SEM / TEM MAPPING

SEM/TEM Mapping Updates And Disturbance Mapping In the Islands Trust Area

FOR:

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September 13, 2017

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SEM/TEM Mapping Updates And Disturbance Mapping In the Islands Trust Area

1 Introduction

Madrone Environmental Services Ltd. (Madrone) was retained by Islands Trust in 2017 to conduct updates to the existing ecosystem mapping in the Trust area to inform future regional conservation initiatives and land use planning. This work was undertaken in two stages. Stage 1 of this contract was completed in March 2017, which included the following tasks:

- Review of ecosystem polygons on Gabriola Island that are currently classified as ‘cultivated field’, and to identify any natural herbaceous meadows occurring within them.
- Review of coastal sand ecosystem polygons to ensure they have been correctly interpreted as per the 2011 “*Status Report on Coastal Sand Ecosystems in British Columbia*”, and propose a methodology to identify and describe these ecosystems within the Trust area.

This report details the methods and results for Stage 2 of the contract and includes the following tasks:

- Reassessment and possible separation of sensitive ecosystem components from mixed polygons (those with both sensitive and non-sensitive components).
- Conduct an update of the ecosystem mapping data to reflect recent disturbances to natural ecosystems, using 2014 ortho-imagery.

2 Methods

2.1 SEM / TEM updates

The contractual agreement specified the following task:
"Review and re-evaluate approximately 1300 polygons with mixed sensitive and non-sensitive ecosystem designations throughout the Island Trust area: do line work to separate these two ecosystem types."

2.1.1 Preparation

The TEM data was queried to find polygons with a mix of both sensitive and non-sensitive components. Because the high amount of mature forest (MF) in the study area, polygons with a MF component were not included in the query.
The final query resulted in about 1300 polygons to reassess. However, due to polygon splitting (such as creating new polygons for non-SEI elements), the total number of examined polygons was expected to exceed this amount.

Mapping was done in ArcGIS version 10.2. The imagery used was a combination of 2014 orthophotos (supplied by Islands Trust) and Esri Basemaps. The orthophotos were in 2D, so Google Earth Pro was used to visualize landforms, slope, and aspect in 3D. No field work was done in support of this project – however the mappers were familiar with many of the islands in the study area.

2.1.2 Ecology of the area

The majority of the Islands Trust area is in the Coastal Douglas Fir marine maritime subzone (CDFmm), with portions of the Coastal Western Hemlock dry maritime zone (CWHdm) and Coastal Western Hemlock very dry maritime zone (CWHxm) occurring at higher elevations on the larger islands in Howe Sound. The climate in the mapping area is generally mild with dry summers. A more continental climate occurs in Howe Sound with hot dry summers, and cold winters with outflow winds frequently moving down Howe Sound. The topography of the Trust area is typically subdued and rolling, however steep slopes and hills do occur throughout the mapping area at the local level.

2.1.3 Map Editing

The mapping of the Islands Trust was done island by island. Desktop mapping and attributing of each target polygon was generally done by considering the following:

- Assess slope, aspect, landform, vegetation cover.

- Examine the distribution of the ecosystems and anthropogenic features (scattered/random vs clustered/grouped).
- Review of the current data base attributes.
- Decide whether to split or not split the polygon, or make linework edits.
- Edit data base attributes as appropriate.
- Attribute adjacent non-queried polygons in some cases to be consistent with the target polygon.

2.1.4 Detailed mapping methodology

Common reasons for splitting polygons

- Splitting out rural residential areas (RW) and other anthropogenic features from undisturbed areas (creating a new polygon).
- Delineating non-sensitive young forest from mature forest or old forest (MF vs OF).
- Delineating non-sensitive closed canopy forest ecosystems from sensitive woodland units (WD:co, WD:mx or WD:br).
- Delineating logged areas and other disturbances.
- Splitting the polygon if the ecosystem distribution was clustered or grouped (depending on polygon size and other considerations).

Reasons for not splitting

- Forested polygons are often hard to break into separate SEI and non-SEI polygons when the different units are randomly distributed. An example would be a woodland forest (WD) and young forest (NS) where local topography results in an indistinct mosaic of ecosystems and stand types, and any linework done to separate them would be too detailed for the scale of mapping. Another example would be a gulley with Cedar – Skunk cabbage (WN:sp) and a Cedar-Foamflower young forest but with unclear boundaries between the two (in this case any management decision would likely consider the whole gulley, rather than the separate components).
- The query polygons are too small to split (e.g. < 0.2 ha).
- Polygons may not have been not split if air photo interpretation indicated that no SEI components were present.
- In cases where numerous small rural lots were mixed in with forested areas it was often not practical to split these out individually. However if a rural development was concentrated in a particular part of the polygon it was split out.

- For some small polygons, the cover of a non-sensitive component may have increased as a result of image interpretation, (e.g. due to new development), however it still may have been impractical to split the polygon.

Linework edits

- Edits were sometimes done to "tighten" up the linework around a feature (i.e. to increase accuracy of linework).
- Existing linework inaccuracies were seen, however in some cases these may be due to imperfect image geo-referencing.
- Linework followed ecosystem breaks when making SEI / non SEI splits (mentioned above).

Merging polygons

- Merging of adjacent polygons, or portions of them, was sometimes done when neighbouring polygons had identical features and landform. Common examples were the merging together of contiguous rural areas with other rural areas (RW), and merging of cultivated field with other fields (CF).
- Similarly, to group identical ecosystems, the target polygon was occasionally split with the ecosystems portions then merged into adjacent polygons. In this case, the original query polygon will no longer exist.

