Metro Vancouver Regional District Regional Land Cover Classification and Sensitive Ecosystem Inventory Update

SUMMARY REPORT

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1.0 BACKGROUND

The Metro Vancouver Land Cover Classification (LCC) and Sensitive Ecosystem Inventory (SEI) datasets are critical spatial products for regional operations and planning. They represent baseline information required for developing regional land-use plans, monitoring regional growth and land use change, and implementing land use management operations. The Metro Vancouver Regional District (MVRD) requires these datasets to be updated every six years to ensure they are spatially and temporally accurate.

The goal of this project was to perform the scheduled update to the LCC and SEI using 2020 imagery to ensure that both products are representative of current regional conditions. To successfully complete the update we addressed the following objectives:

1) Completion of a change detection analysis to identify incidences of land cover change within the study area boundary between 2014 and 2020;
2) Completion of a 2020 land cover classification based on Planet Scope 5 metre multispectral imagery; and,
3) Completion of a 2020 SEI update based on the results of the change detection analysis and mapped using 2020 orthoimagery.

1.1 Study Area

The study area for this project (Figure 1) is comprised of the MVRD boundary and an additional five-kilometre buffer. The buffer was applied to enable the calculation of landscape context for SEI polygons falling along the periphery of the regional district (Figure 1). General land use types present within the study area fall within distinct geographic areas: 11% of the MVRD is agricultural occurring mainly in the South Fraser and Ridge Meadows subregions, 39% is natural falling mainly within the Northshore mountains and watersheds, and 19% is urban occurring mainly within the Burrard Peninsula and South Shore areas.

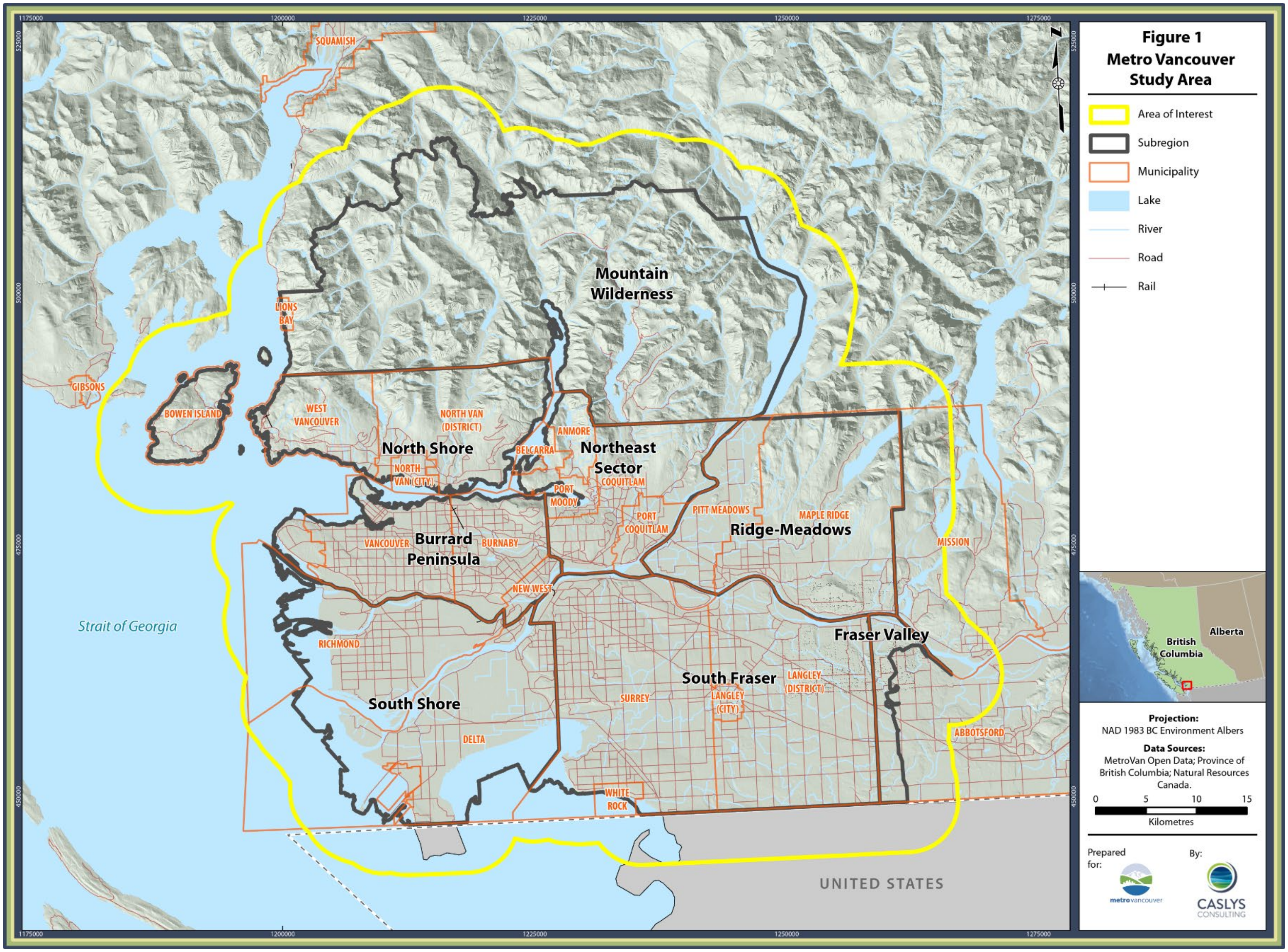

Figure 1. Study area map

1.2 Source Data

1.2.1 Orthophotos

An orthophoto mosaic provided by the MVRD was used as a reference during both the classification and SEI update. The orthoimages were captured in 2020 during the leaf-off months. The For the classification, it was used together with Google Maps and the ESRI ArcGIS Base Imagery during the accuracy assessment to help verify the accuracy of the land cover classification. The leaf-off timing of the images was advantageous as it provided information used to confirm the coniferous and deciduous tree classes. For the SEI update, the orthophotos were used to digitize polygon boundaries and inform the change type attributes associated with each polygon.

1.2.2 PlanetScope Imagery

PlanetScope 5-metre multispectral imagery was the basis of the LCC 2020 update. The imagery was radiometrically corrected and georeferenced for the study area. Five bands were available for use in the analysis: red, green, blue, NIR, and Alpha. In 2014, Rapid Eye 5 metre imagery was used to generate the LCC; however, was not available for the 2020 update. PlanetScope was selected as a replacement as it has comparable resolution and spectral specifications; thus, minimizing the amount of land cover change that can be attributed to changes in source imagery. A monthly image composite generated from images acquired during August 2020 was purchased as it provided a good balance between cloud free conditions and contrast between natural vegetation and agricultural areas (i.e., crops were mature or harvested).

1.2.3 Rapid Eye 2014 Imagery

The Rapid Eye imagery used to generate the 2014 land cover classification was provided by the MVRD. The images were acquired on August 2, 2014 and August 24, 2014 to provide continuous cloud free coverage of the study area. They had been radiometrically corrected and georeferenced. Five bands were available for analysis: red, green, blue, red edge, and NIR.

1.2.4 Sentinel Imagery

A number of cloud-free Sentinel-2 10 metre images were obtained for use in the classification and change detection portions of the project. Images from 2015 to 2020 were acquired through the freely available Google Earth Engine library and were downloaded as seven band geotiffs that were georeferenced to the study area. The seven bands included: red, green, blue, NIR 1, NIR 2, SWIR 1, SWIR 2. These images form a multi-temporal 'stack' that was used to infer seasonal differences (as illustrated in Figure 2).

Figure 2. Seasonal variation in Sentinel-2 Imagery

Sentinel-1 Synthetic Aperture Radar (SAR) data (2015 to 2020) were also included in the analysis. Two bands were used: VV and VH. SAR data was included as it helped identify anthropogenic features such as buildings and paved areas.

1.2.5 Landsat Imagery

Cloud-free Landsat images were obtained for the growing season (May - October) for 2014-2020 for use in the change detection analysis. The 30 m images downloaded geotiffs with five bands: red, green, blue, red edge, and NIR. Similar to the Sentinel data, the images form a multi-temporal image stack that was used to explore regional patterns of changes across the study area.

1.2.6 LiDAR Data

LiDAR data were obtained from the MVRD member jurisdictions where available. As a result, the LiDAR data used in the project represents a mosaic of vintages (Figure 3). LiDAR data were available for much of the study including the Capilano and Seymour watersheds; however, none were available for the rest of the Mountain Wilderness subregion. Three terrain surfaces were generated from the LiDAR data: a digital elevation model (DEM), a digital surface model (DSM) derived from first return values from each LiDAR pulse, and a canopy height model (CHM), which includes vegetation and building heights. These surfaces were resampled to a 5 m resolution to match the PlanetScope imagery.

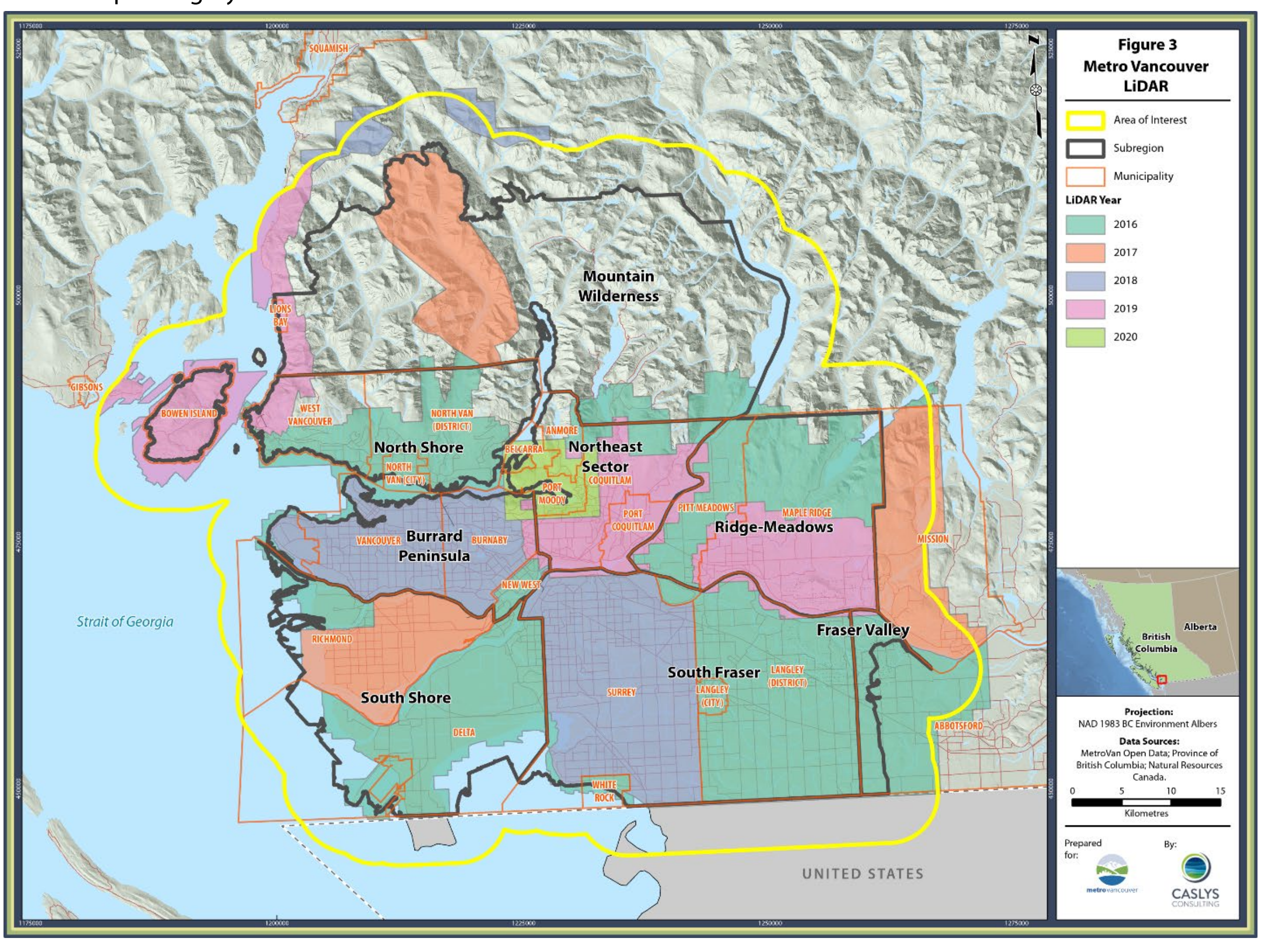

Figure 3. LiDAR Extents

1.2.7 Ancillary vector datasets

Ancillary data were used in the classification process to facilitate the separation of land cover classes that have similar spectral signatures and/or LiDAR derived parameters. For example, 1m tall shrubs in a natural riparian area can be confused with 1m tall crops in an agricultural area – and land use zoning information can help separate the two classes. Each of the ancillary datasets presented in Table 1 was clipped to the appropriate study area and then used as a raster overlay with classification results to modify (re-assign) the classes as appropriate.

Table 1. Summary of ancillary datasets included in the analysis

Dataset	Source	Application
Digital Road Atlas	BC Data Catalogue	Separate paved from barren areas
Freshwater Atlas	BC Data Catalogue	Separate water from trees and shadow
Shoreline	BC Data Catalogue	Resolve confusion in intertidal and coastline areas
Metro Vancouver 2020 Land Use	MVRD	Resolve land use confusion (e.g., agricultural covers from natural)

2.0 LAND COVER CLASSIFICATION

A random forest (RF) approach was selected to perform a supervised classification of the study area (Brieman 2001). This iterative process generates hundreds of unique decision trees, each producing a classified image. The benefit of using a random forest algorithm is that the ensemble method compensates for any model weaknesses present in the individual trees; thereby, producing better classification results. Additionally, it is a data-driven approach that is flexible enough to accommodate a variety of predictor variables and can be easily scaled to fit the study area. The classification workflow is summarized in Figure 4 and involves an iterative model fitting process where the model results are reviewed and adjusted to produce the best possible final classification model.

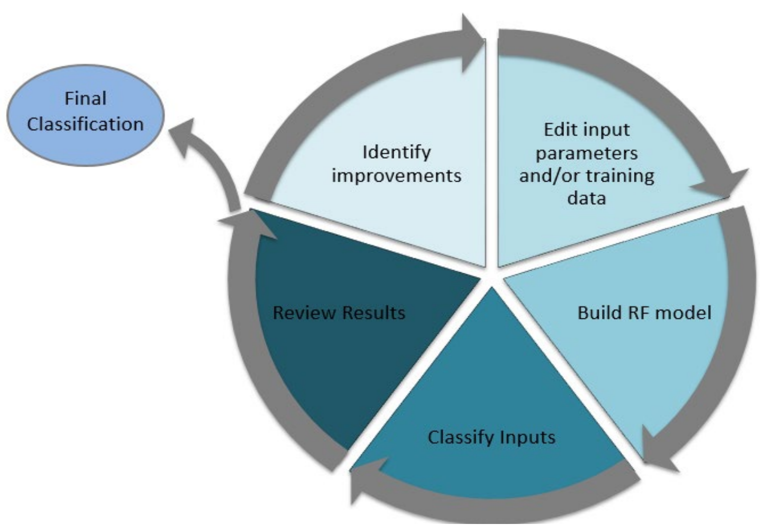

Figure 4. Random forest workflow

For this project, the random forest model was built to match the class framework and definitions used in the 2014 LCC. Using the same class framework facilitated the change detection analysis and SEI updates by minimizing the amount of change caused by method differences. Table 2 summarizes the land cover classes and associated definitions.

Table 2. Land cover classification classes and definitions

Classification*	Criteria*
Buildings	Housing, warehouses, towers, industrial structures, etc.
Paved	Asphalt and concrete surfaces
Other Built	Sports surfaces, transit or rail areas, other impervious surfaces, etc.
Barren	Beaches, alpine rock, shoreline rock, quarries, gravel pits, gravel roads, lacking vegetation, but not soil
Soil	Agricultural soils (light or dark), cleared/open areas where darker colors indicate organic matter present
Coniferous	Predominantly coniferous (>75%)
Deciduous	Predominantly broadleaf (>75%)
Shrub	Woody, leafy, and rough-textured vegetation (~ < 3 to 4 m)
Modified Herb	Most crops, golf course greens, city park grass, lawns, etc.
Natural Herb	Alpine meadows, near-shore grass areas, fine-textured bog/wetland areas
Non-Photosynthetic Vegetation	Dead grass, cutblock slash, and log booms
Water	Lakes, rivers, inlets, irrigation channels, retention ponds, pools, etc.
Shadow	Dark pixels with very low reflectance values
Snow/Ice	Snow or Ice features with high reflectance
*Taken from Williams et al., 2018.	

