REDIGITIZING OF SENSITIVE ECOSYSTEMS INVENTORY POLYGONS TO EXCLUDE DISTURBED AREAS

SUMMARY REPORT

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Abstract

By the late 1980s it had become clear that ecologically significant lands and important wildlife habitats were fast disappearing throughout the lowlands surrounding the Strait of Georgia. This loss was due to intense development pressure fueled by population and economic growth. To address this concern, the joint federal/provincial Sensitive Ecosystems Inventory (SEI) of East Vancouver Island and Gulf Islands was undertaken in 1993 as a pilot project.

In 1993-1997, the Sensitive Ecosystems Inventory mapped seven different natural ecosystem types considered rare and ecologically sensitive on the east coast of Vancouver Island and the Gulf Islands: wetland, riparian, older forest, woodland, terrestrial herbaceous, sparsely vegetated and coastal bluff ecosystems. Two other ecosystem types, although clearly altered by human use, were also mapped because of their general biodiversity and wildlife habitat values: seasonally flooded agricultural field and older second growth forest ecosystems. Results of the SEI mapping project showed that less than 8% of the landscape was occupied by sensitive ecosystems in a relatively natural state.

The air photos used for original polygon designation were acquired over a period from 1984-1992. If the SEI is to continue to be an effective and relevant conservation and land-use planning tool, it must contain up-to-date information. In recognition of that need, AXYS Environmental Consulting, Ltd. was contracted to evaluate the present condition of all original SEI polygons using air photos taken in 2002, and to update the spatial coverage and associated attribute files with information such as disturbance type, percent of polygon disturbed, and extent of polygon fragmentation. This update increases the value of the SEI to both current and potential users, and allows the amount, rate, and type of ecosystem loss since the original inventory to be quantified and summarized.

The disturbance mapping identifies those portions of the original SEI polygons that have been disturbed—by logging, urban or rural use, roads, trail(s), recreation, agriculture or industrial use—over the past decade. The areas of disturbance were identified by digitally overlaying the original polygons (identified on air photos taken primarily between 1990 and 1992) on more recent photographs taken in late July and early August 2002. Changes to polygons were noted, and areas lost to disturbance or heavily modified were digitized, allowing calculation of total hectares lost to disturbance throughout the study area. In addition, the intact remnants of each altered polygon were reviewed to determine if they still qualified for inclusion in the SEI. The disturbed areas identified were retained on the maps to increase awareness of the escalating loss of natural ecosystems and to encourage conservation of those that remain.

Results of this disturbance mapping show an alarming trend. Over 8,800 ha (11%) of the area occupied by the nine SEI ecosystem types in the early 1990s had been disturbed by 2002. Over 1460 ha of disturbed area had originally been occupied by the seven sensitive ecosystems. Older forests had the highest rate of loss at 8.6% (915 ha) followed by riparian (4.6%), woodland (2.6%) and wetland (2.0%) ecosystems. The largest area of loss was 7,363 ha (16.4%) in the older second growth forest category. Losses due to fragmentation are currently being assessed and will add to these totals.

The greatest losses of sensitive ecosystems occurred in the Nanaimo region. Loss to older second growth and seasonally flooded ecosystems are dominated by the harvest of second growth forest, primarily in the Comox-Strathcona and Nanaimo regions. The loss of older second growth and seasonally flooded ecosystems in these two regions comprise the majority (53%) of all loss to SEI area, primarily as loss to older second growth ecosystems. The table below depicts ecosystem losses summarized by region (sub-unit):

	Sensitive Ecosystems			Other Ecosystems (SG, FS)		
SEI Sub-Unit	Original SEI (Ha)	Loss (Ha)	% Loss	Original SEI (Ha)	Loss (Ha)	% Loss
Capital	8500.5	140.2	1.6%	11080	865.9	7.8%
Comox	8684.8	483.6	5.6%	9085.6	2649.3	29.2%
Cowichan	4416.9	205.5	4.7%	4066.5	306.4	7.5%
Islands	5128.8	223.6	4.4%	14751.8	1539.3	10.4%
Nanaimo	5779.2	411.3	7.1%	8685.3	2017.5	23.2%
Total	32510.1	1464.2	4.5%	47669.3	7378.4	15.5%

It is hoped that this project and its map products will not only raise awareness of escalating ecosystem loss on the east coast of Vancouver Island and the Gulf Islands, but will also encourage and facilitate the development of comprehensive conservation strategies to ensure the protection of our remaining natural ecosystems through a strategic landscape or ecosystem approach to land use planning.