2.1.5 Editing existing SEI data

- All polygons were individually assessed and almost all polygons had some changes made to the data base. Edits were generally made in both the TEM and SEI data base and consistency between the two was verified.
- In many cases SEI designations were "downgraded": for example if a logged opening was thought to be a natural herb meadow (HB) or wetland swamp (WN: sp), the coding was changed to the herb or shrub stage of a forested ecosystem (NS).
- In some polygons the total amount (%) of SEI representation may have been reduced as a result of image interpretation, but the polygon may have still been too small to split into a new polygon.
- In other cases, air photo interpretation resulted in "upgrading" the SEI designations: For example Young forest (YF) was sometimes changed to mature (MF), and MF changed to old forest (OF) (less common).

- Where appropriate newer SEI codes were updated: Sparsely vegetated rock (SV:ro) was used instead of Herbaceous rock (HB:ro); new Sand Ecosystems codes (from Stage 1 of contract) were also used, especially beach areas SE:bb.
- Many polygons were reassessed as pure (100%) SEI polygons in two ways:
  1. Air photo interpretation indicated that all components in the polygon were sensitive ecosystems.
  2. Splitting off of non-SEI component (creating new polygon). Common example is the splitting off of rural housing (RW) – leaving a pure SEI polygon.
- Further comments on map edits are presented in Appendix B.

2.1.6 Editing TEM data

The edited TEM data adheres to TEM mapping standards and includes:

- Biogeoclimatic zone.
- Ecosystem site series.
- Site modifiers.
- Structural stage.
- Structural stage modifier (if applicable); and
- Stand appearance (conifer, mixed, or broadleaf).

2.2 Disturbance mapping

Recent disturbances to natural ecosystems were mapped to complement TEM mapping updates for the Islands Trust area. The original TEM mapping used aerial imagery from various years, dating as far back as 1980 in some cases. Because of this, the existing TEM product for the Islands Trust likely provides a very limited representation of recent disturbances. With a map product of recent disturbances, the Islands Trust will have an additional tool to quantify recent development and the loss of sensitive ecosystems. For the purpose of this mapping update, recent disturbances were defined as having occurred between 2004 and 2014 because these are the years for which orthophotos covering the Islands Trust area was available, thereby providing a consistent before and after comparison.

Visually scanning the entire Islands Trust area for disturbances would have been very time consuming and the likelihood of missing disturbances less than one hectare in size would have been relatively high. Therefore, to make the process of identifying disturbances more efficient, we classified land cover within the study area using multispectral satellite imagery from 2004 and 2014 and compared the land cover results using raster analysis tools. The result was a disturbance model that provided direction to mappers to hone in on assessing areas where disturbances were likely, and allowing them to quickly skim over areas where the model did not predict disturbances.

Disturbance Model

The 2004 imagery was from Landsat 7, and was a composite of images from June 30th and August 17th of that year. Landsat 7 images have gaps, which were mostly eliminated by combining two images from different dates. Landsat 8 imagery was used for the 2014 land cover classification, and was captured on May 3rd of that year. These specific satellite images were selected with the following factors in mind:

- Full coverage of the study area.
- Image captured during the growing season to highlight vegetation coverage.
- A reasonably high sun angle to limit shadow length; and
- Little to no cloud cover.

Landsat imagery was preprocessed, which included atmospheric correction and pan-sharpening prior to completing the land cover classification.

Land cover classification was completed using a supervised training process in QGIS. Once the training input was finalized for each of the images, the classifier was run using the minimum distance classification algorithm. Land cover classes included forest, field, rock outcrop / cliff, forest clear-cut, impervious surfaces, exposed soil / gravel, and water. Based on the spatial resolution of the input imagery, the cell size of the land cover raster output was 15m by 15m.

In ArcGIS, the output land cover rasters were reclassed to apply a unique value to each cover type from each year (Table 1). Then the two land cover rasters were summed using the Raster Calculator tool. Because the each of the reclassed values were separated by a minimum of a factor of 2, the before and after land cover combination could be identified by a unique value in the summed raster (Table 2).

TABLE 1. RECLASSED UNIQUE VALUES FOR THE 2004 AND 2014 LAND COVER RASTERS

Reclass	2004	2014
Forest	1	128
Field	2	256
Rock	4	512
Clearcut	8	1024
Impervious	16	2048
Bare Ground	32	4096
Water	64	8192

TABLE 2. UNIQUE BEFORE AND AFTER LAND COVER VALUES IN THE SUMMED RASTER

Change Matrix (2004 below, 2014 right)	Forest	Field	Rock	Clearcut	Impervious	Bare Ground	Water
Forest	129	257	513	1025	2049	4097	8193
Field	130	258	514	1026	2050	4098	8194
Rock	132	260	516	1028	2052	4100	8196
Clearcut	136	264	520	1032	2056	4104	8200
Impervious	144	272	528	1040	2064	4112	8208
Bare Ground	160	288	544	1056	2080	4128	8224
Water	192	320	576	1088	2112	4160	8256

Note: No change values highlighted in green; target change from forest to any other cover type in red; target change from any cover type to impervious surfaces in orange.

At this point the summed raster was converted into a vector polygon feature class. Only the target change values were selected and exported to create a new polygon feature class representing potential disturbances.