2.1 Training Data

The first step required for the random forest classification is the generation of a training dataset. The quality of the training dataset is important to the quality of the classification results as it is the building block for the predictive model. Training sites were generated based on a random stratified sample by land cover class based on the 2014 LCC, resulting in a distribution of samples across each land cover type that is representative of its significance on the landscape. A total of 3006 training locations were generated and interpreted using the 2020 orthophotos and 2020 PlanetScope imagery; 2299 locations within the LiDAR data extent and 707 outside (Table 3). Training data locations outside the LiDAR extent were only collected for the major landcover classes present for the same area in 2014: barren, conifer, shrub, water, and snow and ice.

Table 3. Summary of training data sample sizes for both the LiDAR and non-LiDAR models

Class	Number of Locations	
	LiDAR	No LiDAR
Buildings	225	
Paved	205	

Class	Number of Locations	
	LiDAR	No LiDAR
OtherBuilt	40	
Barren	51	49
Soil	59	
Conifer	446	463
Deciduous	386	
Shrub	155	38
Modified Grass/Herb	464	
Natural Grass/Herb	59	
Nonphotosynthetic Veg	39	
Water	153	143
Shadow	17	
Snow/Ice	0	14

2.2 Predictor Variables

As the LiDAR extent did not cover the entire study area, two random forest classification models were built with different sets of predictor variables. Table 4 summarizes the predictor variables used to produce the classification where LiDAR data were available; while Table 5 summarizes the variables for the areas outside the LiDAR extent. The main difference between the two sets of variables is the inclusion of Sentinel 2 data in the non-LiDAR classification. Sentinel 2 time series data for the 2020 growing season were used as variables to provide seasonal context to the vegetation classes in lieu of the structural information provided by the LiDAR derivative layers.

Table 4. Summary of predictor variables for the LiDAR based classification model

Variable	Source	Type
August Reflectance – R, G, B, NIR	PlanetScope	Spectral
August Normalized Difference Vegetation Index (NDVI)	PlanetScope	Spectral Index
August Soil Adjusted Vegetation Index (SAVI)	PlanetScope	Spectral Index
August Image Brightness	PlanetScope	Spectral Index
August Visible Brightness	PlanetScope	Spectral Index
CHM	LiDAR	Structural Index
CHM Sum Average	LiDAR	Textural Statistic
DEM	LiDAR	Terrain
DSM	LiDAR	Terrain
Image Brightness Inverse Difference Moment	PlanetScope	Textural Statistic
Image Brightness Variance	PlanetScope	Textural Statistic
July VH	Sentinel 1	Spectral
August VH	Sentinel 1	Spectral

Table 5. Summary of predictor variables for the non-LiDAR based model

Variable	Source	Type
August Reflectance – R,G,B,NIR	PlanetScope	Spectral
August Normalized Difference Vegetation Index (NDVI)	PlanetScope	Index
August Soil Adjusted Vegetation Index (SAVI)	PlanetScope	Spectral Index
August Image Brightness	PlanetScope	Spectral Index
August Visible Brightness	PlanetScope	Spectral Index
June Reflectance – R, G, B, NIR1, NIR2, SWIR1, SWIR2	Sentinel 2	Spectral Index
June NDVI	Sentinel 2	Index
June Normalized Difference Built-Up Index (NDBI)	Sentinel 2	Index
June Normalized Difference Wetness Index (NDWI)	Sentinel 2	Index
June Modified Normalized Difference Wetness Index (mNDWI)	Sentinel 2	Index
June – VH, VV	Sentinel 1	Spectral
Growing Season NDVI - max, min, range, std dev.	Sentinel 2	Time Series

2.3 Random Forest Classification

The random forest classification was performed using the 'randomForest' package (Liaw and Wiener 2002), supported by R statistical software (R Core Team 2019). The random forest model has two analysis parameters that can be adjusted to improve model fit and accuracy: the number of predictor variables considered by each decision tree, and the number of decision trees generated for the random forest. Within the R statistical software, each of the random forest models considered the five variables at each split and generated 400 trees. The random forest classification within the LiDAR footprint, classified for all twelve landcover classes; however, the non-LiDAR model classified for only five of the twelve classes: tree, water, bare, snow, and shrub. The model was built for only a subset of the twelve classes as land cover within the Mountain Wilderness subregion is primarily natural. Other land cover classes present in these areas (e.g., natural herb) were added in during the post-processing steps using a masking approach based on ancillary data layers.

Fitting the random forest models was an iterative process, where a model was built, and the results were evaluated both visually and quantitatively. Visually, the classification was compared to the source imagery to ensure that landcover classes were being captured accurately. Quantitatively, the confusion matrix generated from the training data provided a strong indicator of model performance. Through iterations of training data collection, the selected model parameters were determined to be highly effective with strong classification separation accuracy.

2.4 Post-Processing

Once the random forest classification was finalized, the results were refined with the use of ancillary datasets. Ancillary masks were applied to the classification to resolve confusion remaining in the classification. When these ancillary masks are applied, they are used to convert pixel classes occurring within the boundaries of certain features. For example, the preliminary classification may result in a confused barren class that includes roads, buildings, driveways, bare earth, and other anthropogenic features, as the spectral signatures for these cover types are very similar. The confusion in the class could be rectified by overlaying ancillary datasets such as road networks, airports, shorelines, or building footprints to reassign any confused pixels to the correct class. Another example is water pixels occurring within parks or residential resulting from classification confusion with shadow (i.e., shadows are spectrally similar to dark water features). The confused pixels are converted to an appropriate class with the application of the water feature mask (i.e., any water pixel falling outside a defined water feature goes to a vegetation class).

2.5 Accuracy Assessment

An independent operator reviewed the accuracy of the 2020 land cover dataset by comparing the land cover classification to a set of 770 randomly selected sample points. The sample locations were stratified according to the proportion of each of the 2020 land cover classes, with the rarest classes being represented by five locations, and the largest classes by around 270. The sample points were overlaid on the 2020 orthophoto where available, the PlanetScope imagery, and compared to Google Maps imagery. A land cover attribute was assigned by the reviewer based on visual interpretation. These points were then overlaid on the land cover dataset and the attribute assignments compared. A confusion matrix was produced to compare information from reference sites that were assumed to be correct (i.e., based on a manual review of the air photo) to the predicted classes.

2.6 Change Detection Analyses

A series of multi-scale change detection analyses were performed to characterize both regional and local patterns of landscape change across the study area. The regional change patterns were used to understand trends in landscape covers between 2014 and 2020 across the MVRD; while the local scale change analyses were used to streamline the SEI update process by highlighting specific areas of change. Additionally, the local results were used as validation tool for differences detected between the 2014 and 2020 LCC products. The local results provided information that could be used to differentiate between actual change (i.e., changes in land cover type) and apparent change (i.e., changes due to methodology or input data).

2.6.1 Long Term Change Detection

Following the change detection methods described in Fraser et al. 2011, a long-term change detection (LTCD) approach that leverages both Landsat and Sentinel 2 libraries was applied to explore regional patterns of landscape change. This approach used medium resolution satellite imagery to generate a false colour image identifying changes in ground brightness, greenness, and wetness using a tasselled-cap approach and linear regressions for the image time series representing the growing season between 2014 and 2020. For the Landsat imagery, the time series consisted of seven cloud free images (i.e., one for each year) acquired between May and September for the MVRD; while the Sentinel 2 time series consisted of six cloud free images. The results of these analyses cannot be used to quantify change; however, they are valuable as an exploratory tool, as the output can be visualized as a multiband raster that highlights significant land cover changes and informs the timing, degree, and direction of change associated with each. For example, red areas indicate a substantial loss of vegetation, while cyan colour indicates a general greening of the landscape. Orange shades typically indicate an area that was cleared of vegetation but has been regenerating in more recent years. Grey tones have not changed significantly.

2.6.2 Spectral index Comparison

Regional and local change patterns were also identified through the direct comparison of NDVI and visible brightness (VBR) indices generated from the high resolution 5m imagery and coarser resolution Landsat and Sentinel 2 data. Both indices were calculated for the two time periods and a pixel-based comparison performed. To minimize the effects of phenology between the two time periods, cloud free Landsat and Sentinel 2 data were acquired during June for both 2014 and 2020; while the high resolution 5m imagery was acquired in August for both time periods.

As land use and land cover types vary across the MVRD, we subset the study area according to the Metro Vancouver 2020 Land Use layer to produce four analysis units: water, urban, agricultural, and natural. Using the land cover subsets ensures that the change categories are specific to land cover types and spectral index values expected to be associated for each. For example, we would expect that NDVI difference values that represent consequential landscape change to be very different in urban areas as compared to natural or agricultural ones. As such, performing the index comparisons within land use groups will help to capture all important landscape change.

Identifying areas of high change was done by reclassifying the difference layer into seven change classes based on the standard deviation. Classes 1 and 7 were extracted to produce the final change result as they represented areas of extreme negative and positive change, respectively. For the NDVI, the extreme positive change class represents areas where there was an increase in NDVI values between the two time periods; while extreme negative change represents areas where the NDVI value decreased. Increasing NDVI values may be associated with vegetation growth between time periods, regeneration of harvest areas, or differences in agricultural practices. Decreasing NDVI values may be associated with the removal of vegetation during forest harvest, for urban or agricultural development, or from natural disturbance events (e.g., slides, flooding, or fire). For visible brightness, extreme positive values may be associated with the removal of vegetation (i.e., areas are going from dark to bright between time periods). Extreme negative values may be associated with urban development where land was cleared in 2014, and subsequently developed, making the pixels much darker in 2020.

2.7 SEI Update Procedure

The workflow for the 2020 SEI update was taken directly from the technical report produced during the 2014 update (Clark and Meidinger, 2020). Our general workflow involved overlaying the SEI polygons on the 2020 and 2014 imagery and reviewing them for significant disturbance or change between the two time periods (Figure 5). SEI polygons were prioritized for review based on the results of the high-resolution change detection analyses; any SEI polygon that contained pixels identified as high change was flagged for an in-depth review.

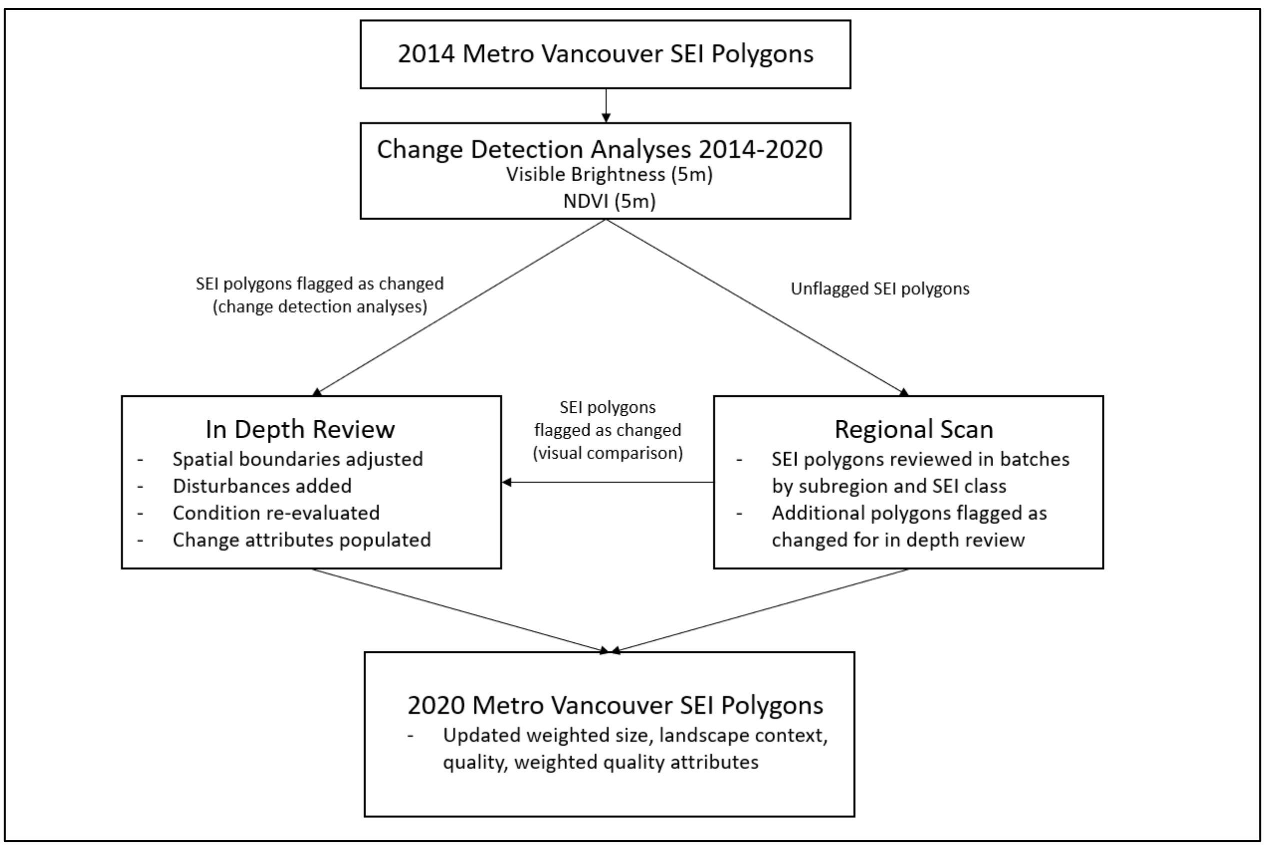

Figure 5. SEI update workflow

Polygons that received an in-depth review were visualized individually to capture any boundary changes, new disturbances, changes in polygon components, changes in condition, and the specific driver of change associated with each. Change attributes such as *Mod_Type, LU_Change, Change*, and *Amend_Comment* were populated for all change polygons to document SEI gains and losses. When required, the SEI components (i.e., component deciles and classes), disturbance, and condition values were also adjusted to ensure that SEI polygons were representative of conditions in 2020.

SEI polygons that were not flagged by the change detection analyses, were scanned to confirm that all major landscape changes were captured. The unflagged polygons were assigned to their respective subregions to generate manageable subsets for review. Within each subregion, the SEI polygons were examined in batches according to the primary SEI class type (e.g., mature forest (MF), young forest (YF), sparsely vegetated (SV)), as we found change was easier to detect visually when the reviewer was scanning one particular class type at a time. Any polygons with new disturbances or land cover changes were flagged for a more in-depth review.

Five attribute fields were added to document updates to the SEI dataset. These fields were populated with polygon specific values used to characterize changes in the SEI between 2014 and 2020, and also to support long term change monitoring for the inventory. Table 6 summarizes the fields added to the SEI during the 2020 update.

Table 6. SEI attributes field added during 2020 update to track change

Field Name	Description	Type	Length
SEI_PolyNbr2014	Holds the SEI polygon number from 2014. Provides a link between the 2020 and 2014 data.	Long	
Adj14Qual	Populated with the 2014 Quality value. Used to calculate changes in quality between 2014 and 2020.	Text	5
Q1420	Indicates whether the polygon was assessed for quality in 2014 and/or 2020.	Text	5
Mod_Type14	Retains the modification attributes from 2014. This information can be used to track the drivers of change for each polygon through time. For example, it may be useful to know that a given mature forest polygon was reduced due to logging in 2014 and then reduced due to residential development in 2020.	Text	10
Change14	Retains the change information for 2014. This information can be used to quantify and visualize spatial patterns of change in sensitive ecosystems across the study area.	Text	5
ChangeYr	Provides information on the year that a polygon was lost or added. This attribute distill the information provided in the Change, Change14 columns into a more user friendly format	Text	15

Once the polygon specific spatial and attribute updates were completed for the change SEI polygons, a set of blanket attribute update actions were taken to bring the Metro Van SEI dataset up to the new 2020 baseline. Table 7 summarizes the blanket changes made to the SEI attributes.