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1 Introduction

1.1 Background

SEI Mapping 1993-1997

By the late 1980s it had become clear that ecologically significant lands and important wildlife habitats were fast disappearing throughout the lowlands surrounding the Strait of Georgia. This loss was due to intense development pressure fueled by population and economic growth. To address this concern, the joint federal/provincial[1] Sensitive Ecosystems Inventory (SEI) of East Vancouver Island and Gulf Islands was undertaken in 1993 as a pilot project.

The purpose of the SEI was to identify, classify, and map terrestrial ecosystem polygons that exist in a relatively unmodified state within the region (Ward et al. 1998). Seven **sensitive ecosystem** types that once defined the ecological character of this region were identified: wetland; riparian; older forest; woodland; coastal bluff; sparsely vegetated (e.g., dunes, spits, and cliffs); and terrestrial herbaceous ecosystems (Ward et al. 1998). SEI results showed that by the early 1990s sensitive ecosystems covered only 7.9% of the regional land base.

The SEI also mapped two **other important ecosystems**—seasonally flooded agricultural fields and older second growth forests—because of their contribution to the general biodiversity values in the region. They are not considered to be sensitive ecosystems because of their widespread distribution and history of recent human disturbance. SEI results showed that these ecosystems covered an additional 11.6% of the regional land base.

The primary objective of the SEI was to conserve remaining examples of the seven sensitive ecosystems in a relatively natural state. The objective with regard to the two 'modified' ecosystems was to maintain their resource use values while minimizing the loss of ecosystem function and to give conservation priority to those surrounding or adjacent to sensitive ecosystems (McPhee et al. 2000).

The seven sensitive ecosystem categories used in the SEI are:

Coastal Bluff (CB) - vegetated rocky islets, shorelines and coastal cliffs;

Sparsely Vegetated (SV) - dunes, spits and inland cliffs;

Terrestrial Herbaceous (HT) - mosaics of coastal grassland meadows and moss-covered rock outcrops;

Riparian (RI) - vegetated floodplains, stream and lake shores and gullies;

Wetland (WN) - marshes, fens, bogs, swamps, shallow water and wet meadows;

[1]SEI project partners include Environment Canada (Canadian Wildlife Service), BC Ministries of Sustainable Resource Management (Conservation Data Centre) and Water, Land, and Air Protection, and the Habitat Conservation Trust Fund. SEI projects have also received funding and support from regional districts, local governments, and industry.

Woodland (WD) - open forests dominated by deciduous trees with canopy cover generally less than 50%; and

Older Forest (OF) - forests older than 100 years

Two additional ecosystem types were mapped for their biodiversity and wildlife values:

Older Second Growth Forest (SG) - large forested stands 60 – 100 years old; and

Seasonally Flooded Agricultural Field (FS) - agricultural fields regularly flooded in winter months

Over 20% of the SEI polygons originally identified contained a mixture of primary and secondary ecosystem components that could not be delineated separately. Such polygons are referred to as 'complexed' units, and have two ecosystems associated with them.

Information generated by the SEI has proven to be a valuable tool in addressing some of the concerns about the loss of sensitive ecosystems. The intent of the program was to develop a scientific database that could be used to promote responsible land stewardship, support sound land use planning decisions, encourage wildlife conservation, and expand the suite of tools available for the protection and conservation of valuable habitats and ecosystems (Ward et al. 1998, Environment Canada 2002). To this end, SEI information has been used to build the case for acquisition of sites such as Tumbo Island, the Galiano bluffs, and portions of the Sooke Hills for the purpose of conserving rare and sensitive ecosystems (AXYS 2003). Additionally, SEI information has been used for such things as establishing buffers along park boundaries, delineating boundaries and establishing terms for conservation covenants, developing natural area plans and evaluating development proposals (AXYS 2003).