Disturbance Polygon Verification

Verification of the modeled potential disturbance polygons was done one island at a time. The mapper panned over each island, toggling between 2004 and 2014 orthoimagery, focusing on areas within the modeled disturbance polygons. Typically, the mapper started out viewing at a scale of 1:10,000 and would zoom in to 1:5,000 or less when actual disturbances were observed. Focus was first given to the largest disturbances, and smaller disturbances (i.e. <0.5 ha) were identified whenever practical.

Where a disturbance was reasonably well represented by an existing potential disturbance polygon, the mapper filled in two fields in the attributes table: “True” under the Disturbance_Verification field and a description of the type of disturbance / development under the Comments field. Often, multiple polygons needed to be merged to represent a single disturbance. Polygon boundaries were edited wherever they did not match well with the actual disturbance boundaries. Occasionally, disturbances were observed outside the modeled polygons, and these were mapped manually.

3 Results

3.1 SEI / TEM

We assessed 1300 polygons with a mix of sensitive and non-sensitive ecosystem components. Wherever possible, sensitive ecosystem components were split from the mixed polygons. Polygon splitting resulted in the creation of 533 new polygons, making a total of 1833 updated polygons. Whether or not a sensitive ecosystem component was split out of a parent polygon, all of the SEM and TEM attributes and linework were updated where necessary.

3.2 Disturbance Mapping

In total, 1,197 disturbance polygons were verified, covering approximately 1,026 hectares. The greatest number of individual disturbance polygons were verified on Salt Spring Island (348), followed by Gabriola Island (127), Hornby Island (91) and Denman Island (84). In terms of total disturbance area, Valdes Island had the most (253 ha) followed by Salt Spring Island (239 ha), Bowen Island (113 ha) and Gambier Island (108 ha). The total number of verified disturbance polygons and total disturbance area is shown by island in the Figure 1 below.

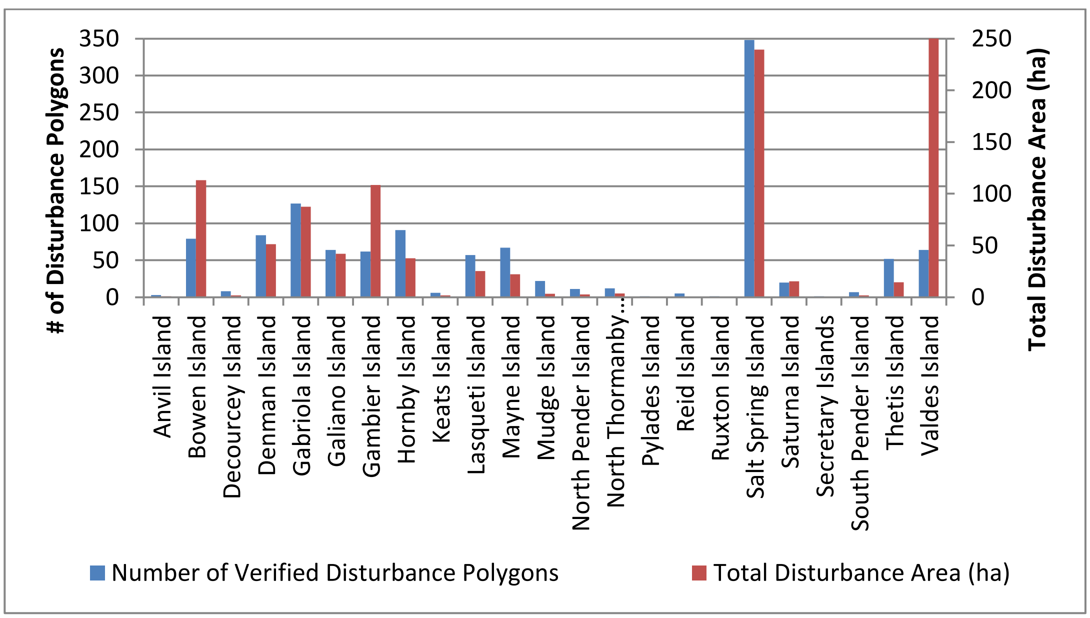


FIGURE 1. THE NUMBER OF DISTURBANCE POLYGONS AND TOTAL DISTURBANCE AREA BY ISLAND.

Please note that the areas of disturbances are rough approximations – please refer to the methods and discussion sections for details about the limitations of this data.

Disturbance types were categorized as follows:

- Deforestation – Either clearcut or partially cleared forest, for any purpose. Often associated with rural development.
- Cleared Vegetation – Cleared shrubs or pole/sapling trees, for any purpose. Often associated with rural development.
- New Buildings and Roads – Constructed in previously cleared areas. Note that these polygons often included cleared areas surrounding the roads or buildings. Also, new buildings and roads that followed deforestation or vegetation clearing are represented by those categories alone.
- Wetland Loss – Drained for agricultural use.
- Soil Disturbance – In previously cleared areas, new gravel pits or fill placement.

Between 2004 and 2014, the most deforestation occurred on Valdes Island (253 ha), followed by Salt Spring Island (202 ha), Bowen Island (111 ha), Gambier Island (108 ha) and Gabriola Island (73 ha). Gabriola Island saw the most clearing of shrub cover or pole/sapling trees at 9 ha, followed by 6 ha on Salt Spring Island and 1.8 ha on Galiano Island. New buildings and roads were most prevalent on Salt Spring Island (28 ha) and Denman Island (14.5 ha), followed by Gabriola Island (4 ha). A single 2.5 ha wetland was converted to agricultural use on Lasqueti Island. Soil disturbances (not associated with deforestation or cleared vegetation) were uncommon, and most prevalent on Salt Spring Island (3 ha) followed by Gabriola Island (0.2 ha). Table 3 provides a summary of disturbance areas by type and by island.