Table 7. The update actions detailed in this table are the blanket attribute updates performed during the 2020 SEI update

SEI Attribute	Fields	Update Action	Polygons Included
Polygon source	SourceName, Source Date	Attributed fields with Caslys and 2023-01-19	Polygons created in 2020
Polygon Mapper	EcoMap, last_editName, last_editDate	Attributed fields with RKite and 2022/2023 date	Change polygons
Size/Weighted Size	WSize_SE1/2/3, Size_SE1/2/3, SizeNo_SE1/2/3, WSize_SE1/2/3_BASIC	Updated polygon size values (Meidinger *et al.*, 2014).	Change polygons
Landscape Context	Context, ContextNo	Updated landscape context attribute using Metro Vancouver 2020 Landcover Classification (Meidinger *et al.* 2014).	All polygons
Quality/Weighted Quality	QualityNo_SE1/2/3, WQuality_SE1/2/3, WCombQuality, Quality, QualityNo	Calculated updated quality values (Meidinger *et al.* 2014)	All polygons

2.8 Small Young Forest

As the 2020 SEI update represents the second update to the SEI dataset, additional actions were required to reconcile and properly capture the conversion of young forest (YF) to small young forest (YS). The YS class is defined as any YF polygon that falls between 0.5/1 ha and 5 ha (Medinger *et al*. 2014). Reviews of the dataset found that many areas of young forest fell below the 5 ha cutoff to be considered YF due to detailed mapping of subclasses within an area of forest. The detailed subclass divisions resulted in areas of young forest >5 ha being mapped as multiple YS polygons and therefore not included as a Modified Ecosystem. To reconcile these classes and ensure that they were appropriately captured in the data, all YS and YF polygons were reviewed. YS polygons were merged if the following conditions were met:

1) The polygons were adjacent;
2) One of the components was YS. In the data, this was most commonly the primary component. There were very few situations where the secondary or tertiary components were YS; and,
3) The composition of the non-YS SEI components and associated deciles were identical, and the YS component only matched at the class level, not the subclass.

Once the polygons were merged, the component attributes were adjusted to reflect the new composition. When the YS subclasses did not match, *mx* was assigned as the new merged subclass. When a merged polygon area exceeded the 5 ha size threshold, YS polygons were reclassified as YF. The merge rules applied to the YS polygons are outlined in Table 8.

Table 8. Summary of YS reconciliation decision rules

Primary Component	Secondary Component	Tertiary Component	Merge action
Polygon A = Polygon B	Polygon A= YS, Polygon B = YS	Polygon A = Polygon B	Merge
Polygon A ≠ Polygon B	Polygon A=YS, Polygon B = YS	Polygon A ≠ Polygon B	Do not merge
Polygon A= YS, Polygon B = YS	Polygon A ≠ Polygon B	Polygon A ≠ Polygon B	Do not merge
Polygon A= YS, Polygon B = YS	Polygon A =Polygon B	Polygon A = Polygon B	Merge
Polygon A = Polygon B	Polygon A = Polygon B	Polygon A= YS, Polygon B = YS	Merge
Polygon A ≠ Polygon B	Polygon A ≠ Polygon B	Polygon A= YS, Polygon B = YS	Do not merge

One further change was made to aid accurate loss calculations for young forest, a new *Change* attribute was implemented: DF, for situations where YF polygons were reduced to below the 5ha threshold to become YS. The DF code will allow for the conversion of YF polygons to YS to be captured as loss in future SEI dataset summaries and updates.

2.9 Field Program

A two-day field program was organized to provide field information on 50 sites. Field site visits were conducted on October 18th and 19th, 2022. The field sites were determined based on the results of the high-resolution change detection analyses and the change observed between the 2014 and 2020 Metro Vancouver landcover classifications. The classes in the two landcover products were aggregated into four general categories to reduce the classification noise contributing to any change detected during the comparison. The four general categories were: anthropogenic covers, natural vegetation, natural bare, and water. Only change between anthropogenic covers and natural vegetation was considered. Similar to the SEI polygon update workflow, SEI polygons were flagged as changed if they contained high change pixels or if there was a change in the percentage in anthropogenic or natural land covers between 2014 and 2020. The polygons were attributed with the percentage of the polygon classified as anthropogenic or natural by the 2020 landcover classification. From the flagged polygons, field sites were selected based on proximity to roads (i.e., only easily accessible polygons were selected), SEI class (i.e., a variety of SEI classes were selected), and percentage anthropogenic versus natural (i.e., a range of percentages was selected from majority anthropogenic to majority natural). At the field sites, information on-site condition, size, context, disturbance types, and class proportions was collected. The field data was incorporated into the attribute updates and flagged using the *SmplTyp* field.

3.0 RESULTS

3.1 Accuracy Assessment

The accuracy assessment for the 2020 LCC produced a kappa value of 0.85 and an overall accuracy value of 88.3% (Low CI 85.8%, High CI 90.6%) (Table 8). This is comparable to the accuracy reported for the 2014 LCC (Williams et al. 2018). The tree classes had relatively accuracies, ranging from 80%-95%. The natural herb and shrub classes had lower accuracies, as there was some confusion with the treed classes where the LiDAR vintage was older than the imagery and did not capture tree loss due to forest harvest and development. The building class had both user and producer accuracies above 80%. The other built class had the lowest class accuracy at 15%, which reflects large variations of land uses and cover types that fall within it. The shadow class also had a low accuracy, as in some cases the random forest model could predict a land cover class based on the LiDAR and Sentinel 2 information, even though the high resolution PlanetScope Imagery contained shadow.

Table 9. Accuracy Assessment Confusion Matrix

Accuracy Assessment Confusion Matrix

Land Cover Mapping	Building	Paved	Other	Barren	Soil	Coniferous	Deciduous	Shrub	Modified Herb	Natural Herb	Non Photosynthetic	Water	Shadow	Ice	Row Total	User Accuracy
Building	25						1	2							28	89.29%
Paved		61	1	2	1		2		2						69	88.41%
Other		7	4	1					3						15	26.67%
Barren	1		1	19	2	1						1			25	76.00%
Soil		1		1	12	2			1						17	70.59%
Coniferous				1		252	7	2	2						264	95.45%
Deciduous		5				1	54								60	90.00%
Shrub				1		2	1	25	1	1					31	80.65%
Modified Herb	2	7					2	1	79		2				93	84.95%
Natural Herb						4		1	1	19					25	76.00%
Non Photosynthetic											5				5	100.00%
Water				1		2						127			130	97.69%
Shadow				1		4		1					6		12	50.00%
Ice						1								4	5	80.00%
Column Total	28	81	6	27	15	269	67	32	89	20	7	128	6	4	779	
Producer Accuracy	89.29%	75.31%	66.67%	70.37%	80.00%	93.68%	80.60%	78.13%	88.76%	95.00%	71.43%	99.22%	100.00%	100.00%		88.30%

3.2 Land Cover Classification Results

The random forest classification for the LiDAR based model resulted in an out of bag error of 80%. CHM and NDVI were strong drivers for the classification. The model predicted the major classes (i.e., trees, buildings, and water) well but there was some confusion associated with the less represented classes (I.e., other built, barren, non photosynthetic veg, and soil). In contrast, the non-LiDAR based model had an out of bag error of 96% and was influenced heavily by the NIR band and Sentinel 2 NDVI variables. Confusion occurred between the tree and shrub classes due to the lack of information about vegetation height in the model.

The 2020 landcover classification is shown in Figure 6. When the land cover types were examined at a regional scale, the classification correctly captured the general landcover trends across the MVRD: mainly natural vegetation covers in the Mountain Wilderness subregion, the modified herb class dominating the agriculture areas in the South Fraser, and anthropogenic cover types dominating the urban core in the Burrard Peninsula. Table 9 summarizes the percentage of each class to better illustrate land cover patterns for each subregion.

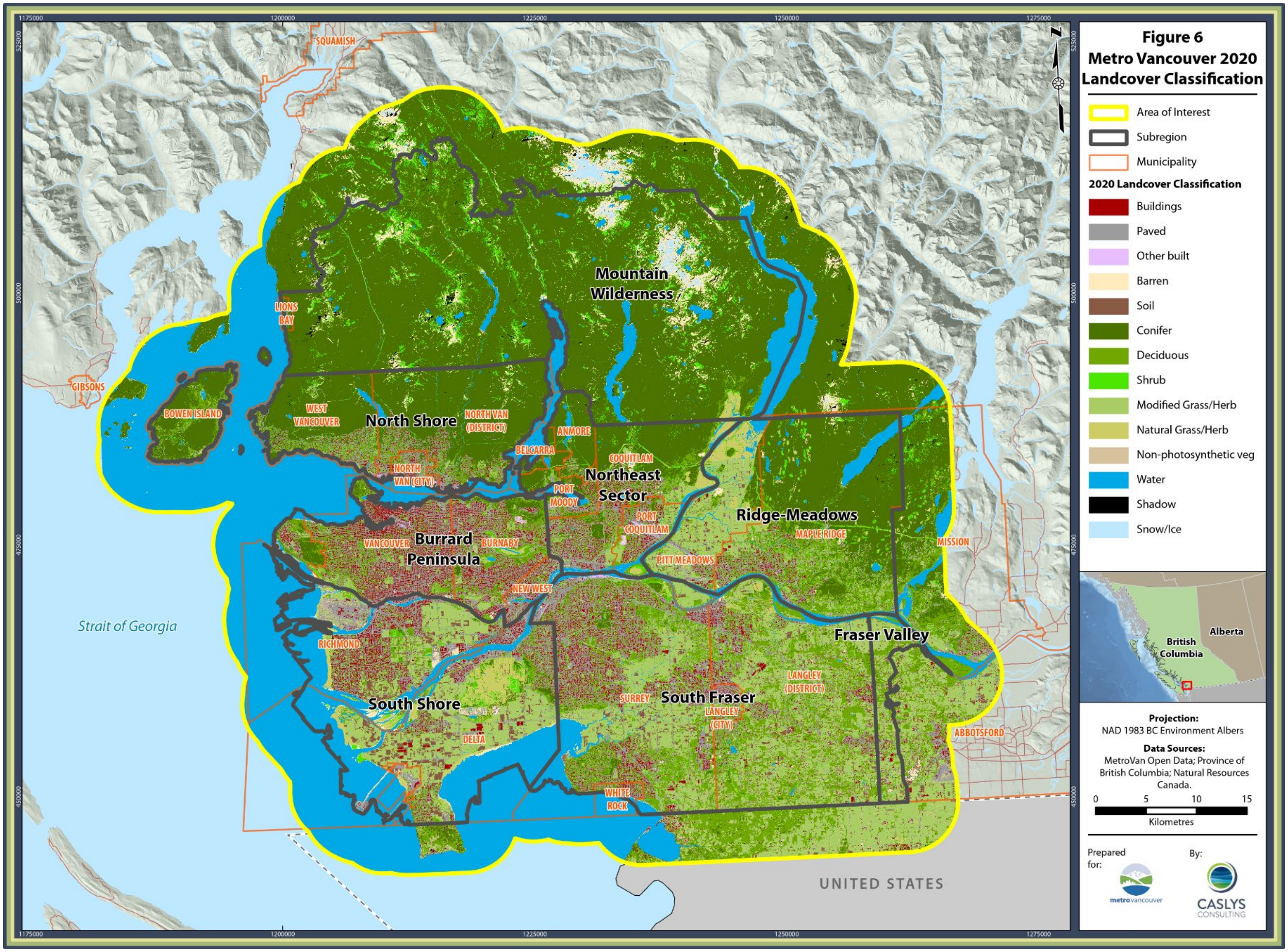

Figure 6. Metro Vancouver 2020 land cover classification

At the local scale, the classification does a good job of distinguishing the natural cover types from anthropogenic ones within the dense urban core. Figure 7 is an example of the classification results where there is a mix of land use types in the South Shore subregion. The agricultural area and golf course were correctly classified as the modified herb class, with the log booms identified as non-photosynthetic vegetation, and the buildings and roads falling into the building and paved class, respectively. The area of water within the agricultural area represents a seasonally flooded field. The barren area next to the river corresponds to a gravelled industrial area.

Figure 7. Fine scale view of the 2020 land cover results showing mosaic of land cover types in the South Shore subregion

At the local scale for a natural area within the Mountain Wilderness subregion, the classification correctly distinguishes between natural vegetation classes and natural bare areas (Figure 8). The classification identified barren areas associated with avalanches and slides, along with the shrubby vegetation associated with vegetation regrowth post disturbance. The classification also pulls out the shrub and natural herb areas in the transition zone between the tree line and barren rock in the alpine areas. There are also some areas of shadow where vegetation classes could not be predicted.

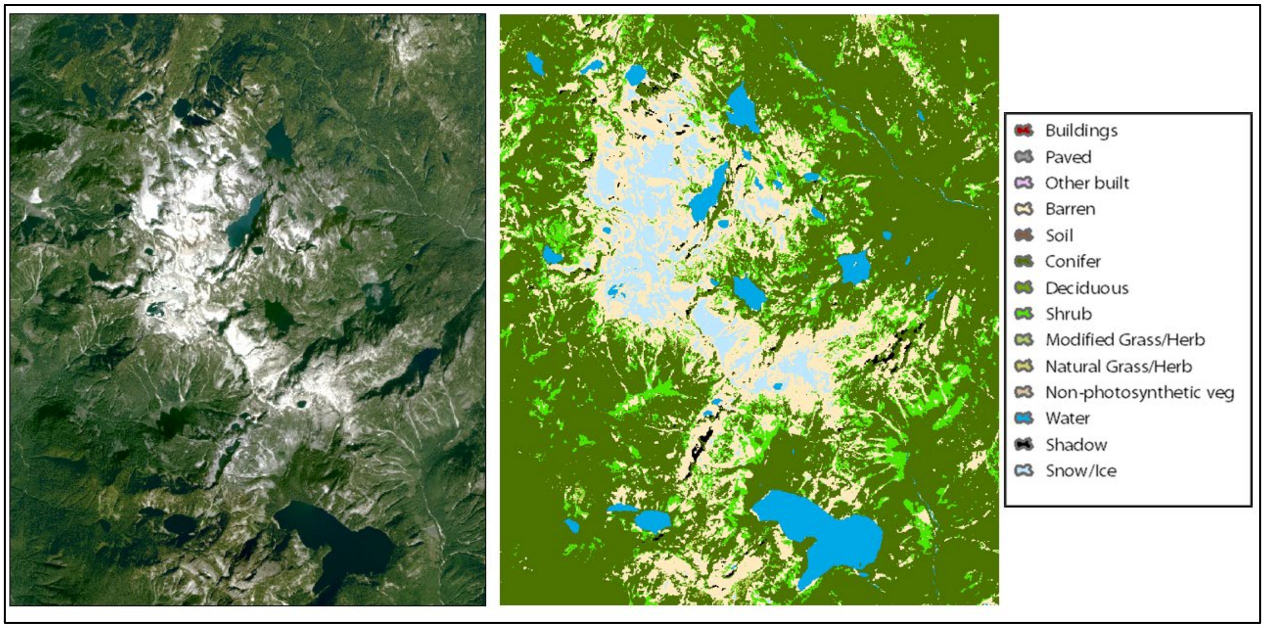

Figure 8. Fine scale view of the 2020 classification results showing natural land cover types in the Mountain Wilderness subregion

Comparing the 2014 and 2020 LCC revealed good class agreement between the two products as indicated by the consistent relative class proportions within each of the subregions (Table 9). When individual class proportions are compared, three classes stand out: buildings, modified herb, and natural herb. The buildings class is consistently higher in the 2014 LCC than in the 2020 LCC. As this class was classified using an object-based segmentation approach in the 2014 analysis (Williams et al. 2018), this difference may be due to a change in method rather than an actual decrease in building footprint across the MVRD. Conversely, there is an inverse relationship for loss and gains in the modified and natural herb between the time periods. For example, when modified herb decreases for an area, there is a corresponding increase in the natural herb class. This relationship is likely due to extra post-processing steps performed on the 2020 LCC focused on better separating these two classes.