Preliminary SEI Audit 2001

Eastern Vancouver Island and the adjacent Gulf Islands are subject to intense urban and rural development pressures that are a continual threat to the integrity of sensitive ecosystems. Development activities routinely result in the loss of SEI polygons, and remaining sensitive ecosystems may be affected by fragmentation, human use, and the presence of exotic or invasive species (Ward et al. 1998, Caskey and Henigman 2002). A 1999-2001 audit (based on 1999 orthophotos) of the status of 27% of the original SEI polygons indicated that 11.2% of those polygons had been either lost or affected by disturbances with 1.3% of the sites classified as 'Severely Disturbed/Degraded'. The 11.2% statistic yields an average rate of change of 1.6% per year, and the study noted that the level of disturbance had increased during the last half of the 1990s (Caskey and Henigman 2002). Of particular concern is the level of disturbance in Older Second Growth Forests (24.9%) and Older Forests (17.6%) due to forestry activities and urban encroachment (Caskey and Henigman 2002). Not surprisingly, these results have prompted valid concerns about the rate and extent at which rare and ecologically sensitive ecosystems continue to be altered or lost in the eastern Vancouver Island and Gulf Islands region.

SEI Disturbance Mapping 2003-2004

The air photos used for original polygon designation were acquired over a period from 1984-1992. If the SEI is to continue to be an effective and relevant conservation and land-use planning tool, it must contain up-to-date information. In recognition of that

need, AXYS Environmental Consulting, Ltd. was contracted to evaluate the present condition of all original SEI polygons using air photos taken in 2002, and to update the spatial coverage and associated attribute files with information such as disturbance type, percent of polygon disturbed, and extent of polygon fragmentation. This update increases the value of the SEI to both current and potential users, and allows the amount, rate, and type of ecosystem loss since the original inventory to be quantified and summarized.

1.2 Objectives

The objectives of this project are to:

- Identify areas of disturbance from air photos taken in July and August of 2002 and update the original SEI polygon boundaries (and associated attributes) to reflect these areas;
- Update the ecosystem classification attributes for the new coverage;
- Update the SEI data structure to allow temporal changes in the data to be tracked;
- Identify and document any polygons with classification or georeferencing errors;
- Summarize the spatial and attribute data changes made; and
- Summarize the amount and rate of ecosystem loss over time, according to ecosystem type and SEI sub-unit

2 Methodology

2.1 Polygon Evaluation

2.1.1 Identifying Disturbance

The original polygon designation was made using air photos taken in the period 1984-1992. 'New' human-caused disturbance to SEI polygons (i.e., disturbance that has occurred since the original polygon designation) was identified by examining each of the 7388 SEI polygons individually in conjunction with 1:10,000 digital orthophotos taken in July-Aug 02. The majority of the study area was rendered in black and white. Colour images were only available for Lasqueti Island and its adjacent islets. Section 3.2 discusses limitations of this methodology.

Seven types of disturbance were identified: cleared/logged, industrial, rural use, agriculture, urban use, trails/recreation and 'other'. Disturbance was often obvious and easy to categorize, particularly when the area of disturbance was large and continuous (e.g., clearcut logging, suburban housing development) rather than patchy or small (e.g., selective logging, minor roads and trails). However, there were some cases when it was necessary to refer to the original photos and polygon linework to distinguish between 'new' disturbance and pre-existing disturbance (i.e., disturbance that had been included as part of the original polygon). The original SEI allowed for some fragmentation if, in the opinion of the qualified professional interpreting the air photos or doing the groundtruthing, disturbance was considered not to compromise the integrity of a functioning ecosystem.

Some forms of disturbance were impossible to identify within the scope of this project (e.g., invasion of exotic species) and others were easier to identify in some units than in others (e.g., trail networks in non-forested versus forested units). Natural disturbances that altered the composition or boundaries of a polygon were not considered a disturbance in the context of this project although a brief descriptive comment was added to the database. Examples of such natural disturbance include changes to a river course affecting bank and island polygons, and erosion or depositional changes to soft-sediment islands in marine or estuarine environments.

Disturbances that infringed on the edges of a polygon were assessed as to whether they were an actual infringement on the polygon or whether the appearance of infringement was actually an artifact of inaccurate digitizing of the original typing. This distinction was generally based on an assessment of how accurate the rest of the polygon appeared to be, how easily distinguished the ecosystem unit was or by referring to the original photos.

More specifically, the disturbance types were identified as follows:

- **Cleared/Logged:** This disturbance type was generally easy to identify and was the most common type of disturbance encountered. The combination of cleared and logged land as a single disturbance type may have over-estimated the amount of industry-based logging taking place since removal of tree cover could proceed non-forestry related developments in forested units. Where adjacent land use indicated the purpose for which clearing had taken place, such as agriculture or urban use, the appropriate disturbance type was selected rather than simply identifying the polygon

as Cleared/Logged. The boundaries of clearcuts were readily apparent, but areas of selective logging were often harder to delineate and sometimes required reference to the original photos. Areas of low volume selective logging may have been missed in some cases. The boundaries of logging are harder to delineate in polygons that are a complex of HT and forested units as recent clearcuts can appear similar to HT.