TABLE 3. DISTURBANCE TYPE

Island	Deforestation	Cleared Vegetation	New Buildings and Roads	Wetland Loss	Soil Disturbance	Total Area (ha)
Anvil Island	0.81					0.81
Bowen Island	111.34		1.91			113.26
DeCourcy Island	1.57		0.07			1.64
Denman Island	36.80		14.56			51.37
Gabriola Island	73.28	9.21	4.27		0.23	86.98
Galiano Island	40.01	1.78	0.08			41.87
Gambier Island	108.31		0.27			108.58
Hornby Island	37.39		0.31			37.69
Keats Island	1.64					1.64
Lasqueti Island	22.82			2.55		25.37
Mayne Island	22.14		0.09			22.23
Mudge Island	3.25					3.25
North Pender Island	2.82					2.82
North Thormanby Island	3.63					3.63
Pyleides Island	0.27					0.27
Reid Island	0.27					0.27
Ruxton Island	0.04					0.04
Salt Spring Island	202.29	6.24	28.00		2.65	239.19
Saturna Island	15.54					15.54
Secretary Islands	0.13					0.13
South Pender Island	1.66					1.66
Thetis Island	14.46	0.07				14.53
Valdes Island	252.55		0.33			252.87
Total Area	953.03	17.30	49.88	2.55	2.88	1025.64

Mapped disturbances were also summarized by the type of development or industry involved. Rural development accounted for the bulk of the mapped disturbances (613 ha or 56%), followed by forestry (401 ha or 38%) and road development (32 ha or 3%). Salt Spring Island experienced the most rural development (188 ha), followed by Bowen (108 ha), Gabriola (79 ha), Gambier (63 ha), Denman (37 ha) and Hornby (37 ha) Islands. Forestry impacts were by far most prevalent on Valdes Island (253 ha), followed by Gambier Island (45 ha), Salt Spring Island (35 ha) and Galiano Island (16 ha). Road development was most pronounced on Denman Island at 14.5 ha. Note that this number is likely skewed by these disturbance polygons including some of the area surrounding the road surface itself. Islands that also saw notable road development included Salt Spring (9 ha), Bowen (5 ha), Saturna (1.3 ha) and Gambier (1.2 ha). The agriculture category likely underestimates the area of agricultural development, as agricultural land use was frequently a component of rural development. Table 4 provides a summary of disturbance areas by development type / industry and by island.

TABLE 4. DEVELOPMENT TYPE / INDUSTRY

Island	Agriculture	Forestry	Gravel Pit	Industrial	Pond	Road	Rural	Total Area (ha)
Anvil Island							0.81	0.81
Bowen Island						5.27	107.98	113.26
DeCourcy Island							1.64	1.64
Denman Island					0.18	14.52	36.67	51.37
Gabriola Island	3.00	1.01	3.63		0.43	0.59	78.75	87.41
Galiano Island		16.20		1.12		0.26	24.29	41.87
Gambier Island		44.57				1.21	62.80	108.58
Hornby Island					1.06		36.64	37.69
Keats Island							1.64	1.64
Lasqueti Island	2.55					0.33	22.48	25.37
Mayne Island		0.40				0.04	21.79	22.23
Mudge Island							3.25	3.25
North Pender Island							2.82	2.82
North Thormanby Island							3.63	3.63
Pyleides Island							0.27	0.27
Reid Island							0.27	0.27
Ruxton Island							0.04	0.04
Salt Spring Island	4.31	34.89	3.09		0.45	8.78	187.66	239.18
Saturna Island		11.36				1.31	2.87	15.54
Secretary Islands							0.13	0.13
South Pender Island							1.66	1.66
Thetis Island					0.32	0.14	14.06	14.53
Valdes Island		252.55					0.33	252.87
Total Area	9.86	401.15	6.73	1.12	2.44	32.46	612.88	1066.63

4 Discussion

4.1 SEM / TEM

While every effort was made to achieve accuracy, the attributes for each polygon were assessed through air-photo interpretation, and are therefore subject to some imprecision. Some errors are more serious than others.

For example if field verification confirms that the actual ecosystem present is different than the mapped ecosystem <u>but is ecologically similar</u> (CWHxm/02 vs CWHxm/03) it would perhaps be an acceptable error; however, using the same example, if the confirmed actual ecosystem type was not a dry forest ecosystem but was wetland (such as CWHxm/12) the error would be more significant.

Similarly for structural stage: if the actual mapped structural stage is different than the mapped structural stage but are similar (old forest vs mature forest) it could be an acceptable error, however if the confirmed actual structural stage was not old forest but was shrub stage, the error is more significant.

On the other hand, for both of these examples, even a small shift in attributes could result in changes to the SEM classification and the designation of whether an ecosystem is sensitive or not. It is less serious if a non-sensitive ecosystem is upgraded in error to being sensitive, than if a sensitive ecosystem is downgraded to non-sensitive. It is for this reason that we recommend field visits to confirm the mapping and SEM designation for planned developments in sensitive areas.