Losses in the tree classes for the Northeast and Mountain Wilderness subregions reflect loss in vegetation due to harvest and natural disturbances such as avalanches and slides. However, the vegetation loss due to forest harvest may be underestimated due to differences in LiDAR vintage and image dates. Losses in trees in the South Fraser and Ridge Meadows areas are likely due to development projects. The change detection analysis highlighted areas of significant change in both subregions associated with clearing of vegetation for agriculture and development. The increase in the soil class for the Fraser Valley, South Fraser and South Shore areas is associated with changes in agricultural season and practices between the 2014 and 2020 source imagery as the soil class is primarily associated with agricultural land use (Table 10). Similarly, changes to the water class are likely due to differences in tidal heights between the two time periods as they are observed for the subregions bordering the ocean.

Table 10. Proportion of land cover classes by subregion generated from the 2020 land cover classification

	Fraser Valley	South Fraser	South Shore	Burrard Peninsula	Ridge-Meadows	Northeast Sector	North Shore	Mountain Wilderness
Buildings	2.37	7.72	6.26	20.26	2.12	7.08	3.10	0.00
Paved	4.73	18.29	16.00	37.37	6.45	16.38	9.49	0.11
OtherBuilt	0.10	0.31	0.22	0.75	0.24	0.77	0.31	0.03
Barren	1.05	0.45	1.86	0.63	0.53	0.74	1.26	5.80
Soil	6.71	3.31	4.72	0.11	1.03	0.21	0.03	0.00
Conifer	2.00	2.18	1.29	5.45	42.48	41.23	68.56	78.66
Deciduous	25.38	24.04	5.78	18.26	13.09	12.43	8.46	0.66
Shrub	1.49	2.85	2.42	3.09	3.77	3.79	3.25	6.69
Modified Grass/Herb	46.74	33.55	22.56	8.35	17.15	7.34	2.65	0.02
Natural Grass/Herb	2.53	1.79	6.47	0.75	5.08	3.54	0.59	1.37
Nonphotosynthetic Veg	0.05	0.15	0.93	0.59	0.04	0.13	0.02	0.00
Water	6.85	5.33	31.48	4.27	7.93	6.24	2.01	5.49
Shadow	0.01	0.02	0.02	0.12	0.09	0.10	0.25	0.47
Snow/Ice	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.71

Table 11. Percent difference between the 2014 and 2020 land cover classifications by class and subregion. Negative values indicate loss and positive values indicate gain between the two time periods

Land Cover Class	Fraser Valley	South Fraser	South Shore	Burrard Peninsula	Ridge-Meadows	Northeast Sector	North Shore	Mountain Wilderness
Buildings	-0.80	-1.60	-0.48	-3.47	-1.04	-0.24	-1.55	-0.01
Paved	-1.27	4.80	3.73	11.19	2.10	3.03	3.13	0.05
OtherBuilt	0.07	0.24	0.13	0.63	0.22	0.73	0.29	0.03
Barren	-0.79	-1.69	-1.95	-1.27	-1.39	-1.38	-0.33	0.47
Soil	3.68	1.13	1.89	-0.37	0.31	0.05	-0.07	-0.19
Conifer	-1.39	-3.41	-0.68	-2.37	0.78	-0.79	-2.34	-2.79
Deciduous	-2.15	0.35	-2.00	-2.46	-3.24	-3.80	-0.10	-1.80
Shrub	-0.08	0.20	1.80	2.14	2.26	3.33	2.57	5.85
Modified Grass/Herb	1.29	-0.65	-2.66	-3.06	-1.61	-2.07	-0.61	-1.11
Natural Grass/Herb	2.12	1.36	2.82	0.42	2.29	1.67	0.34	0.29
Non PS Veg	-0.48	0.00	-0.01	0.40	-0.32	-0.05	-0.03	-0.02
Water	0.10	0.01	-2.43	-0.88	0.39	-0.19	-0.19	-0.20
Shadow	-0.30	-0.75	-0.17	-0.89	-0.54	-0.29	-1.12	-1.01
Snow/Ice	0.00	0.00	0.00	0.00	-0.21	0.00	0.01	0.45

3.3 Change Trends

The LTCD analysis highlighted areas of change across the MVRD between 2014 and 2020 are depicted in Figure 9. The grey and muted areas correspond to consistent spectral characteristics across the time-series, while the bright areas identify areas of significant change. For example, the red areas correspond to pixels that became brighter over the time period due to the removal of vegetation for development. Agricultural areas are a mosaic of colours corresponding to both the seasonal variation in the associated land cover types and the variation in agricultural practices field to field. While both the Sentinel 2 and Landsat imagery highlight the same areas as "changed", the 10m resolution of the Sentinel data appears to be more appropriate for capturing the high degree of spatial variation in land cover types within the study area (Figure 10).

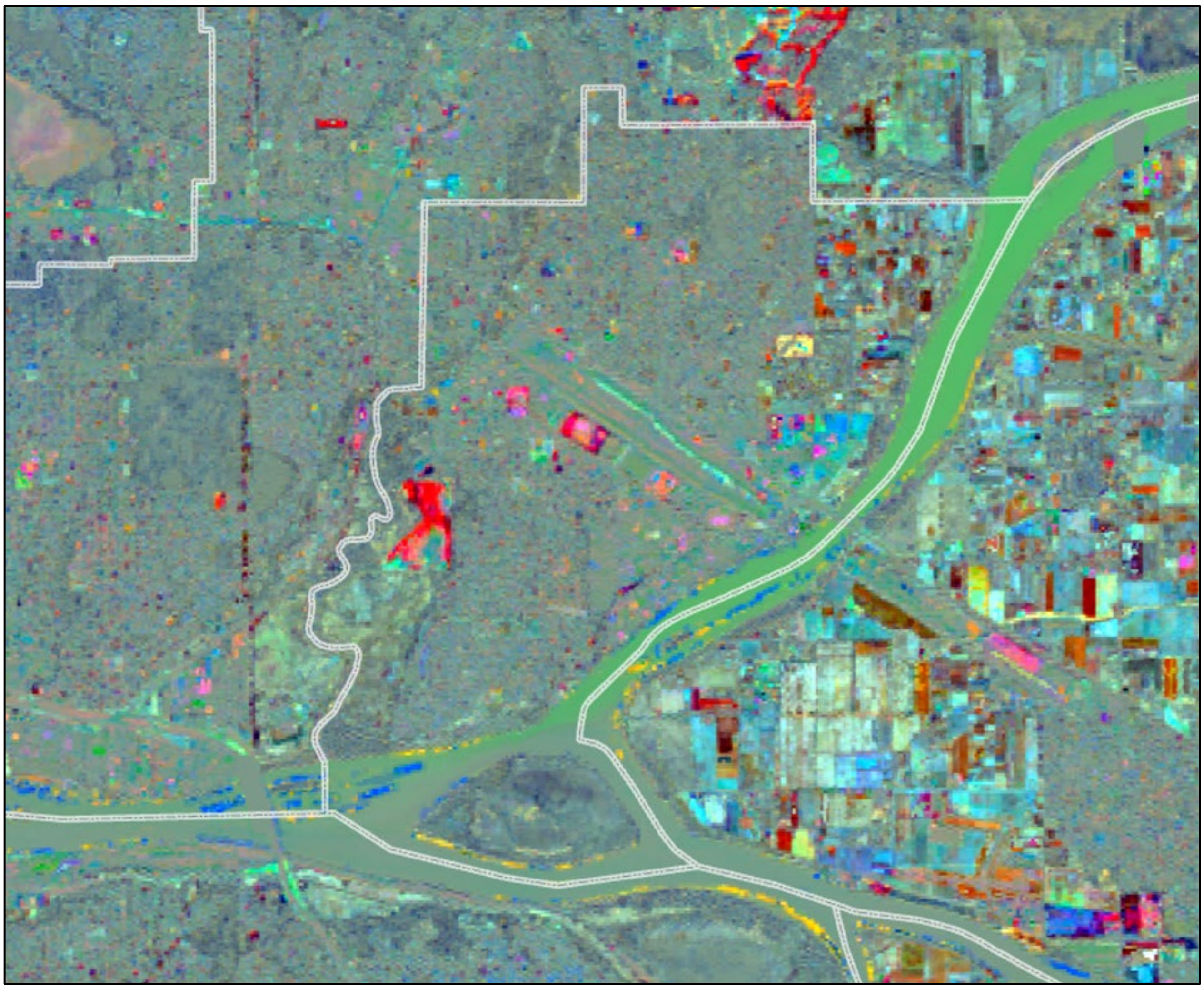

Figure 9. Example of the results of the LTCD analysis derived from a 2014-2020 Landsat time series

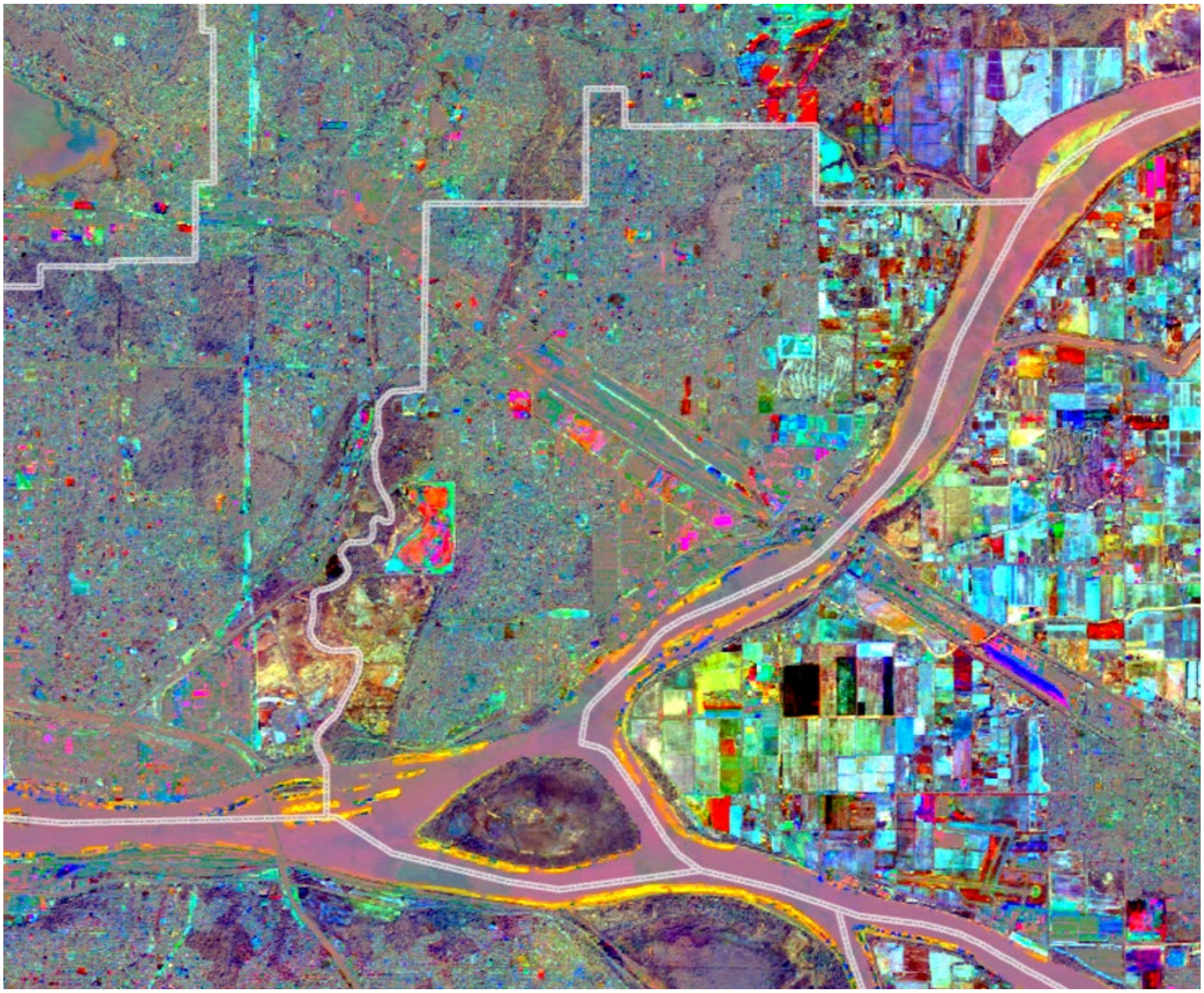

Figure 10. Example of the results of the LTCD analysis derived from a 2015-2020 Sentinel 2 time series

When the NDVI and VBR indices were compared between the two time periods, the results successfully highlighted areas of change at a finer, more local scale. VBR characterized areas of high change in terms of areas where pixel brightness increased or decreased between the two time periods (Figure 11). Areas of change were highlighted across the MVRD, with increasing brightness being the more prevalent of the two change types. Increasing brightness is associated with the removal of vegetation, seasonal changes in agriculture, changing sedimentation levels in waterbodies, tidal height, and vegetation health (e.g., green grass versus dry brown grass). Areas of decreasing brightness were predominantly associated with regenerating vegetation in cut blocks, along transmission lines and building construction on barren ground (Figure 12).

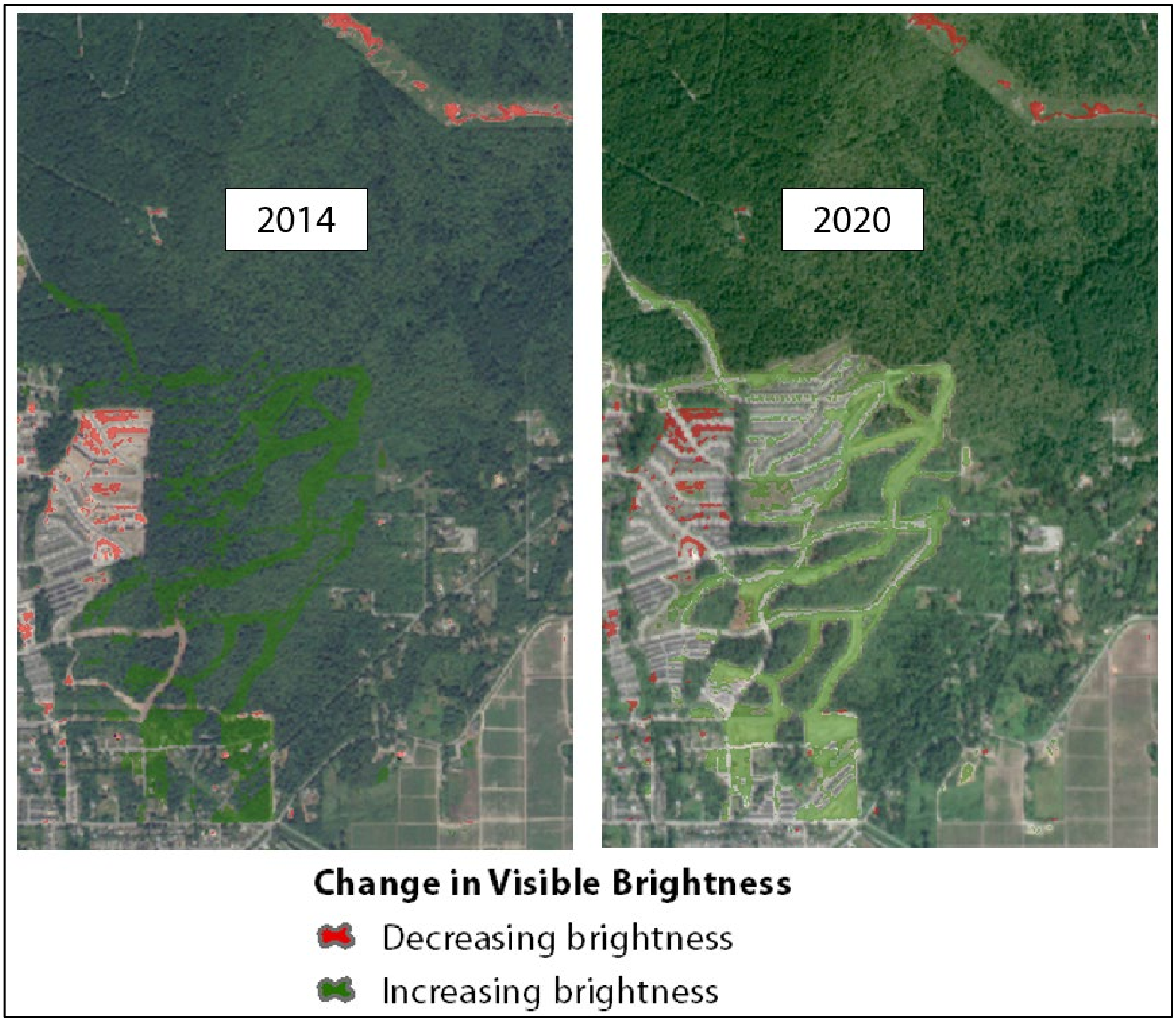

Figure 11. Fine scale example of landscape change characterized by a change in visible brightness