- **Industrial:** Disturbances included in this category were gravel pits, dams, work yards, fish farms, and large buildings in rural or low density settings not associated with fields (although some of these 'light industry' buildings may actually have been commercial). This disturbance type might have included activities that could have been classified as other disturbance types (e.g., urban use) and vice versa.
- **Agriculture:** Fields that appeared to be actively tilled, mowed or obviously planted were included in this category unless the ecosystem type was FS, in which case these activities were not considered to be a disturbance. This disturbance type likely included activities that could have been classified as rural use and vice versa.
- **Trails/Recreation:** This disturbance type included golf courses, playing fields and trails. As noted previously, trails were likely underestimated, particularly in forested units.
- **Rural Use:** Farm buildings, fields and pastures (non-mowed, non-tilled or non-planted), docks, isolated houses or houses in low density on large properties were considered to be rural use. Irrigation ponds and reservoirs were considered a disturbance in wetland types but not in FS. This disturbance type likely included activities that could have been classified as agriculture and vice versa.
- **Urban Use:** Suburban housing developments, malls and office complexes were considered to be urban use. This disturbance type might have included activities that could have been classified as other disturbance types (e.g., industrial use) and vice versa.
- **Road(s):** This disturbance type included all categories of roads from multi-lane highways to logging spur roads. Highway bridges were also included in this category.
- **Other:** This disturbance type category was seldom used. Included here were airport development, borrow pits (associated with logging activities), and channels and other human-made structures with unknown purposes.

A polygon may be impacted by more than one type of disturbance, in such cases, the dominant disturbance was selected and the other disturbance(s) were noted in the comments field.

2.1.2 Fragmentation

Fragmentation was considered to be patches of disturbance less than 0.2 ha in area or linear disturbances too narrow to be digitized at 1:10,000 (*e.g.*, road across riparian corridors). Polygons were originally included in the SEI when fragmented if, in the opinion of the ecologist interpreting the air photos, they were still considered to be functioning, viable ecosystems or to provide adequate representation of the ecosystem type. A notation of Fragmented was added to ecosystems where this situation occurred. A Fragmentation Rate (percentage of the polygon affected) assignment was begun but is not currently complete. Consequently, the values stored in the DIST_FRAG field described below should not be considered to be comprehensive.

2.1.3 Deleting a Polygon

Ecosystem polygons that cease to be viable due to disturbance were marked as 'deleted'. They were not physically deleted from the SEI, but given an attribute which states that the polygon is no longer a valid SEI ecosystem. The original ecosystem value is retained as an attribute to allow change statistics to be calculated. Ecosystems were marked as 'deleted' if:

- disturbance affects the entire polygon to the extent that all remaining intact portions (if any) are less than 0.2 ha;
- the level of fragmentation within the polygon was greater than 25% of the area; or
- a polygon has been reduced in size due to disturbance, and the remaining intact ecosystem is deemed no longer viable.

A polygon was 'deleted' if the disturbance affected the whole polygon or if the disturbance affected the entire polygon to the extent that all remaining individual patches of the original ecosystem type were less than 0.2 hectares in area. Small polygons were also 'deleted' if the level of fragmentation within the polygon was greater than 25% of the area. A good example of where this criterion might be applied is in areas of selective logging and extensive road and trail networks in non-treed units. Any remaining intact parts (> 0.2 ha, see above) of a disturbed polygon were considered 'reduced'. In a few cases it was necessary to revise the ecosystem interpretation for the remnant polygon if it had been part of a complex unit but now was composed of a pure type.

Wetland units are the exception to the above protocol in that the original typing included wetland polygons less than 0.2 hectares in area. This methodology was adhered to in the update and therefore some remnant wetland polygons may be less than 0.2 hectares in area.