4.2 Disturbance Mapping

Ideally, the raw disturbance model output would be a reasonably accurate representation of actual disturbances. However, there were limitations that meant mappers still needed to visually verify which of the polygons represented true disturbances. Overall, the model was successful in identifying true disturbances. In addition to the true disturbances though, there were many false positive errors (i.e. the model produced polygons where there were no disturbances). These false positive errors likely occurred for the following reasons:

- The best available Landsat imagery was from mid-late summer in 2004, and from the spring in 2014. So deciduous plants were at different stages in the growing season with different reflectance signatures. Many false positive polygons were observed over mixed and deciduous forests.

- Again, the difference in season, as well as the time of day the images were captured meant that there were differences in shadow length and orientation. Shadows along the edges of forested areas were a commonly misinterpreted by the model as potential disturbances.

Another limitation of the model output to note is the spatial resolution/accuracy. As the model was based on the analysis of raster layers with a cell size of 15m by 15m, the output polygons tend to have a 'blocky' appearance. For larger disturbances, the polygons often provided a reasonable representation of the extent of the disturbances. But for smaller disturbances (<0.5 ha) the polygon outlines were frequently an imperfect and sometimes poor match of the disturbance extents. In these situations, the mapper made a judgment call on whether or not to edit the polygon boundaries. And if the polygon was edited, the mapper's judgment was used to determine how much to edit. The goal was to provide a reasonable representation of the extent, distribution and type of disturbances in the Islands Trust area. In total, 831 (almost 70%) of the mapped disturbances were less than 0.5 ha and many polygon outline edits were made where needed and practical to improve the result. However, please note that many of the disturbance polygons are only rough approximations of the actual extents of disturbances.

The linework of the disturbance mapping layer could be improved manually to more accurately represent the disturbances. Also, further information could be derived about the types of ecosystems that were affected by the disturbances. This could be done by overlaying the disturbance data with the original SEM/TEM data (prior to our updates). To do this, the Union tool in ArcMap could be used to combine all features and attributes from the two datasets. Then, the polygons that have a disturbance layer attribute could be selected, and the resulting table exported to summarize in excel. Then it would be possible to summarize the disturbances (area and type) by the type of ecosystem that was disturbed. That way the loss of particular sensitive ecosystems could be quantified. Again, the quantified areas would only be roughly approximate unless the linework of the disturbance mapping layer was improved prior to completing this analysis.

4.3 Data base edits

Some fields that were intended for number entry were formatted as text fields in the original database (SDEC_2, SDEC_3, STRCT_S2, and STRCT_S3). This meant that there was a higher likelihood of typos occurring in these fields, and the simple QA task of checking if the deciles add up to 10 could not be completed on the TEM side of the dataset. So these fields were replaced with number formatted fields (Double for SDEC and Short Integer for STRCT).

In order to populate the descriptive fields (RATING#, SITEMCS#, SITES# and STRCTS#) using the mapper-updated code fields (RATING_#, SITEMC_S#, SITE_S# and STRCT_S#), python scripts were applied in the field calculator. Copies of these scripts are provided in Appendix C.

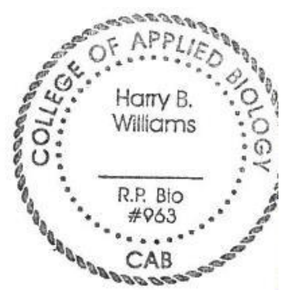
4.4 Summary

From 1300 polygons with a mix of sensitive and non-sensitive ecosystem components, an additional 533 polygons were created in the process of separating the sensitive ecosystem components. So a total of 1833 SEM/TEM polygons have been updated with improvements made to their attributes and linework, and sensitive ecosystems were separated wherever possible.

Disturbances that occurred between 2004 and 2014 were identified using a raster analysis model. In total, 1,197 disturbance polygons were visually verified, covering approximately 1,026 hectares. Each disturbance polygon was assigned a disturbance type, and the linework was manually improved wherever necessary and practical. As a product of a raster analysis with a limited spatial resolution, the degree to which the polygon boundaries match the actual disturbance extents varies, and was more of an issue with smaller polygons. So the areas of mapped disturbances should be considered rough (ballpark) approximations.

5 Recommendations

- For areas where development is planned in or adjacent to sensitive ecosystems, a site visit to confirm the ecosystem mapping is recommended.
- Address the errors in the larger database as described in Appendix A. As mentioned, all of these errors were addressed in our target polygons.
- Convert the Islands Trust database to TEIS standards. This would achieve considerable improvements including:
    - The ability to use provincially developed tools for QA (TEIS Contractor Package);
    - Remove redundancy within the database such as removing fields with the same information present in others;
    - Make the data-base simpler, with fewer fields.
- Manually update the disturbance mapping linework to improve the spatial accuracy, particularly for polygons less than 0.5 hectares in size.
- Overlay the disturbance mapping data with the original SEM/TEM data to quantify disturbances to specific ecosystem types, particularly to quantify the loss of sensitive ecosystems between 2004 and 2014.



Sincerely,
MADRONE ENVIRONMENTAL SERVICES LTD.

Ian Wright, PAg, RBTech
Restoration Ecologist and GIS Analyst

Harry Williams, PAg, RPBio
Senior Vegetation Ecologist

6 References

BC Ministry of Environment. 2006. Standard for Mapping Ecosystems at Risk in British Columbia: An Approach to Mapping Ecosystems at Risk and Other Sensitive Ecosystems (Version 1.0). Ecosystems Branch for the Resources Information Standards Committee.

BC Ministry of Environment. 2008. Terrestrial Ecosystem Mapping (TEM) of TIXEN/Cordova Shore. Retrieved from http://a100.gov.bc.ca/appsdata/acat/documents/r16805/Cordova_map_12518437174 73_018f3a08d8276ba8270185b110752ec34aa0dca96cdb049427cbebfad4c0af20.pdf in March of 2017.