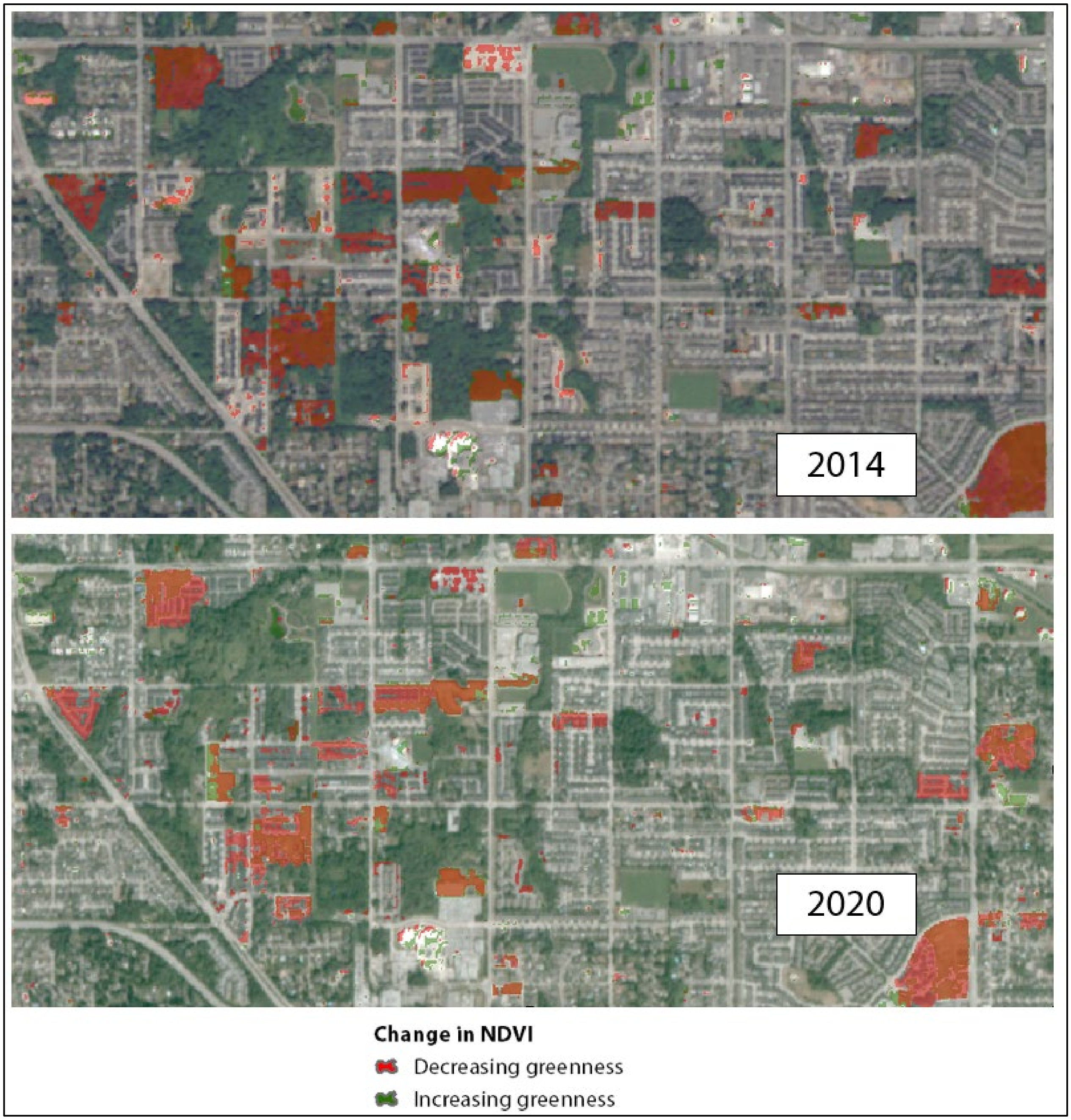

Figure 12. Fine scale example of landscape change characterized by a change in NDVI values

Comparing NDVI values between the two time periods produced similar results to the VBR analysis. Using NDVI characterized change in terms of increasing and decreasing greenness. Both types of change were identified within the study area with decreasing greenness being the predominant change type in the south, and increasing greenness being the predominant type in the north (Figure 13). The areas of decreasing greenness in the south were associated with agriculture and development, while the increasing greenness in the north was driven by the presence/absence of shadows in the mountains in the high-resolution imagery (Figure 14).

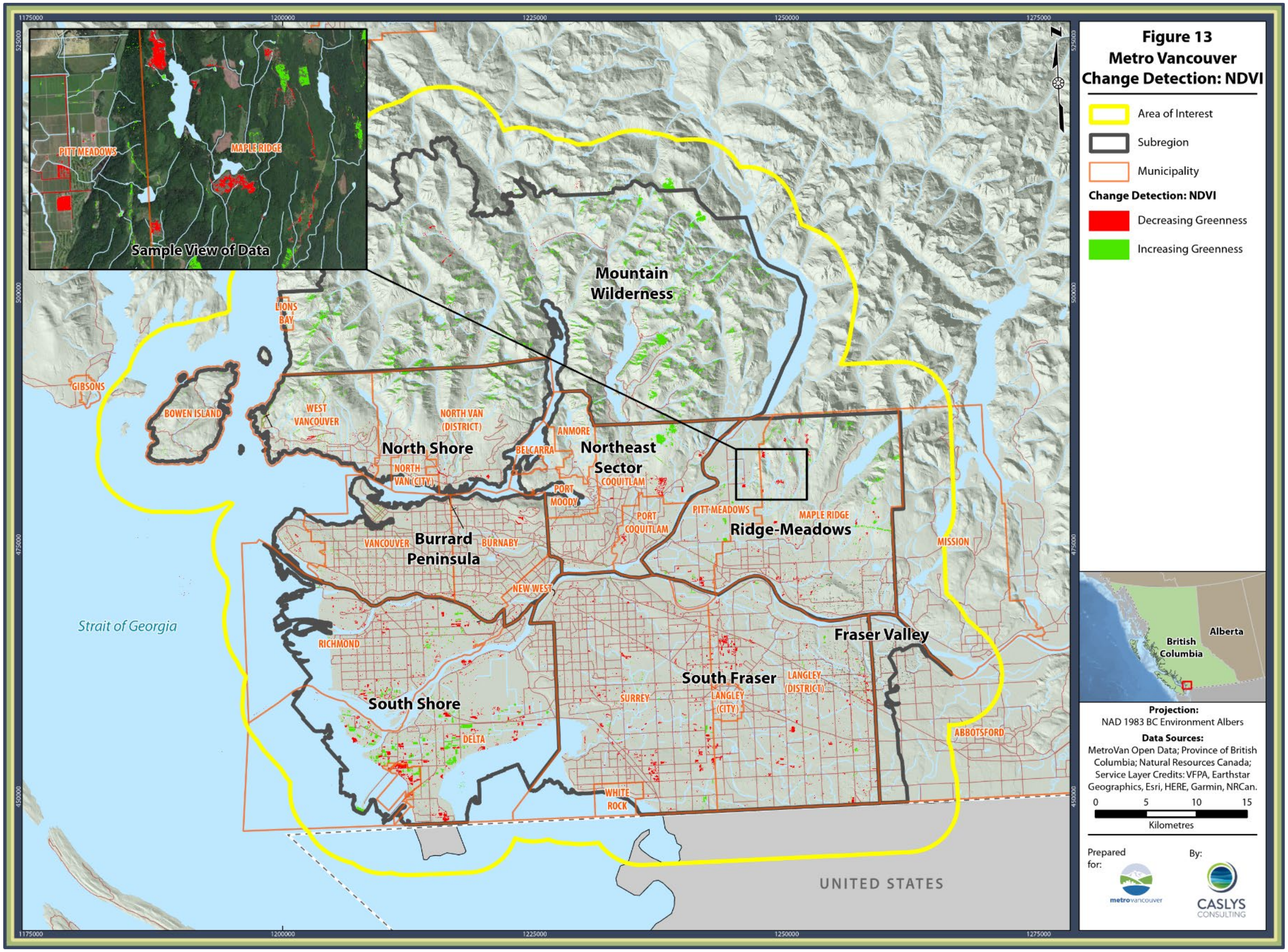

Figure 13. High resolution NDVI change detection results

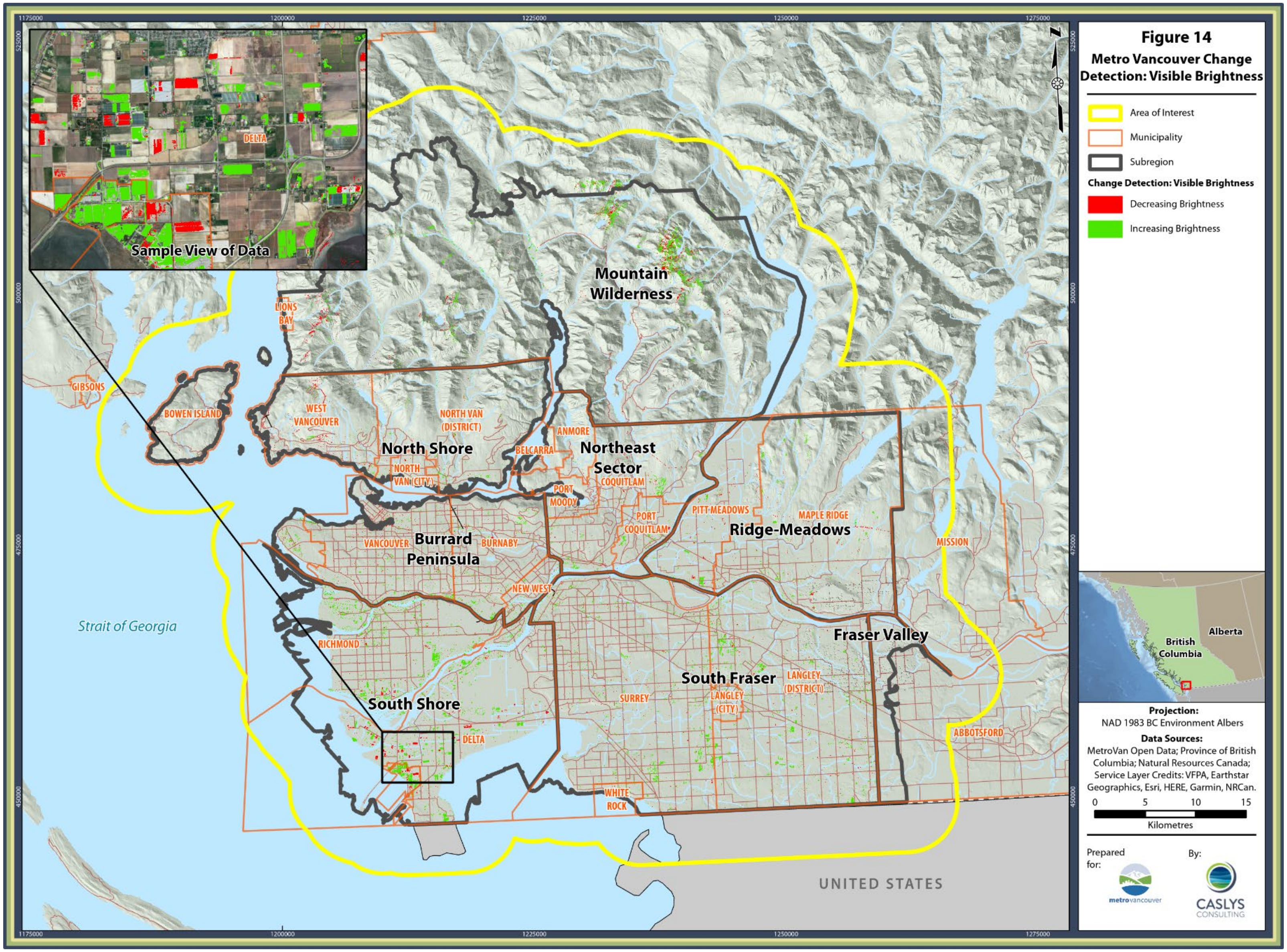

Figure 14
Metro Vancouver Change Detection: Visible Brightness
Area of Interest
Municipality
Subregion
Change Detection: Visible Brightness
Decreasing Brightness
Increasing Brightness
Sample View of Data
DELTA
Mountain Wilderness
LIONS BAY
GIBSONS
BOWEN ISLAND
WEST VANCOUVER
NORTH VAN (DISTRICT)
North Shore
NORTH VAN (CITY)
BELCARRA
ANMORE
Northeast Sector
COQUITLAM
PORT MOODY
PORT COQUITLAM
PITT MEADOWS
MAPLE RIDGE
Ridge-Meadows
MISSION
VANCOUVER
Burrard Peninsula
BURNABY
NEW WEST
Strait of Georgia
RICHMOND
Fraser Valley
South Fraser
LANGLEY (DISTRICT)
LANGLEY (CITY)
SURREY
South Shore
ABBOTSFORD
WHITE ROCK
UNITED STATES
British Columbia
Alberta
Projection:
NAD 1983 BC Environment Albers
Data Sources:
MetroVan Open Data; Province of British Columbia; Natural Resources Canada; Service Layer Credits: VFPA, Earthstar Geographics, Esri, HERE, Garmin, NRCan.
0 5 10 15
Kilometres
Prepared for:
By:
CASLYS CONSULTING

Figure 14. High resolution visible brightness change detection results

3.4 SEI Update

A total of 901 ha of sensitive and modified ecosystems were lost due to human activity between 2014 and 2020 (Table 11) for the Metro Vancouver region. For the regional core (Figure 15), 607 ha were lost, with the majority of the losses occurring in modified ecosystems. Human related losses were dominated by forest harvest in the northern areas of the region and losses due to development - both agricultural and residential in the regional core.

Natural losses to both sensitive and modified ecosystems were much less with 16 ha lost in the regional core and 53 ha lost across the whole region. Natural losses to the SEI included losses due to slides in the mountains and the succession of old agricultural fields to shrub dominated ecosystems.

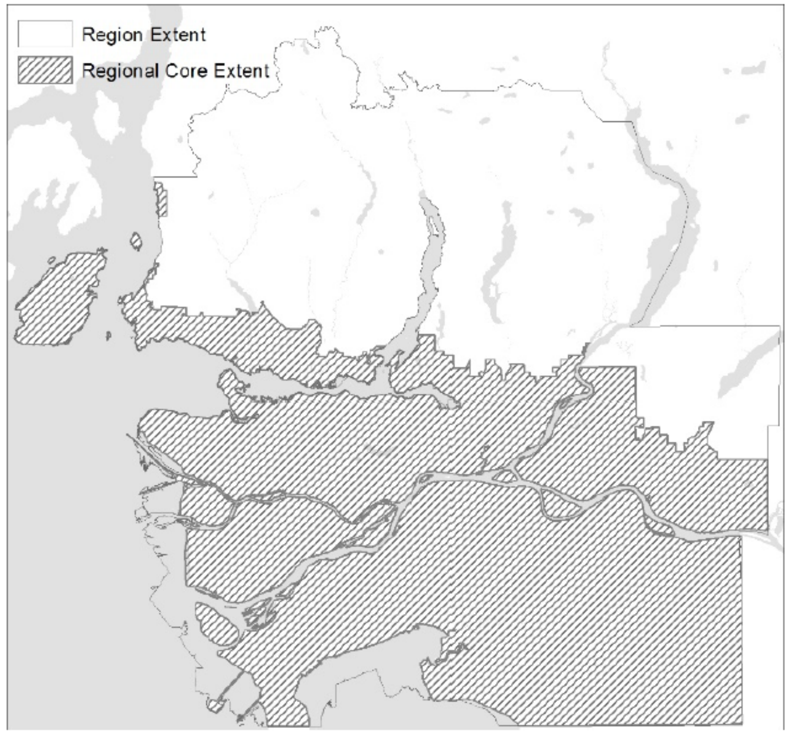

Figure 15. Region and regional core extents for Metro Vancouver . Figure taken from Clark and Meidinger, 2020.