2.1.4 Removing a Polygon

Distinct from the process of flagging deletions described above, a small number of polygons were physically removed from the database. Cases were identified by Canadian Wildlife Service (CWS) staff during the assessment process where the original SEI identification process resulted in the creation of an SEI polygon which had been identified in error (usually due to air photo scale). Fifteen such polygons were physically deleted from the database to ensure their treatment was distinct from loss due to disturbance. The following polygons were deleted from the SEI database:

N0340	S1083	S1505	S65003	V0076A
N1269B	S1366-R1	S52027C	T1244	V0108
S0942	S1366-R3	S57022C	T1539	V0582C

2.1.5 Position Errors

Polygons were flagged as a 'position error' if they appeared to be inaccurately placed and if their boundaries could be revised simply (e.g., 'dragged' as opposed to redigitized) to improve the accuracy of the map product. This type of error was much easier to determine (with no access to stereo imaging) for well-defined units (e.g., wetlands, islets, coastal bluff areas). In a small number of cases, very poorly digitized polygon boundaries were redigitized.

2.1.6 Reinterpretation

There could be several reasons for reinterpretation of a polygon. Although it was not within the scope of this project to evaluate the accuracy of ecosystem typing in the SEI, any striking inconsistencies were noted. If a complex unit appeared to be reduced to a pure unit due to disturbance this was categorized as 'reinterpretation'.

2.1.7 Disturbance Comments

The disturbance *Comments* field was used to note the location of pre-existing disturbance (*e.g.*, old roads). Comments on location of new disturbance in fragmented polygons were provided if the situation was not immediately obvious (*e.g.*, selective logging), otherwise the codes for disturbance type and fragmentation percentage were considered adequate.

2.2 Modification of Database Structure

To allow temporal land use attributes to be stored the structure of the database was updated to allow polygonal changes and attribute classifications to be tracked over time. Both the state of the SEI before adding the disturbances, and the updated (2003) state of the SEI are retained in a single polygonal coverage whose attributes indicate areas that have been disturbed and the nature of this disturbance. The database modifications enable disturbance type and affected area to be mapped and quantified through time. For discussion purposes, the original SEI database is referred to as 'Version 1', the altered database with updated polygons is referred to as 'Version 2'.

The process of monitoring SEI disturbance involved making several alterations to the existing database structure, as outlined below:

A. Addition of a number of fields to the original SEI Polygon database structure, as indicated in Table 1.

Table 1. Fields Added to the Data Structure

Field Name	Contents
PARENT_ID	The polygon ID of the previously-existing SEI Version 1 polygon
REV2_ECOSYS1	Dominant or primary ecosystem code after 2003 assessment (Version 2)
REV2_ECOSYS2	Secondary ecosystem code after 2003 assessment
MOD_TYPE	Type of modification made to the SEI polygon. The following code values are present for completed polygon assessments: **N** = No change; all SEI polygons left intact after the 2003 reassessment will have this value. **DD** = Deleted due to disturbance; polygons are not physically deleted from the database. This flag functionally toggles the polygon on/off based on the temporal scenario being mapped. **DF** = Deleted due to fragmentation; greater than 25% of the polygon has been fragmented by disturbances too small to be mapped individually. Polygons are not be physically deleted from the database. This flag functionally toggles the polygon on/off based on the temporal scenario being mapped. **DR** = Deleted due to remnant assessment; a polygon has been reduced in size due to disturbance, and the remaining intact ecosystem is deemed no longer viable. **R** = Reduced; some portion of this polygon has been deleted due to disturbance, thus reducing the size of the intact ecosystem.

	F = Fragmented; disturbance areas are too small to digitize or are spread throughout a larger polygon and cannot be differentiated. **I** = Reinterpretation; a change was made in the ecosystem classification for the polygon. **A** = Addition; a new Riparian ecosystem identified as part of the 2004 assessment. Note that the codes A, R, F and I may be used in combination (e.g., RF indicates Reduced and Fragmented; a remaining portion of an ecosystem after disturbed areas are deleted also been fragmented by smaller disturbances).
DIST_TYPE	Disturbance type which caused the deletion of the polygon or portion of the polygon (see Section 2.1.1 for detailed discussion of disturbance types) • Trails/Recreation • Road(s) • Urban use • Rural use • Agriculture • Industrial Use • Cleared/logged (selectively or completely) • Other (will be specified)
DIST_DESC	Disturbance description; used when disturbance type (DIST_TYPE) is 'Other', or when some explanation is necessary to describe complex or pre-existing disturbance.
DIST_FRAG	Disturbance fragmentation; when disturbance areas are too small to digitize, an existing SEI polygon is classified with the degree of fragmentation • < 6% • 6 – 25% • > 25%; polygon will be assigned a 'DF' (deleted) attribute in the MOD_TYPE field if disturbance exceeds 25%
REV2_ PHOTO	The 'quad' number on which the polygon is delineated (*e.g.*, 92F0662).
REV2_SCALE	The scale of the air photo(s) on which the polygon is delineated. For 2002 imagery, scale will be 1:10,000.
REV2_DATE	Date of the air photo(s) used for delineation. For 2002 imagery other than Lasqueti Island, this date will be 'July-August 2002'. For Lasqueti Island imagery, the date will be '2002'.