APPENDIX A

Mapping Quality Assurance

Data base Quality Assurance

Various errors were seen while working with the existing data. These errors were addressed if they occurred within the target polygons. The lists below indicate some errors found. Some of these errors were also found while doing QA on our own data. Mapping errors fall under several categories: Coding, Thematic, and Mapping Standards.

Coding:

- Incorrect coding or coding in the wrong fields.
- Date entry errors, such as incorrect spelling.
- Mismatches between 2-letter map code and the site series number.
- Deciles in cases did not add up to 10.
- Lots of adjacent polygons had the same attributes, probably a result of past map edits such as subdivision of larger polygon.
- Missing codes, such as site series.
- Unknown mapcodes used (eg BA).
- Site series numbers missing for some units.
- Tiny polygons (eg 0.12 ha) having 3 eco components. Technically not an error but anything this small should be a pure unit (only 1 component).
- It was noted that there were multiple types of entries indicating an intentionally blank cell in the dataset (i.e. ‘’, ‘ ‘, or <null>). To reduce the potential for confusion, all of the intentionally blank cells were set to <null> for the SEM and TEM records we edited.

Thematic:

Thematic errors are those attributed to incorrect air photo interpretation. Some of these examples may have occurred more easily if the original mapping was done in 2D (ie mappers may not have recognized slopes and aspect).

- Small forest harvest openings currently in shrub or herb stage, or cleared rural areas (RW) areas, were mistaken for wetlands, herb meadows, or dry shallow-soil ecosystems [logging can usually be identified by gravel road network, and possibly piles of logging debris].
- Some wetlands were mapped on steep slopes.

- Obviously incorrect attributes were found: forested units attributed in a non-forested area such as cultivated field (possible legacy of polygon splitting); or mesic and moist units attributed on an obviously very dry landform with no source of seepage or moisture accumulation (perhaps the result of past polygon splitting where small polygons retain the attributes of a former large polygon).
- Considering that the Gulf Islands are quite dry, we felt that forested wetland swamp ecosystems (WN:sp) were significantly over-attributed. In many of these cases, formerly logged areas now covered with young red alder (*Alnus rubra*), were attributed as wetland swamps. To verify if something is a wetland or not you can use the following steps:
    - Check the landscape position – does it occur at the base of a slope or in a depression.
    - Presence of water inlet or outlet, or any sign of connecting streams.
    - Check for signs of logging such as old roads as well as adjacent land use.
- Pastures (PA) and cultivated field (CF) were often mistaken for wetlands or forested ecosystems.
- Coastal bluff (CB) was called riparian (RI:ff) in a few cases (ie on Sidney Island).
- Natural herb meadows on exposed bedrock (RO) were sometimes mistaken for land-clearing rural development (RW), or the opposite: rural land clearing sometimes mistaken for bedrock.
- Closed canopy forests were sometimes called Woodland (WD) however WD should have a fairly open canopy. I think that all CDF/02 were assumed to be woodland (which is accurate in most cases).
- In some cases red alder forest (perhaps resulting from past logging) were mistaken for dry broadleaf (Garry oak or arbutus).
- Some tiny polygons had up to 3 components (the obvious result of polygon splitting at some point); conversely some large polygons had only 1 component where 2 or 3 components would be expected.
- Incorrect structural stage applied – ie stage 2 (herb stage) for a forested ecosystem.
- Legacy data in fields. For example map codes present in component 3 with no supporting additional data – but complete data in 1st and 2nd components. This is

probably the result of splitting polygons at some point but not being thorough in making sure the new polygons have the correct attributes.

- Bio-terrain polygon linework should follow slope and aspect breaks, as well as being reasonably close to the mapped ecosystems or successional stages. However this was not always the case – but perhaps was due to the original mapping done in 2D where slope was hard to determine in places.

TEM standards not applied

- BEC Site Series numbers appeared as single digits (instead of 01, 02, 06 etc.)
- Adjacent polygons sometime had identical attributes (polygons should be merged if the attributes are the same)
- Missing core attributes such as stand composition, appropriate modifiers, deciles
- Site modifiers were sometimes added where not required (eg shallow soil modifier ("s") added for RW or other anthropogenic units, or "s" added for CF when attributed in SEI as seasonally flooded (FS).
- The following modifiers were sometimes used incorrectly or when there didn't seem to be enough visual information to support their use: w (warm), k (cool), n (fluvial fan), r (ridge), and v (very shallow). Some modifiers were not used at all: for example s (shallow soil) was only very rarely used, but instead v (very shallow) was over-used.

APPENDIX B

Mapping Notes for Certain Islands

General observations were made for some islands. Some of these comments refer to errors in the existing data base, and were addressed if seen in the target polygons.

Salt Spring Island

- Some logged areas on Mt. Tuam were mistaken for natural grassland or dry woodland ecosystems (forest with large gaps).
- When appropriate we would look at adjacent non-queried polygons and edit attributes for consistency.
- Some of the most common ecosystems in the queried polygons on Salt Spring Island were woodland ecosystems (DA, DO), and HB (rock outcrops).

Galiano

- Cultivated fields (CF) were often mistaken for wetlands.