Table 12 summarizes SEI losses due to human activity by ecosystem type. For the region, the greatest sensitive ecosystem losses were seen for the mature forest class, while for modified ecosystems, the greatest loss was in old fields class. Losses to the mature forest class were due to both forest harvest and clearing agricultural or residential development. Losses to the old field class were from residential and agricultural development. At the core level, the loss trends are the same; however, larger losses were observed for both the modified mature forest and young forest classes.

Similar to the 2014 update, SEI losses were large within the forest classes. Table 13 summarizes the losses by forest ecotype for both the region and the regional core. While the loss trends are the same as in 2014, the observed losses were smaller between 2014 and 2020 than between 2009 and 2014. 91 ha of forest was converted to YS from other forest classes.

Table 12. Summary of SEI losses by change type and subregion in hectares*.

	Sensitive Ecosystems (SE)			Modified Ecosystems (ME)			Totals - SE and ME		
	2014 SEI (Ha)	Loss (Ha)	% Loss	2014 SEI (Ha)	Loss (ha)	% Loss	2014 SEI (Ha)	Loss (Ha)	% Loss
Region	149,952	335	0.2	27,378	566	2.1	177,330	901	0.5
Regional Core	24,785	207	0.8	9,376	399	4.3	34,161	607	1.8

Table 13. Summary of SEI losses by ecosystem type*.

	Region			Regional Core		
Ecosystem Type	2014 SEI (Ha)	Loss (Ha)	% Loss	2014 SEI (Ha)	Loss (Ha)	% Loss
Alpine	14,573	0	0	0	0	0
Estuarine	8,581	0	0	1,211	0	0
Herbaceous	109	0	0	85	0	0
Intertidal	8,154	0	0	223	0	0
Freshwater (SE)	7,094	1	0	400	1	0.2
Mature Forest (SE)	21,719	196	0.9	7,517	82	1.1
Old Forest	34,322	4	0	118	0	0
Riparian	30,604	77	0.3	7,902	67	0.8
Sparsely Vegetated	9,125	0	0	98	0	0
Woodland	5,689	0	0	314	0	0.1
Wetland	9,983	56	0.6	6,917	56	0.8
Total Sensitive Ecosystem	**149,952**	**335**	**0.2**	**24,785**	**207**	**0.8**
Young Forest	21,014	300	1.4	5,312	142	2.7
Old Field	1,745	216	12.4	1,745	216	12.4
Freshwater (ME)	141	0	0.2	139	0	0.2
Mature Forest (ME)	4,478	49	1.1	2,180	41	1.9
Total Modified Ecosystem	**27,378**	**566**	**2.1**	**9,376**	**399**	**4.3**

* Only includes human caused SEI losses -natural loss not considered. Gains not included.

Table 14. Losses to SEI forest ecosystems*.

	Region			Regional Core		
Forest Ecosystem	2014 SEI (Ha)	Loss (Ha)	% Loss	2014 SEI (Ha)	Loss (Ha)	% Loss
Mature Forest	26,197	245	0.9	9,697	123	1.3
Young Forest	21,014	300	1.4	5,312	142	2.7
Small Young Forest	4,965	149	3.0	2,821	131	4.6
Total	**52,176**	**694**	**1.3**	**17,830**	**396**	**2.2**

*Only includes human caused SEI losses -natural loss not considered. Gains not included.

4.0 DISCUSSION

The random forest classification models successfully identified land covers with strong performance for a variety of end-user applications. The efforts from this project have resulted in an updated landcover classification that is easily comparable to the 2014 product. While the two products showed good class agreement, the following points should be considered when comparing the two time periods:

- The resolution of the 2014 product was 5m, while the resolution of the 2020 product is 4.77 m – a difference in 2.25m^2 per pixel. This small change in resolution should not change the areal estimates between the two time periods significantly and it is a systematic bias that affects all classes equally.
- The classification produced in 2014 was a mixture of object based and pixel-based classification, while the 2020 was a purely pixel-based workflow. This change in method has affected the classification of buildings with lower building estimates in 2020 than in 2014.
- A larger LiDAR data extent was available for the 2020 classification than the 2014 product. As a result, the natural vegetation classes were predicted with a high level of confidence.
- Post-processing steps to accurately separate modified and natural herb classes were applied; mainly resulting in these classes being flipped back and forth. As such, when comparing change in the herb classes, we recommend pooling them to account for the difference in methodology. This applies particularly to the agricultural areas where we saw the most confusion.

4.1 Lessons Learned and Recommendations

The following sections are lessons learned pertaining to work-flow and data inputs for both the land cover and SEI phases of the project. The goal of this section is to strengthen the update process moving forward thus facilitating long term landscape monitoring for the Metro Vancouver area.

4.1.1 Seasonality

Incorporating seasonality into the data inputs for the classification and change detection analyses has both strengths and weaknesses. Seasonality is a valuable tool for distinguishing between land cover types that can support the definition of natural land cover classes and help resolve classification confusion around agricultural fields and natural herbaceous areas. For example, comparing leaf-off and leaf-on images can provide insight into deciduous versus coniferous tree types and using an image time stack for the growing season can parse out agricultural areas. However, changes in vegetation associated with different seasons can look like landscape change or could mask actual landscape change when comparing two images. For example, the ortho imagery available for 2014 and 2020 for the study area were taken at leaf-on and leaf-off times, respectively. As a result, no spectral comparisons could be made to quantify vegetation loss as any apparent loss would more likely be due to a change in season rather than a change in landscape.

Recommendation – The five-meter imagery used to generate the land cover classifications for both 2014 and 2020 were captured in August. To minimize any land cover changes due to seasonality during the next update, choose another late season image.

4.1.2 LiDAR data and ancillary data

LiDAR data is an important input parameter for the classification. It facilitates building identification and the differentiation of natural vegetation classes. However, if the LiDAR data is not collected at the same time as the classification imagery it can lead to discrepancies between the vegetation and building heights in the CHM and the spectral values in the imagery. This impacts the classification of features that have changed between image capture date and the LiDAR data capture dates. This issue could be minor over a large study area but could be more problematic in areas with a high degree of development over this timeframe. For example, in this project a mosaic LiDAR data were used captured between 2016 and 2020. As such, in areas where the LiDAR vintage was newer (i.e., 2019/2020) we have a higher degree of confidence in the agreement between the LiDAR derivatives and the associated spectral signatures. Similarly, the classification implements a post processing masking stage to integrate ancillary vector data into the process. As a result, the accuracy, precision, and coverage of the ancillary datasets have an impact on the final classification accuracy. As such, it is important that the best possible data is being acquired to inform the masking stage.

Recommendation – A confidence layer could be produced alongside the land cover classification that represents areas where there is a high degree of confidence in the ancillary datasets, like LiDAR, used in the classification and where there is a larger temporal mismatch between the imagery and ancillary data.

4.1.3 Classification Schema

To support the long-term monitoring of landscape change in Metro Vancouver, the classification schema for the land cover product could be revisited to refine some of the existing classes with broad definitions. Having easily reproducible land cover classes and definitions facilitates the update process and minimizes change due to method or input data changes. Classes that have a mixture of natural and anthropogenic cover types and land uses are difficult to replicate leading to poor class accuracies in subsequent classification updates. For example, the current barren class is a mixture of human land uses such as quarries, gravel pits and gravel roads with natural cover types like beaches and alpine rock. This class could be split in two, anthropogenic bare and natural bare, for better classification results. Having class definitions based solely on land cover types rather than a mix of cover type and land use would speed up mapping as fewer post processing steps would be required to refine mixed classes. For example, minimizing the use mixed classes would reduce the need to generate custom spatial masks that isolate specific land uses.

Recommendation – Revisit classification schema to reduce the occurrence of mixed class definitions in the land cover classification. Class divisions may be better defined by aggregating the paved, other built, barren and soil classes into two classes: anthropogenic bare and natural bare. These classes could be further split into impervious anthropogenic bare, permeable anthropogenic bare, impervious natural, and permeable natural.

4.1.4 Freely Available Image Libraries: Sentinel 2 and Landsat

Incorporating freely available Sentinel 2 and Landsat data into the change detection analyses allowed for a regional characterization of change across the study area for 2014 to 2020. Visualizing change at the regional scale helped us to become familiar with areas that were relatively stable over the period and areas where we may expect to see a high degree of landscape change due to development. However, the resolution of these two image products was too coarse to be useful in quantifying change at the scale of the SEI. While the 10m and 30 m resolution precludes the use of these image libraries in the official updates of the land cover classification and SEI datasets, the fact they are freely available and continually updated makes them a valuable annual monitoring tool. Regional scale change detection using Sentinel 2 data could be done on an annual basis to provide on-going change detection for the study area. A 10m change detection product could be a valuable resource for visualizing landscape change in years that experience major climatic events.

Recommendation – Perform annual change detection analyses for the study area using Sentinel 2 imagery to highlight areas of the Metro Vancouver area that are experiencing large land cover/land use changes. Annual change detection analyses could be easily performed using NDVI values to specifically identify loss of vegetation. Using imagery from the peak growing season (i.e., July or August) would reduce the effects of seasonality and would help isolate actual changes in vegetation due to human related or natural causes.

4.1.5 The Metro Vancouver Land Cover Classification is a regional planning tool

The five metre resolution of the Metro Vancouver 2020 land cover classification makes it a valuable tool for land cover analysis at the regional scale as it balances level of detail with the large extent of the district. The five meter scale provides sufficient detail to facilitate change detection and long term monitoring of cover types and land uses in the context of regional changes such as the expansion of agricultural activities, residential development, natural disturbances, and changes in the transportation network. However, for finer scale analyses, the five metre pixel size may generalize cover types of interest. For example, in urbanized areas, the mosaic of cover types is highly variable resulting in blended pixels at the five metre scale. These blended pixels are assigned cover types that best represent the mixed spectral signal and so features such as individual houses or trees may be masked. Our post-processing steps help to manage classification confusion in these areas; however, the logic used in the application of post-processing masks can have an impact on the land cover types assigned to blended pixels. The technical memo included in Appendix A summarizes the influence of our post-processing logic in terms of the relationship between impervious surfaces and canopy cover in urban areas.

Recommendation – The Metro Vancouver 2020 land cover classification is an effective tool for regional monitoring of land cover change. For finer scale analyses in complex land cover areas (e.g., highly urbanized areas) there may be different datasets or approaches that leverage fine scale data to capture specific cover types and uses. For example, the application of LiDAR data to delineate individual tree crowns and quantify tree canopy at fine scales.

4.1.6 Additional reconciliation of the small young forest class (YS)

The steps taken during the 2020 SEI update to reconcile the YS class involved merging adjacent polygons with identical components. As such, only a small subset of YS polygons was examined. Situations where adjacent YS polygons with differing components remains unresolved and could afford another opportunity to merge YS polygons to form larger contiguous young forest (YF) areas.

Recommendation – Revisit adjacent YS polygons with different components to determine if they can be merged and the deciles for each component adjusted.

4.1.7 SEI update does not track changes in class or polygon boundaries associated with succession

The SEI 2020 update was primarily focused on vegetation loss and only tracked changes to polygon attributes and boundaries associated with anthropogenic or natural disturbance. As a result, polygons that have changes resulting from succession (i.e., YS and YF polygons that have aged) were not captured in the update. The exception is within regional park boundaries where successional changes would have been captured as part of the Regional Parks TEM mapping update.

Recommendation – Revisit areas outside regional parks where successional changes are likely to be present (e.g., Malcolm Knapp Research Forest).

5.0 LITERATURE CITED

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6.0 APPENDIX: SEI DATA MODEL[1]

The SEI Data Model, as updated for 2020, is presented here.

Fields

Field Name	Alias	Description	Type	Length
SourceName	Source Name	Field to identify the agency or organization that created the data.	Text	12
SourceDate	Source Date	Date the data was sourced or created.	Date	12
Jurisdiction	Jurisdiction	Internal MV field. MV department the data is associated with.	Text	20
Location	Location	Used only when polygon originates from MV Terrestrial Ecosystem Mapping (TEM). Internal MV field. Specific name of park or watershed.	Text	40
Classification	Classification	Used only when polygon originates from MV TEM. Internal MV field. Type of ecological or administrative unit.	Text	30
TEM_PolyNbr	TEM Poly No.	Used only when polygon originates from TEM. Identifying number for the related polygon in the TEM dataset.	Long Int	
SEI_PolyNbr	SEI Poly No.	Polygon Number - An identifying number for each mapped polygon.	Long Int	
SmplType	Sample Type	Field check of polygon - describes the level of field checking completed for the current polygon.	Text	2
PlotNo	Plot No.	Field Plot number.	Text	10
ProjType	Project Type	Project Type - Indicates the type of mapping project.	Text	9
Proj_ID	Project ID	Project Identification - A unique identifier for each project.	Text	5
EcoMap	Eco Mapper	First initial and surname of individual who performed the mapping.	Text	15
EcoSec	Ecosection	Ecosection Label - Component of the hierarchical Ecoregion Classification system.	Text	3
BGC_Unit	BGC Unit	Combination of BGC Biogeoclimatic Zone/subzone/variant.	Text	7
SEDec_1	Ecosystem 1 Decile	Ecosystem Decile of Ecosystem Component 1 - Proportion of the polygon covered by ecosystem component 1, in deciles.	Short Int	
SECl_1	Ecosystem 1 Class	Sensitive Ecosystem Class of Ecosystem Component 1.	Text	2
SEsubcl_1	Ecosystem 1 Subclass	Sensitive Ecosystem Subclass of Ecosystem Component 1.	Text	2
Strct_S1	Stuc Stg, Ecosystem 1	Structural Stage of Ecosystem Component 1.	Text	2
StrctMod_1	Struc Stg Mod, Ecosystem 1	Structural Stage Substage or Modifier of Ecosystem Component 1.	Text	2
Stand_A1	Stand Comp, Ecosystem 1	Stand Composition Modifier of Ecosystem Component 1 - Differentiates forest stands	Text	1

[1] Administrative GIS fields are not included.