B. Existing SEI polygon attributes were updated, where necessary, during the airphoto interpretation process to reflect the fact that modifications have been made. This affected the following fields:

POLYGON_ID — When polygons are divided (*e.g.*, when a portion is deleted due to disturbance), the two new polygons will have modified polygon identifiers. Each new polygon will have a '-R1', '-R2', etc. appended to the polygon identifier. For example, if a polygon with an identifier of 'S0035' is split, the two resulting polygons would have identifiers 'S0035-R1' and 'S0035-R2'.

HECTARES — The total area of the polygon in hectares, calculated digitally.

2.3 Modify Polygon Boundaries and Attributes

Modification to the polygonal boundaries involved the following steps:

2.3.1 Digitize Polygon Changes

Updating the polygon boundaries involved:

- The polygons were heads-up digitized (digitized on screen) in ArcMap using the digital orthophoto as a backdrop to define the revised spatial extents of the polygons to be updated.
- Heads-up digitizing was performed with a display scale of 1:10,000.
- Resulting polygons had to be at least 0.2 hectares in size (with the exception of wetlands). Areas of disturbance less than 0.2 hectares were noted in the database by updating the Disturbance Fragmentation field for the ecosystem to indicate the percent disturbance. Remnant ecosystem polygons under 0.2 ha were not retained.
- In unusual cases, where problems were encountered with either boundary definition or attribute assignment, the identifier(s) for polygons in question were noted for review with the SEI Technical Advisory Group.

2.3.2 Update Polygon Attributes

The attributes associated with the polygons underwent the following revisions:

- Attribute values were updated as the polygonal boundaries were changed (*e.g.*, the operator modifies the boundary and then edits the attribute record(s) of affected polygons within ArcMap immediately after the spatial edit)
- Newly created disturbance polygons have the following updates to attributes:
  - Area calculated (in hectares);
  - New identifier assigned (when a portion of a polygon is disturbed), by appending a '-Rn' notation to the existing identifier;
  - Modification type set to 'Deleted'; and
  - Disturbance type (*e.g.*, Road(s), Urban use, etc.) set appropriately.
- Polygons reduced in size by disturbance (i.e., the remaining intact portion of a polygon) have the following updates to attributes:
  - Area recalculated (in hectares);
  - 2003 Primary and Secondary ecosystems have values carried over from 1992 values;
  - Where the polygon is a Complexed Ecosystem, an assessment is made to determine if both ecosystems are still present in the new polygon and, if necessary, the modification type is set to 'Reinterpreted' and 2003 Primary and Secondary ecosystem values are changed;
  - Disturbance type (*e.g.*, Road(s), Urban use, etc.) set appropriately; and
  - Modification type set to 'Reduced'.

- Polygons with disturbance(s) less than 0.2 hectares in size will have the following updates to attributes:
  - Disturbance fragmentation attribute set appropriately;
  - 2003 Primary and Secondary ecosystems have values carried over from 1992 values;
  - Disturbance type (*e.g.*, Road(s), Urban use, etc.) set appropriately; and
  - Modification type be set to 'Fragmented'.
- Unaltered ecosystem polygons will have the following updates to attributes:
  - 2003 Primary and Secondary ecosystems will have values carried over from 1992 values; and
  - The modification type set to 'No Change'.

Figure 1 illustrates an example of a straightforward polygon disturbance, and the resulting changes to the spatial and attribute data are shown in Table 2 following.