Mayne and Pender Islands

- Many polygons had duplicate attributes (eg on North Pender everything seemed to be 8DS, 2 DA), suggesting that at some point larger polygons were subdivided without revising the attributes (any change in polygon size generally requires a re-evaluation of ecosystem representation).
- Some extremely small polygons were seen in some areas – some polygon merging would be good if the attributes are identical. One would assume that small polygons would have accurate linework, but the linework was inaccurate in places (eg a polygon that is attributed as 100% RW may have a woodland component, or a polygon line going through the middle of an obvious feature. These linework inaccuracies may also be explained by imperfect geo-referencing of images.
- Tiny polygons were seen with up to 3 components (not realistic). Conversely large polygons were seen that had only 1 component, where 2 or 3 components are likely.

Saturna

- Obvious grassland areas with warm aspect and shallow soils were mapped as forested in some areas.
- Multiple adjacent polygons had the same attributes.

Denman and Hornby

- Logged areas were often mistaken for wetlands.

- An inconsistency was seen where some polygons attributed the roads (RZ), but other nearby polygons did not (usually roads are not mapped in a TEM product).
- Small fields (CF) were mistaken for rock (RO) in places.
- Mismatches between the ecosystem map symbol and the site series number.

APPENDIX C

Scripts Used to Populate Descriptive Fields

RATING# Field Calculation	SITEMCS# Field Calculation and QA Check between assigned mapcode and site series code	STRCTS# Field Calculation
Reclass(!RATING_1!)	Reclass(!SITEMC_S1! , !SITE_S1!)	Reclass(!STRCT_S1!)
def Reclass (MC):	def Reclass (MC, SS):	def Reclass (STS):
if (MC == "NS"):	if (MC == "AM" and SS == "00"):	if (STS == 1):
return 'Non-Sensitive'	return 'Arbutus - Hairy manzanita'	return 'Sparse/bryoid'
elif (MC == "CL:cc"):	elif (MC == "AS" and SS == "00"):	elif (STS == 2):
return 'Cliff:coastal'	return 'Trembling Aspen - Slough Sedge'	return 'Herb'
elif (MC == "FS"):	elif (MC == "BE" and SS == "00"):	elif (STS == 3):
return 'Seasonally Flooded'	return 'Beach'	return 'Shrub'
elif (MC == "FW:la"):	elif (MC == "CD" and SS == "08"):	elif (STS == 4):
return 'Freshwater:lake'	return 'Black Cottonwood - Red-osier dogwood'	return 'Pole/Sapling'
elif (MC == "FW:pd"):	elif (MC == "CF" and SS == "00"):	elif (STS == 5):
return 'Freshwater:pond'	return 'Cultivated Field'	return 'Young Forest'
elif (MC == "GR:gr"):	elif (MC == "CO" and SS == "00"):	elif (STS == 6):
return 'Grasslands:grasslands'	return 'Cultivated Orchard'	return 'Mature Forest'
elif (MC == "GR:ss"):	elif (MC == "CL" and SS == "00"):	elif (STS == 7):
return 'Grasslands:steep slope, shallow soils'	return 'Cliff'	return 'Old Forest'
elif (MC == "HB:cs"):	elif (MC == "CS" and (SS == "14" or SS == "15")):	elif (STS == 0):
return 'Herbaceous:coastal'	return 'Western redcedar - Slough sedge'	return None
elif (MC == "HB:hb"):	elif (MC == "CW" and (SS == "09" or SS == "10")):	else:
return 'Herbaceous:herbaceous'	return 'Black Cottonwood - Willow'	return None
elif (MC == "HB:sh"):	elif (MC == "DA" and SS == "02"):	
return 'Herbaceous:shrub'	return 'Douglas-fir - Shore Pine - Arbutus'	
elif (MC == "IT"):	elif (MC == "DC" and SS == "02"):	
return 'Intertidal'	return 'Douglas-fir - Western hemlock – Cladina'	
elif (MC == "MF"):	elif (MC == "DF" and SS == "04"):	
return 'Mature Forest'	return 'Douglas-fir - Sword fern'	
elif (MC == "MF:bd"):	elif (MC == "DG" and SS == "04"):	
return 'Mature Forest:broadleaf'	return 'Douglas-fir - Grand Fir - Oregon Grape'	
elif (MC == "MF:co"):	elif (MC == "DO" and SS == "03"):	
return 'Mature Forest:coniferous'	return 'Douglas-fir - Oniongrass'	
elif (MC == "MF:mx"):	elif (MC == "DS" and SS == "01"):	
return 'Mature Forest:mixed'	return 'Douglas-fir - Salal'	
elif (MC == "OF:bd"):	elif (MC == "DS" and SS == "03"):	
return 'Old Forest:broadleaf'	return 'Douglas-fir - Western hemlock - Salal'	
elif (MC == "OF:co"):	elif (MC == "Em02" and SS == "00"):	
return 'Old Forest:coniferous'	return 'Glasswort - Sea Milkwort'	
elif (MC == "OF:mx"):	elif (MC == "Em03" and SS == "00"):	
return 'Old Forest:mixed'	return 'Seashore Saltgrass'	
elif (MC == "RI:fh"):	elif (MC == "Em05" and SS == "00"):	
return 'Riparian:mid bench'	return 'Lyngbyes Sedge'	
elif (MC == "RI:fl"):	elif (MC == "ES" and SS == "00"):	
return 'Riparian:low bench'	return 'Exposed Soil'	
elif (MC == "RI:fm"):	elif (MC == "FC" and SS == "00"):	
return 'Riparian:high bench'	return 'Fescue - Camas'	
elif (MC == "RI:gu"):	elif (MC == "GC" and SS == "00"):	
return 'Riparian:gully'	return 'Golf Course'	
elif (MC == "SE:ba"):	elif (MC == "GO" and SS == "00"):	

```
    return 'Sand Ecosystem:bar'
  elif (MC == "SE:bb"):
    return 'Sand Ecosystem:beach'
  elif (MC == "SE:bl"):
    return 'Sand Ecosystem:bluff'
  elif (MC == "SE:du"):
    return 'Sand Ecosystem:dune'
  elif (MC == "SE:sm"):
    return 'Sand Ecosystem:salt marsh'
  elif (MC == "SE:sp"):
    return 'Sand Ecosystem:spit'
  elif (MC == "SV:cl"):
    return 'Sparsely Vegetated:cliff'
  elif (MC == "SV:ro"):
    return 'Sparsely Vegetated:rock outcrop'
  elif (MC == "SV:sh"):
    return 'Sparsely Vegetated:shrub'
  elif (MC == "WD"):
    return 'Woodland'
  elif (MC == "WD:bd"):
    return 'Woodland:broadleaf'
  elif (MC == "WD:co"):
    return 'Woodland:coniferous'
  elif (MC == "WD:mx"):
    return 'Woodland:mixed'
  elif (MC == "WN:bg"):
    return 'Wetland:bog'
  elif (MC == "WN:fn"):
    return 'Wetland:fen'
  elif (MC == "WN:ms"):
    return 'Wetland:marsh'
  elif (MC == "WN:sp"):
    return 'Wetland:swamp'
  elif (MC == "WN:sw"):
    return 'Wetland:shallow water'
  else:
    return None
```

```
    return 'Garry Oak - Ocean Spray'
  elif (MC == "GP" and SS == "00"):
    return 'Gravel Pit'
  elif (MC == "HD" and SS == "06"):
    return 'Western hemlock - Western redcedar - Deer fern'
  elif (MC == "HK" and SS == "01"):
    return 'Western hemlock - Douglas fir - Oregon beaked moss'
  elif (MC == "HM" and SS == "01"):
    return 'Western hemlock - Flat moss'
  elif (MC == "LA" and SS == "00"):
    return 'Lake'
  elif (MC == "LM" and SS == "00"):
    return 'Dunegrass - Beach pea'
  elif (MC == "LS" and SS == "10"):
    return 'Shore pine - Sphagnum'
  elif (MC == "MU" and SS == "00"):
    return 'Mudflat'
  elif (MC == "OM" and SS == "00"):
    return 'Garry Oak - Moss'
  elif (MC == "OR" and SS == "00"):
    return 'Oceanspray - Rose'
  elif (MC == "OW" and SS == "00"):
    return 'Shallow Open Water'
  elif (MC == "PA" and SS == "00"):
    return 'Pasture'
  elif (MC == "PD" and SS == "00"):
    return 'Pond (>2m deep)'
  elif (MC == "QB" and SS == "00"):
    return 'Garry oak - Brome (or mixed graminoids)'
  elif (MC == "RA" and SS == "00"):
    return 'Nootka Rose - Pacific Crab Apple'
  elif (MC == "RB" and SS == "13"):
    return 'Western redcedar - Salmonberry'
  elif (MC == "RC" and (SS == "11" or SS == "12")):
    return 'Western redcedar - Skunk cabbage'
  elif (MC == "RF" and SS == "06"):
    return 'Western redcedar - Grand fir - Foamflower'
  elif (MC == "RF" and SS == "07"):
    return 'Western redcedar - Foamflower'
  elif (MC == "RK" and SS == "05"):
    return 'Western redcedar - Douglas-fir - Oregon beaked mo*'
  elif (MC == "RO" and SS == "00"):
    return 'Rock Outcrop'
  elif (MC == "RP" and SS == "13"):
    return 'Western redcedar - Indian-plum'
  elif (MC == "RS" and SS == "07"):
    return 'Western redcedar - Snowberry'
  elif (MC == "RS" and SS == "05"):
```