Field Name	Alias	Description	Type	Length
		based on coniferous, broadleaf and mixed stand composition.		
SEDec_2	Ecosystem 2 Decile	Ecosystem Decile of Ecosystem Component 2 - Proportion of the polygon covered by ecosystem component 2, in deciles.	Short Int	
SECl_2	Ecosystem 2 Class	Sensitive Ecosystem Class of Ecosystem Component 2.	Text	2
SEsubcl_2	Ecosystem 2 Subclass	Sensitive Ecosystem Subclass of Ecosystem Component 2.	Text	2
Strct_S2	Struc Stg, Ecosystem 2	Structural Stage of Ecosystem Component 2.	Text	2
StrctMod_2	Struc Stg, Ecosystem 2	Structural Stage Substage or Modifier of Ecosystem Component 2.	Text	2
Stand_A2	Stand Comp, Ecosystem 2	Stand Composition Modifier of Ecosystem Component 2 - Differentiates forest stands based on coniferous, broadleaf and mixed stand composition.	Text	1
SEDec_3	Ecosystem 3 Decile	Ecosystem Decile of Ecosystem Component 3 - Proportion of the polygon covered by ecosystem component 3, in deciles.	Short Int	
SECl_3	Ecosystem 3 Class	Sensitive Ecosystem Class of Ecosystem Component 3.	Text	2
SEsubcl_3	Ecosystem 3 Subclass	Sensitive Ecosystem Subclass of Ecosystem Component 3.	Text	2
Strct_S3	Struc Stg, Ecosystem 3	Structural Stage of Ecosystem Component 3.	Text	2
StrctMod_3	Struc Stg, Ecosystem 3	Structural Stage Substage or Modifier of Ecosystem Component 3.	Text	2
Stand_A3	Stand Comp, Ecosystem 3	Stand Composition Modifier of Ecosystem Component 3 - Differentiates forest stands based on coniferous, broadleaf and mixed stand composition.	Text	1
Microsite	Microsite	Microsite - ecosystem representing < 10% of the polygon.	Text	4
Condition_SE1	Condition, Ecosystem 1	Condition assessment of the first component present in the polygon expressed as a letter - A (best) to E (worst).	Text	1
ConditionNo_SE1	Condition (Num), Ecosystem 1	Condition assessment for component 1 expressed as a number - 5 (best) to 1 (worst).	Short Int	
Condition_SE2	Condition, Ecosystem 2	Condition assessment of the second component present in the polygon expressed as a letter - A (best) to E (worst).	Text	1
ConditionNo_SE2	Condition (Num), Ecosystem 2	Condition assessment for component 2 expressed as a number - 5 (best) to 1 (worst).	Short Int	
Condition_SE3	Condition, Ecosystem 3	Condition assessment of the third component present in the polygon expressed as a letter - A (best) to E (worst).	Text	1

Field Name	Alias	Description	Type	Length
ConditionNo_SE3	Condition (Num), Ecosystem 3	Condition assessment for component 3 expressed as a number - 5 (best) to 1 (worst).	Short Int	
Disturb_1	Disturbance (1st)	Disturbance (of greatest importance).	Text	7
Disturb_2	Disturbance (2nd)	Disturbance.	Text	7
Disturb_3	Disturbance (3rd)	Disturbance.	Text	7
Disturb_4	Disturbance (4th)	Disturbance (of least importance).	Text	7
Context	Context	Landscape context assessment for the entire polygon expressed as a letter - A (best) to E (worst).	Text	1
ContextNo	Context (Num)	Landscape context assessment for the polygon expressed as a number - 5 (best) to 1 (worst).	Short Int	
WSize_SE1	Weighted Size, Ecosystem 1	Area of polygon covered by ecosystem component 1. Only completed for components > 2 deciles. This is an intermediate field used to calculate the Size grade only.	Double	
Size_SE1	Size, Ecosystem 1	Size grade for component 1 expressed as a letter - A (best) to E (worst). Based on SumWSize_SE1	Text	1
SizeNo_SE1	Size (Num), Ecosystem 1	Size grade for component 1 expressed as a number. Based on SumWSize_SE1.	Short Int	
WSize_SE2	Weighted Size, Ecosystem 2	Area of polygon covered by ecosystem component 2. Only completed for components > 2 deciles. This is an intermediate field used to calculate the Size grade only.	Double	
Size_SE2	Size, Ecosystem 2	Size grade for component 2 expressed as a letter - A (best) to E (worst). Based on SumWSize_SE2.	Text	1
SizeNo_SE2	Size (Num), Ecosystem 2	Size grade for component 2 expressed as a number. Based on SumWSize_SE2.	Short Int	
WSize_SE3	Weighted Size, Ecosystem 3	Area of polygon covered by ecosystem component 3. Only completed for components > 2 deciles. This is an intermediate field used to calculate the Size grade only.	Double	
Size_SE3	Size, Ecosystem 3	Size grade for component 3 expressed as a letter - A (best) to E (worst). Based on SumWSize_SE3.	Text	1
SizeNo_SE3	Size (Num), Ecosystem 3	Size grade for component 3 expressed as a number. Based on SumWSize_SE3.	Short Int	
QualityNo_SE1	Quality (Num), Ecosystem 1	Quality assessment for component 1, combination of condition, landscape context and size ratings.	Double	
WQuality_SE1	Weighted Quality (Num), Ecosystem 1	Quality rating (QualityNo_SE1) weighted by the proportion of the polygon covered by component 1.	Double	

Field Name	Alias	Description	Type	Length
QualityNo_SE2	Quality (Num), Ecosystem 2	Quality assessment for component 2, combination of condition, landscape context and size ratings.	Double	
WQuality_SE2	Weighted Quality (Num), Ecosystem 2	Quality rating (QualityNo_SE2) weighted by the proportion of the polygon covered by component 2.	Double	
QualityNo_SE3	Quality (Num), Ecosystem 3	Quality assessment for component 3, combination of condition, landscape context and size ratings.	Double	
WQuality_SE3	Weighted Quality (Num), Ecosystem 3	Quality rating (QualityNo_SE3) weighted by the proportion of the polygon covered by component 3.	Double	
WCombQuality	Weighted Quality (Num), all	Total quality rating for the polygon, combining the weighted quality ratings for each component (WQuality_SE1, WQuality_SE2, WQuality_SE3)	Double	
Quality	Quality	Final quality grade for the polygon (based on WCombQuality) expressed as expressed as a letter - A (best) to E (worst).	Text	1
QualityNo	Quality (Num)	Final quality grade for the polygon (based on WCombQuality) expressed as a number - 5 (best) to 1 (worst).	Short Int	
SE_ME_1	SE/ME, Ecosystem 1	Status of component 1 as a sensitive, modified or non-sensitive ecosystem.	Text	3
SE_ME_2	SE/ME, Ecosystem 2	Status of component 2 as a sensitive, modified or non-sensitive ecosystem.	Text	3
SE_ME_3	SE/ME, Ecosystem 3	Status of component 3 as a sensitive, modified or non-sensitive ecosystem.	Text	3
WSize_SE1_BASIC	Area, Ecosystem 1	Area of polygon covered by ecosystem component 1.	Double	
WSize_SE2_BASIC	Area, Ecosystem 2	Area of polygon covered by ecosystem component 2.	Double	
WSize_SE3_BASIC	Area, Ecosystem 3	Area of polygon covered by ecosystem component 3.	Double	
PolyCom	Polygon Comment	Polygon comments.	Text	250
Mod_Type	Modification Type	Type of modification observed in 2020.	Text	10
LU_Change	LU Change	Land use change observed (i.e. from Sensitive/Modified Ecosystem to a different land use).	Text	35
LU_Change_Desc	LU Change Description	Additional information about land use change.	Text	250
SEI_PolyNbr2009	SEI Poly No.2009	Holds the original SEI Polygon Number. Provides a link between the 2020 update and the original 2009 SEI.	Long	
AmendDate	Amend Date	Date of amendment to the SEI polygon.	Date	
AmendComment	Amend Comment	Brief details of the amendment made.	Text	50

Field Name	Alias	Description	Type	Length
AmendMapper	Amend Mapper	First initial and surname of the mapper who made the amendment.	Text	15
Change	Change	Notes if this polygon was added or deleted between 2014 and 2020. This field summarizes the Mod_Type field.	Text	3
Adj09Qual	Adjusted 2009 Quality	An adjusted Quality score for 2009, to account for errors identified in the original data. This field is used to calculate changes in Quality between 2009 and 2014.	Text	5
Q0914	Quality Assess 0914	Indicates whether the polygon was assessed for Quality in 2009 and/or 2014.	Text	5
last_editme	Last Editor	Last Editor. First initial and surname of the mapper who made the last edit.	Text	15
last_editDate	Last Edited Date	Last Edited Date.	Date	
SEI_PolyNbr2014	SEI Poly No.2014	Holds the original SEI Polygon Number from 2014. Provides a link between the 2020 update and the original 2014 SEI.	Long Int	
Adj14Qual	Adjusted 2014 Quality	An adjusted Quality score for 2014, to account for errors identified in the original data. This field is used to calculate changes in Quality between 2014 and 2020.	Text	5
Mod_Type14	Modification Type	Type of modification observed in 2014.	Text	10
Change14	Change 2014	Notes if this polygon was added or deleted between 2009 and 2014. This field summarizes the Mod_Type14 field.	Text	3
Q1420	Quality Assess 1420	Indicates whether the polygon was assessed for Quality in 2014 and/or 2020.	Text	5
Comp1Lgnd	Comp 1 Legend	Class and type (sensitive, modified or non-sensitive) of Ecosystem Component 1. Labeling field.	Text	50
Comp2Lgnd	Comp 2 Legend	Class and type (sensitive, modified or non-sensitive) of Ecosystem Component 2. Labeling field.	Text	50
Comp3Lgnd	Comp 3 Legend	Class and type (sensitive, modified or non-sensitive) of Ecosystem Component 3. Labeling field.	Text	50
Comp1Lgnd_Full	Comp 1 Legend – Full	%, Class and type (sensitive, modified or non-sensitive) of Ecosystem Component 1. Labeling field.	Text	125
Comp2Lgnd_Full	Comp 2 Legend – Full	%, Class and type (sensitive, modified or non-sensitive) of Ecosystem Component 2. Labeling field.	Text	125
Comp3Lgnd_Full	Comp 3 Legend - Full	%, Class and type (sensitive, modified or non-sensitive) of Ecosystem Component 3. Labeling field.	Text	125

Field Descriptions[2]

SourceName

Code	Description
Acres Int.	Acres International Consortium (GVRD Ecological Inventory)
Blackwell	B.A. Blackwell and Associates Ltd.
Diamondhead	Diamond Head Consulting Ltd.
FIS	FIS (GVRD Ecological Inventory)
Hemmera	Hemmera
MV	Metro Vancouver
Madrone	Madrone Environmental Services
Raincoast	Raincoast Applied Ecology
Timberline	Timberline Natural Resource Group

Jurisdiction

Code	Description
O&M	Metro Vancouver Operations and Maintenance Dept.
Parks	Metro Vancouver Regional Parks Dept.
Non MV	Non Metro Vancouver lands

SmplType[3]

Code	Description
A	Aircall – data recorded from low-flying helicopter
D	Desktop verified - photo interpretation checked using another imagery source
E	Full plot – data recorded on FS882 forms from the ground
G	Ground inspection plot – data recorded on GIF cards from the ground
P	Photo interpretation – data interpreted from ortho/air photo
Code	**Description**
V	Visual inspection – abridged data recorded on plot card
VF	Visually inspected by FREMP

ProjType

Code	Description
NEM	Terrestrial ecosystem mapping without terrain
NEMNSS	Terrestrial ecosystem mapping with no bioterrain or structural stage
NEMSEI	Terrestrial ecosystem mapping (without bioterrain) and sensitive ecosystem inventory
SEI	Sensitive ecosystem inventory
TEM	Terrestrial ecosystem mapping

EcoSec

Code	Description
FRL	Fraser Lowlands
GEL	Georgia Lowland
NWC	Northwestern Cascade Ranges
SOG	Strait of Georgia
SPR	Southern Pacific Ranges

[2] Self explanatory fields not included.

[3] Not always available for records originating from TEM due to merging process (the Watersheds and Lynn Headwaters Regional Park). Refer to original TEM datasets for exact locations of field checked polygons.

BGC_Unit

Code	Description
CDFmm	Moist Maritime Coastal Douglas Fir Subzone
CWHdm	Dry Maritime Coastal Western Hemlock Variant
CWHxm1	Eastern Very Dry Maritime Coastal Western Hemlock Variant
CWHvm1	Submontane Very Wet Maritime CWH Variant
CWHvm2	Montane Very Wet Maritime CWH Variant
MHmm1	Windward Moist Maritime MH Variant
MHmmp	Parkland Moist Maritime MH Variant
CMA	Coastal Mountain-heather Alpine

SECl_1-3

Code	Description
AP	Alpine
ES	Estuarine
FW	Freshwater
HB	Herbaceous
IT	Intertidal
MF	Mature Forest
OD	Old Field
OF	Old Forest
RI	Riparian
SV	Sparsely Vegetated
WD	Woodland
WN	Wetland
XX	Non SE or ME
YF	Young Forest
YS	Young Forest (small)[4]
x	An x in front of any of the above code means the ecosystem has been recorded as lost, either to natural or human causes, e.g. xMF or xMature Forest

SEsubcl_1-3

Code	Description
av	avalanche tracks
bd	broadleaf
bg	bog
bs	beaches and rocky shorelines
ca	canyon
cl	cliff
co	coniferous
cs	coastal herbaceous
ds	dwarf shrub
el	eelgrass
ff	fringe
fh	high bench floodplain
fl	low bench floodplain
fm	medium bench floodplain
fn	fen

[4] Young Forest patches of < 5 ha are not considered an SE or ME, but are included for tracking purposes.

Code	Description
gu	gully
hb	herbaceous
kr	krummholz
la	lake
md	meadow
mf	mudflat
ms	marsh
mx	mixed
pd	pond
pf	parkland forest
ri	river
ro	rocky outcrop
rs	reservoir
sd	sand dune
sh	shrub
sp	swamp
st	spit
sw	shallow water
ta	talus
tf	tidal flat
ts	tall shrub
vo	very old
vs	vegetated shoreline
wm	wet meadow
xx	non SE or ME

Strct_S1-3 and **StrctMod_1-3** (see below for further details on structural stage definitions)

Code - Strct	Code - StrctMod	Description
1	a	Sparse/cryptogam: Sparse
1	b	Sparse/cryptogam: Bryoid
1	c	Sparse/cryptogam: Lichen
2	a	Herb: Forb-dominated
2	b	Herb: Graminoid-dominated
2	c	Herb: Aquatic
2	d	Herb: Dwarf shrub
3	a	Shrub/Herb: Low shrub
3	b	Shrub/Herb: Tall shrub
4		Pole/Sapling
5		Young Forest
6		Mature Forest
7	a	Old Forest: old
7	b	Old Forest: Very old
	99	Attribute not assessed (from original TEM)

Stand_A1-3

Code	Description
B	Broadleaf - > 75% of total tree cover is broadleaf
C	Coniferous - > 75% of total tree cover is coniferous
M	Mixed - Neither coniferous or broadleaf is > 75% of total tree cover

Disturb_1-4
(see *Field Manual for Describing Terrestrial Ecosystems* for additional codes)
Adjacent disturbance assessed within 15m of polygon

Code	Description
A	Atmospheric related effects
Aesn	Heavy snow
Aw	Windthrow
B	Biotic (plant and animal) effects
Bb	Beaver tree cutting
Bd	Grazing
Bv	Aggressive vegetation
Bvbk	Aggressive vegetation - blackberry
Bvbs	Aggressive vegetation – Birch salal woodland
Bvrcg	Aggressive vegetation – reed canary grass
Dc	Disposal – chemical spill or disposal
Dg	Domestic garbage disposal
Fc	Overstorey crown fire
Fh	Fire - harvest related
Fn	Fire confirmed - natural
Fs	Fire suspected
G	Gap replacement
H	Harvesting
Hbad	Buildings or structures (adjacent)
Hbw	Buildings or structures (within)
Hla	Human log accumulation
Hmh	Modified hydrology, e.g. dikes, man-modified lake/pond
Hmv	Modified vegetation, e.g. agriculture, recreation fields (adjacent)
Ho	Harvesting - old
Hr	Harvesting - recent
Hrad	Roads (adjacent)
Hrw	Roads (within)
Hs	Harvesting - recent, selective
Htad	Trails (adjacent)
Htr	Tree removal – recent
Htw	Trails (within polygon)
Huad	Utility right-of-way (adjacent)
Huw	Utility right-of-way (within)
I	Inundation
L	Landslide
Lc	Forest harvesting – clearcut system
Le	Forest harvesting – selective system
Ll	Land clearing
Ls	Selective logging
Lt	Active talus
M	Plant or site modification effects
Mc	Herbicide (chemical) use
Mg	Planted or seeded to grasses
Mh	Planted or seeded to herbs
Ms	Planted or seeded to shrubs

Code	Description
Mt	Planted or seeded to trees
Mw	Mowed
P	Unknown (watersheds only)
S	Soil disturbances
Sa	Cultivation (agriculture)
Sc	Snow creep
Se	Excavation
Sf	Sidecast Fill
Shp	Soil disturbance – harvesting of peat
Sr	Road bed, abandoned
T	Terrain related effects
Ta	Avalanching
Tq	Rock quarrying (incl. open pit mines)
Ts	Terrain failures
V	Vehicle tracks
W	Water related effects
Wb	Windthrow by cutblock boundaries
Wd	Water table control (diking, damming)
We	Water table depression
Wi	Inundation

SE_ME_1-3

Code	Description
ME	Modified Ecosystem
SE	Sensitive Ecosystem
XX	Non SE, ME or YS ecosystem type
YS	Small patches of young forest (< 5 ha) (not an SE or ME)
x	An x in front of any of the above code means the ecosystem has been recorded as lost, either to natural or human causes (e.g. xME or xModified Ecosystem)

Condition_SE1-3 and **Context** and **Size_SE1-3** and **Quality**

Code	Description
A	Excellent
B	Good
C	Moderate
D	Poor
E	Very Poor

ConditionNo_SE1-3 and **ContextNo** and **SizeNo_SE1-3** and **QualityNo**

Code	Description
5	Excellent
4	Good
3	Moderate
2	Poor
1	Very Poor

Mod_Type and **Mod_Type14**

Code	Description	Additional Information
A	Addition	New to the inventory (completely new polygon), e.g. newly created reservoir; restored habitat.