Figure 1. Spatial Data Modification Example

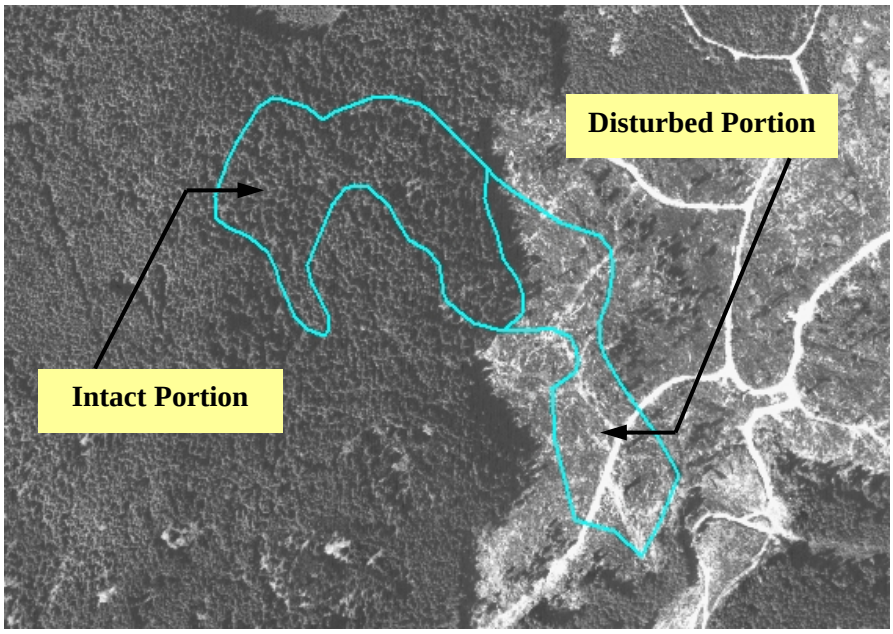
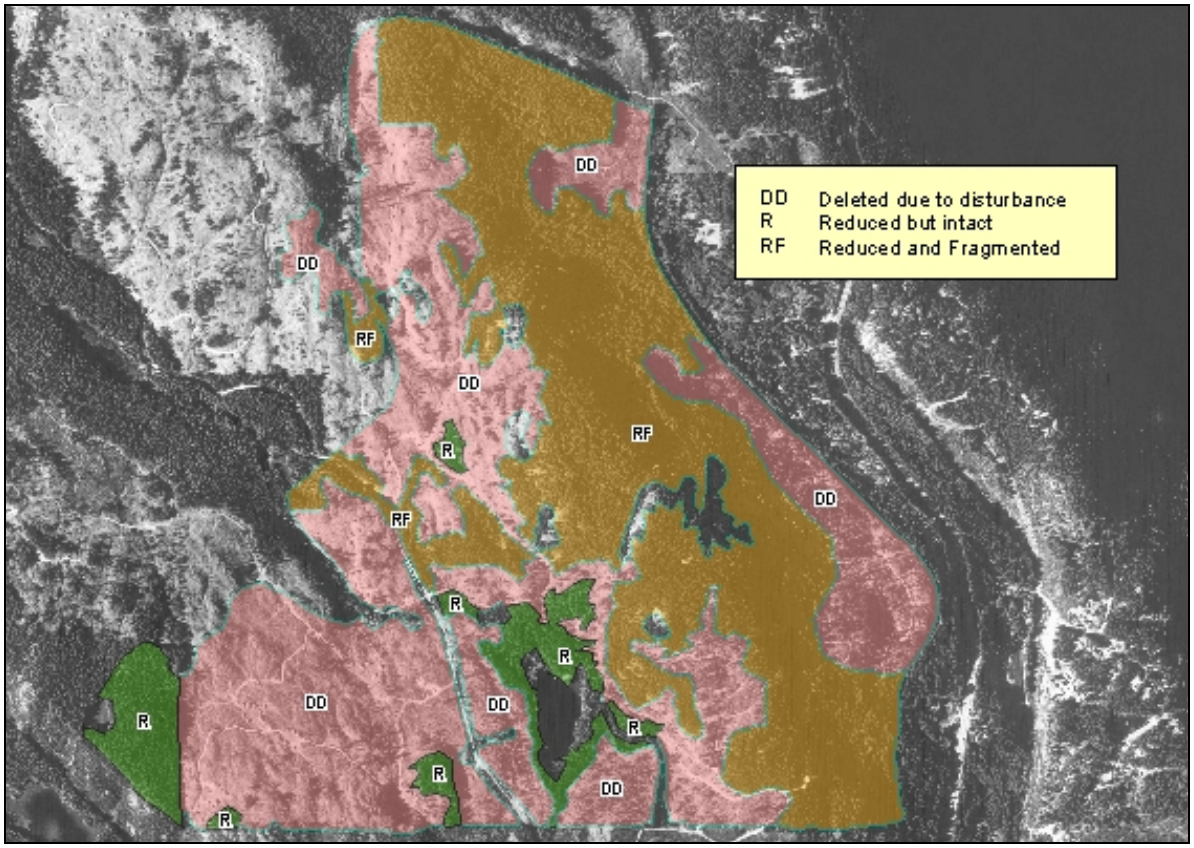