	return 'Western redcedar - Swordfern'
	elif (MC == "RV" and SS == "12"):
	return 'Western redcedar - Vanilla-leaf'
	elif (MC == "RW" and SS == "00"):
	return 'Rural Residential'
	elif (MC == "RZ" and SS == "00"):
	return 'Road Surface'
	elif (MC == "SC" and SS == "00"):
	return 'Cladina - Wallaces selaginella'
	elif (MC == "SS" and SS == "08"):
	return 'Sitka spruce - Salmonberry'
	elif (MC == "TA" and SS == "00"):
	return 'Talus'
	elif (MC == "TL" and SS == "00"):
	return 'Transmission Line'
	elif (MC == "UR" and SS == "00"):
	return 'Urban'
	elif (MC == "Wf51" and SS == "00"):
	return 'Sitka sedge - Peat-moss'
	elif (MC == "Wf53" and SS == "00"):
	return 'Slender sedge - White beak-rush'
	elif (MC == "Wm05" and SS == "00"):
	return 'Cattail'
	elif (MC == "Wm06" and SS == "00"):
	return 'Great bulrush'
	elif (MC == "Ws50" and SS == "00"):
	return 'Hardhack (pink spirea) - Sitka sedge'
	elif (MC == "Ws51" and SS == "00"):
	return 'Three-way sedge'
	elif (MC == "Ws53" and SS == "00"):
	return 'Red alder - Skunk cabbage'
	else:
	return 'Check MC - SS Combination'	