Code	Description	Additional Information
AC	Extension	Extension of existing polygon as adjacent area should now be included (used for significant extensions only), e.g. adjacent area to an Old Field now old enough to be included.
C	Change	Change in classification (from one SEI class to another), usually due to natural change. Possible that changes are human-caused (e.g. drainage in an nearby area) but not obvious. e.g. changes in water levels have resulted in shifts of different wetland types; beaver activity.
CD	Change due to disturbance	Disturbance resulted in a change to a different class, e.g. wetland converted to a freshwater reservoir.
CR	Reduced due to change	Change (as described in C above) resulted in a reduction in the size of a polygon. Change appears to be due to natural factors. e.g. changes in water levels have shrunk a wetland.
D	Disturbed	Condition rating has been reduced due to disturbance.
DC	Deleted due to Change	Natural change has resulted in the site no longer meeting the classification requirements for any classes, e.g. Old Field that has become too overgrown; beaver activity has flooded an area and killed the trees.
DD	Deleted due to disturbance	Area deleted from the SEI due to disturbance which resulted in complete or reduction in condition below the level of 'E'. Polygons retained as a separate layer.
DR	Deleted due to remnant assessment	Part of the polygon deleted due to disturbance. The remaining intact ecosystem is now so small as to not meet the size criteria for inclusion.
I	Reinterpretation	Classification, components, or linework has been reassessed and amended. Usually due to an error in original data or improved imagery.
IA	Reinterpretation - Addition	Polygon was reassessed and found to meet the standard required to be included in the inventory so was added (may be a fully new polygon or an extension to an existing one).
ID	Reinterpretation - Disturbance	The polygon was reinterpreted which led to a change in the disturbance coding.
IDD	Reinterpretation - Deleted due to disturbance	Polygon was reinterpreted and found to be too disturbed to be included and so deleted from the inventory. *Polygons with this coding were removed from the inventory*.
IDR	Reinterpretation - deleted due to remnant assessment	Polygon was reinterpreted and part of it was found to be too disturbed and deleted from the inventory. The remainder of the polygon is now too small so does not meet the size criteria for inclusion. *Polygons with this coding were removed from the inventory*.
IR	Reinterpreted - Reduced	The polygon was reinterpreted which led to a reduction in size.
IRD	Reinterpretation - Reduced and Disturbed	The polygon was reinterpreted which led to a reduction in size and a change in the disturbance coding.
N	No Change	No change observed since the last assessment.
NB	No Change (Brief)	Brief scan of area rather than in-depth look (only for watersheds and large provincial parks in the north).
ND	Change in disturbance due to natural factors	Used for Old Field where condition has been reduced or improved due to natural succession.

Code	Description	Additional Information
R	Reduced	Reduced in size due to disturbance.
RD	Reduced and Disturbed	The polygon was both reduced in size and disturbed.
Any codes with an underscore between them, e.g. R_C	Indicates two separate issues that apply to the same polygon. E.g. Reduced and Changed	EXAMPLES ONLY PROVIDED BELOW. ADDITIONAL CODES EXIST IN THE DATABASE.
I_R	Reinterpreted and reduction due to new disturbance	Reinterpretation of initial classification or linework. Plus reduction in size due to new disturbance.
I_DD	Reinterpreted and deleted due to disturbance	Reinterpretation of initial classification or linework. Since the original call, it was disturbed and so will be deleted from the inventory.
I_D	Reinterpreted and new disturbance	Reinterpretation of initial classification or linework. Plus reduction in condition rating due to new disturbance.
I_IR	Reinterpreted, and reinterpreted and reduced	Reinterpretation led to a change in classification or other attribute, plus the polygon has been reduced due to reinterpretation.
I_RD	Reinterpreted plus reduced and disturbed	Reinterpreation of initial classification or linework. Plus a reduction in size and condition due to new disturbance.
IR_R	Reinterpreted and Reduced, and reduced	The polygon was reinterpreted which led to a reduction in size (and potentially other changes e.g. classification). Plus the polygon was reduced due to new disturbance.

LU_Change

Code	Description
Agriculture	Land used for agricultural production. Includes cultivated field crops, farm infrastructure, crop cover structures, equestrian.
Cleared/Mowed	The area was cleared of vegetation or mowed and no further development has occurred or looks like it will occur. 2016 orthos were used to confirm that development had not occurred two years later.
Commercial & Services	Retail services, cultural, and entertainment.
Drainage	The area was cleared in order to install drainage features (ponds, culverts, etc.).
Extraction	Mineral or petroleum extraction.
Golf Course	Golf course.
In Transition	The area was cleared and development is in process but the land use is unclear.
Industry	Includes work yards and buildings associated with industrial activities.
Institutional & Community	Government, religious, medical, educational, and correctional.
Logged	Trees logged as part of forestry operations (includes the academic research forests).
Outdoor Storage	Areas cleared and now used to store equipment, vehicles, etc. Not clearly associated with another land use type.
Recreation	Playing fields, trails.
Residential	Housing and associated driveways, lawns (immediately adjacent to the property) and small streets leading to the house. In cases where an area has been cleared and a residential development with roads was added, the individual local roads were not separated and classified as Transportation & Communication, they are included

Code	Description
	within Residential. Larger roads were separated out. Larger areas of clearing that appear associated to a residence but are not clearly lawn are classified as 'Cleared/Mowed'.
Restoration	Occasionally, restoration activities result in clearing of vegetation (usually to remove invasive species). These areas will likely return to the inventory in a few years.
Transportation & Communication	Roads, rail, airports, or telecommunications.
Unknown	Used to the minimum extent possible where the purpose of a development cannot be determined.
Utilities	Energy transmission, water or sewer lines.

Change and **Change 14**

Code	Description
AN	Added due to natural change (an ecosystem now meets the classification requirements).
DN	Deleted due to natural change (e.g. an aged old field that no longer meets the classification requirements).
DM	Deleted due to mapping change (e.g. fixing error)[5].
DH	Deleted due to human activities (an ecosystem lost due to human activities).
DF	Deleted YF polygons in 2020 due to reduction in size below the 5ha threshold to become YS.

Adj09Qual

Code	Description
A	Excellent
B	Good
C	Moderate
D	Poor
E	Very Poor
N/A	For polygons with no quality score in 2009.

Q0914

Code	Description
QAll	Assessed for quality in both 2009 and 2014.
Q14	Assessed for quality in 2014 but not 2009.
NQ	Not assessed for quality.

Adj14Qual

Code	Description
A	Excellent
B	Good
C	Moderate
D	Poor
E	Very Poor
N/A	For polygons with no quality score in 2014.

Q1420

Code	Description
QAll or QALL	Assessed for quality in both 2014 and 2020.

[5] These polygons have been removed in the final version of the database.

Q20	Assessed for quality in 2020 but not 2014.
NQ	Not assessed for quality.

APPENDIX A

Technical Memo – Addition of Two Classes to the Metro Vancouver 2020 Land Cover Classification

In December 2023, two additional classes were added to the Metro Vancouver Regional District (MVRD) 2020 land cover classification to facilitate the assessments of canopy cover and impervious surfaces for the region. In the original 14 class land cover product, the logic applied during classification post-processing resulted in a bias towards impervious surfaces. To rectify this bias and to support monitoring of canopy cover and impervious surfaces for the MVRD, a tree adjusted land cover classification was produced that differentiated between tree classes in vegetated areas and tree classes that covered impervious surfaces.

During post-processing, a series of masks are applied to the classification to resolve any remaining confusion. Classification confusion tends to occur in areas of highly variable and complex land covers since the five-metre resolution of the base imagery results in blended pixels for these locations. Blended pixels are assigned cover types that best represent the mixed spectral information, so individual features of interest may be masked by a more dominant spectral signal. For example, the spectral signal of roads in residential neighbourhoods can be masked by a stronger vegetation signal from trees, shrubs, and lawns located in yards or on boulevards. A road mask applied during post-processing can cut these roads back into the classification by conditionally turning any vegetation classes falling within the road mask to the paved class. When this condition was applied to the MVRD 2020 classification, it resulted in a bias towards impervious surfaces in urbanized areas as pixels where the tree canopy covered a residential road were assigned to the paved class. To address this bias and better characterize areas where tree canopy and impervious surfaces are not mutually exclusive, two classes were added to the classification schema: conifer over paved (class 15) and deciduous over paved (class 16) (Table A-1).

Table A-1. 16- class tree adjusted MVRD 2020 land cover classification schema

Classification	Criteria*
Buildings	Housing, warehouses, towers, industrial structures, etc.
Paved	Asphalt and concrete surfaces
Other Built	Sports surfaces, transit or rail areas, other impervious surfaces, etc.
Barren	Beaches, alpine rock, shoreline rock, quarries, gravel pits, gravel roads, lacking vegetation, but not soil
Soil	Agricultural soils (light or dark), cleared/open areas where darker colors indicate organic matter present
Coniferous	Predominantly coniferous (>75%)
Deciduous	Predominantly broadleaf (>75%)
Shrub	Woody, leafy, and rough-textured vegetation (~ < 3 to 4 m)
Modified Herb	Most crops, golf course greens, city park grass, lawns, etc.
Natural Herb	Alpine meadows, near-shore grass areas, fine-textured bog/wetland areas
Non-Photosynthetic Vegetation	Dead grass, cutblock slash, and log booms
Water	Lakes, rivers, inlets, irrigation channels, retention ponds, pools, etc.
Shadow	Dark pixels with very low reflectance values
Snow/Ice	Snow or Ice features with high reflectance
Coniferous over Paved	Areas when coniferous tree canopy over hangs paved areas
Deciduous over Paved	Areas when deciduous tree canopy over hangs paved areas

The two new tree/paved classes were defined using the road mask derived from the digital road atlas. Instead of changing any tree class pixels to paved, as was done previously to obtain the 14-class product, the tree pixels falling within the mask were broken out into the two separate tree/paved classes. This change in logic will reduce the bias towards impervious surfaces and provide a more flexible characterization of tree canopy and impervious surfaces across the region.

Table A-2 summarizes the land cover totals for the 14-class MVRD classification by administrative boundary for the MVRD; while Table A-3 summarizes the land cover totals for the 16-class tree adjusted product. The difference in the totals between the two products is found in the paved and tree/paved classes. The loss to the paved class in the tree adjusted product corresponds to the gain in the tree/paved classes as the change to the post-processing logic deals with those two classes. Table A-4 shows the increase in tree canopy for each administrative area when calculated using the 16-class tree adjusted product. The areas with the largest differences are the highly urbanized areas with rural and less densely developed areas showing smaller changes.

Table A-2. Land cover class percent totals by administrative areas for the MVRD calculated from the 14-class land cover product.

	Bowen Island	City of Burnaby	City of Coquitlam	City of Delta	City of Langley	City of Maple Ridge	City of New Westminster	City of North Vancouver	City of Pitt Meadows	City of Port Coquitlam	City of Port Moody	City of Richmond	City of Surrey	City of Vancouver	City of White Rock	District of North Vancouver	District of West Vancouver	Electoral Area A	Township of Langley	Tsawwassen First Nation	Village of Anmore	Village of Belcarra	Village of Lions Bay
Building	0	17	7	3	17	2	19	13	2	13	6	7	10	22	8	3	3	0	4	2	1	1	0
Paved	3	33	17	9	43	6	44	38	7	28	14	15	23	37	16	8	9	0	11	19	2	2	8
Other Built	0	1	0	0	0	0	1	2	0	3	1	0	0	1	0	0	0	0	0	0	0	0	0
Barren	1	0	1	1	0	1	1	0	1	1	1	2	0	1	1	2	1	5	0	4	0	0	0
Soil	0	0	0	4	0	0	0	0	3	0	0	3	2	0	0	0	0	0	5	4	0	0	0
Conifer	56	7	41	1	0	55	0	3	6	2	36	0	2	1	0	69	61	60	2	1	76	33	57
Deciduous	14	20	13	4	18	15	9	10	7	17	15	5	19	15	7	5	7	1	29	2	1	4	2
Shrub	2	4	4	2	4	4	2	2	3	4	3	2	3	2	2	3	4	5	2	1	3	1	2
Modified Herb/Grass	2	10	7	18	12	8	8	4	44	15	4	14	25	7	3	2	3	1	41	15	1	1	1
Natural Herb/Grass	1	2	5	6	4	2	0	0	14	3	1	2	1	0	0	0	0	1	3	6	1	0	0
Non-PS Vegetation	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Water	20	6	5	51	0	6	14	27	13	14	20	49	13	14	64	8	10	26	3	47	14	58	29
Shadow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Snow/Ice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Table A-3. Land cover class percent totals by administrative areas for the MVRD calculated from the 16-class land cover product.

	Bowen Island	City of Burnaby	City of Coquitlam	City of Delta	City of Langley	City of Maple Ridge	City of New Westminster	City of North Vancouver	City of Pitt Meadows	City of Port Coquitlam	City of Port Moody	City of Richmond	City of Surrey	City of Vancouver	City of White Rock	District of North Vancouver	District of West Vancouver	Electoral Area A	Township of Langley	Tsawwassen First Nation	Village of Anmore	Village of Belcarra	Village of Lions Bay
Building	0	17	7	3	17	2	19	13	2	13	6	7	10	22	8	3	3	0	4	2	1	1	0
Paved	1	31	15	8	41	5	41	35	6	27	13	15	22	32	14	6	7	0	9	19	2	2	5
Other Built	0	1	0	0	0	0	1	2	0	3	1	0	0	1	0	0	0	0	0	0	0	0	0
Barren	1	0	1	1	0	1	1	0	1	1	1	2	0	1	1	2	1	5	0	4	0	0	0
Soil	0	0	0	4	0	0	0	0	3	0	0	3	2	0	0	0	0	0	5	4	0	0	0
Conifer	56	7	41	1	0	55	0	3	6	2	36	0	2	1	0	69	61	60	2	1	76	33	57
Deciduous	14	20	13	4	18	15	9	10	7	17	15	5	19	15	7	5	7	1	29	2	1	4	2
Shrub	2	4	4	2	4	4	2	2	3	4	3	2	3	2	2	3	4	5	2	1	3	1	2
Modified Herb/Grass	2	10	7	18	12	8	8	4	44	15	4	14	25	7	3	2	3	1	41	15	1	1	1
Natural Herb/Grass	1	2	5	6	4	2	0	0	14	3	1	2	1	0	0	0	0	1	3	6	1	0	0
Non-PS Vegetation	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Water	20	6	5	51	0	6	14	27	13	14	20	49	13	14	64	8	10	26	3	47	14	58	29
Shadow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Snow/Ice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Conifer/Paved	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	3
Deciduous/Paved	0	2	1	0	2	1	2	2	0	1	1	0	1	5	1	1	1	0	1	0	0	0	0

Table A-4. Increase in canopy cover by administrative area associated with the addition of the two tree/paved classes to the MVRD land cover classification. Totals are given in percentages of total land cover for an area.

	Conifer/Paved	Deciduous/Paved	Total
City of Vancouver	0.5	4.8	**5.3**
Village of Lions Bay	3.1	0.5	**3.6**
City of North Vancouver	0.9	2.3	**3.2**
City of Langley	0.3	2.5	**2.8**
City of New Westminster	0.2	2.4	**2.6**
City of Burnaby	0.3	2.0	**2.4**
District of West Vancouver	1.0	1.1	**2.0**
City of Port Moody	0.5	1.3	**1.7**
City of Surrey	0.2	1.5	**1.7**
City of Port Coquitlam	0.2	1.3	**1.5**
City of Coquitlam	0.3	0.9	**1.3**
City of White Rock	0.2	1.1	**1.3**
Bowen Island Municipality	0.8	0.5	**1.3**
Township of Langley	0.1	1.0	**1.1**
District of North Vancouver	0.5	0.5	**1.1**
City of Maple Ridge	0.3	0.5	**0.8**
Village of Belcarra	0.3	0.3	**0.6**
City of Richmond	0.1	0.5	**0.5**
Village of Anmore	0.3	0.1	**0.4**
City of Delta	0.1	0.3	**0.4**
City of Pitt Meadows	0.0	0.3	**0.3**
Tsawwassen First Nation	0.0	0.2	**0.2**
Electoral Area A	0.0	0.0	**0.0**