Basin there's very little old growth.
- *[KC: Again my thinking, so you understand where I'm coming from, is primarily just about getting better, more up to date spatial tools to local governments and First Nations to help them with their decision making. First Nations get a lot of referrals and I think if we can provide them with some improved spatial layers and making them a little easier to use e.g. providing some better interpretation of the layers. At least they have the information to consult when they're making their decisions. That's as far as we can go.]* Absolutely. And the fire risk piece is huge.
- *[KC - We're partnering with Transition Salt Spring. They've received funding from the feds to do a study on the Maxwell Creek Watershed. They're looking to do a data driven project with modelling to try to*

develop wildfire protocols. Including ecological restoration that improves wildfire and watershed resilience and protects biodiversity. They're really focusing on the wildfire resilience and the information collected may be used to form a decision tree of protocols for restoration in the CDF. That would be a policy piece. Maybe talking to some people about risk mapping and whether there's something we can do to improve that. The other thing we're hearing from local governments is they seem to be open to the idea of pooling resources to come up with products, rather than pursuing things individually. If we can get some agreement on what those products should look like, then maybe it'll happen that way.]

- I just got back from California and I saw the area that was burned that took out the town of Paradise in 2018. I went on a field trip to that area and it's very sobering. I just think about the south end of Quadra is within the Georgia Basin. In 2017, all the forests of Quadra burned. The whole thing. The whole island. I'm sure there was tons of logging slash and everything else, but that was pretty much climate change, so I'm always just super aware that the best laid plans.
- I think I'm starting to see that although your project has many different aspects, it's the framework creation that is probably the valuable core of what you can do. *[KC: That's why we're focusing on developing regional policy and decision-support frameworks. And trying to get more exchange between the different groups who aren't necessarily talking to each other all the time, as well as getting some academic expertise injected].*
- Listening to the conversation, I hadn't really thought about trying to develop decision support tools at that sort of level, so it's a new vision for me.
- So when we've been talking about climate change in this conversation I've mostly been hearing you talk about carbon. To me climate change adaption is really about restoring wetlands, and that's what our latest application with the WASANEC Leadership is focused on, wetland stewardship and restoration, and building capacity to do that. And secondarily the project will contribute to carbon sequestration. I don't want to lose the adaptation side, because it's so important, but there's little money for it compared to carbon. Climate change will be causing fires, droughts, famine and disease outbreaks, but there seems to only be money for modeling carbon. *[KC: With respect to terminology, when I'm talking about carbon that's the climate change mitigation piece. When we're talking about climate change adaptation, that's mainly related to enhancing watershed and wildfire resilience. But we need to be mainstreaming the notion of climate change adaptation into all aspects of the project, because we'll need to be thinking about how we adapt to climate change impacts on biodiversity and cultural resources, as well as watersheds and wildfire. For example, we could be exploring ways of using the TEM and BEC to predict/model how ecosystems and habitat for species at risk are likely to shift and change, as well as plants that are culturally important to First Nations (e.g. cedar). This could be used to help decide where green infrastructure networks and biodiversity corridors should go].*
- I think, from my head I'm interested to see where it goes. It sounds really interesting.
- Yeah, I think it's a good idea. Great initiative. I think that there needs to be some consistency across BC regions on this type of work.