Table 2. Attribute Modifications Example

Intact Portion	Disturbed Portion
• Assign a new polygon identifier (append '-R1' to the original polygon identifier) • Set Parent ID to the original polygon identifier • Recalculate hectares • Modification Type set to *Reduced* (R) • Carry forward original ecosystem(s) to REV2 ecosystems • Disturbance Type is set to *Cleared/Logged* • Assess complexed ecosystems and reclassify if necessary	• Assign a new polygon identifier (append '-R2' to the original polygon identifier) • Set Parent ID to the original polygon identifier • Recalculate hectares • Modification Type set to *Deleted by Disturbance* (DD) • REV2 ecosystems are left empty • Disturbance Type is set to *Cleared/Logged* •

More often, however, situations were encountered which produced a much larger number of new polygons. Some large second-growth polygons, for example, were divided into more than forty new polygons. Figure 2 shows, for a single original SEI polygon, the resulting revised polygons. In this case 17 new polygons resulted from the disturbances found within a single original SEI polygon.

Figure 2. Example of a Complex Polygon Modification



2.4 Quality Assurance

Five levels of Quality Assurance (QA) were performed against the completed database:

A. Verify the internal structure of the delivered coverage. The following tests were performed:

- Ensure Arc/Info topologies have been built and no uncommitted feature edits exist;
- Ensure coverage adheres to requirements for projection, feature types (point, arc and polygon), and precision; and
- Arc/Info commands NODEERRORS, INTERSECTERR and LABELERRORS pass.

B. Verify the attribute domains. Checks were made to ensure that MOD_TYPE, DIST_TYPE and DIST_FRAG adhere to the allowable values identified in Table 1.

C. Verify the logical consistency of delivered attribute data. A total of ten such consistency tests were performed, identifying:

- A modification type of *deleted by disturbance* or *deleted by fragmentation*, but with ecosystem values (a deleted ecosystem should not have values in the REV2 ecosystem fields);
- A modification type of *deleted*, *fragmented* or *reduced* but with no disturbance type;
- A disturbance type populated but with no modification type involving *deletion*, *reduction* or *fragmentation*;
- Polygon ID values which are duplicated;
- A modification type relating to fragmentation, but with no fragmentation rate;
- A fragmentation rate, but with a modification type unrelated to fragmentation;
- A modification type of *deleted by fragmentation* and a fragmentation other than > 25%;
- A modification type other than *deleted by fragmentation* with a fragmentation of > 25%;
- Modification type not filled in; and
- Parent ID is not the prefix of polygon ID of the form *Xnnnnn-Rnn*.

D. An independent operator examined a random sample of <u>all</u> SEI polygons to verify the initial classification (i.e., disturbed/fragmented/not disturbed) was made correctly. This test is referred to as an Overview Test in the discussion below.

E. An independent operator examined a random sample of <u>modified</u> SEI polygons to verify the spatial edits (*e.g.*, portions deleted) made to the polygon were made correctly. This test is referred to as a Detail Test in the discussion below.

Tests (a), (b) and (c) are exhaustive tests, and tests cannot be considered passed until all errors are repaired. Tests (d) and (e) are sample-based, and produce an estimate of error for the entire dataset. Both tests (d) and (e) were performed twice: after the first 1000 polygons were reviewed, to ensure the AXYS internal process was producing satisfactory

results, and once upon project completion. Sampling rates for the Overview Test were lower for the final QA due to confidence in the process resulting from testing of the first 1000 polygons. Results of this testing are as follows:

Table 3. Quality Assurance Sampling Results

Test	Polygons Reviewed	Sample Size	Minor Errors[1]	Critical Errors[2]	Comment
QA 1000 Overview	58	5%	0	0	No errors.
QA 1000 Detail	32	10%	1	0	Minor digitizing error.
QA Final Overview	100	2%	1	0	Different selection of dominant disturbance type where several existed.
QA Final Detail	214	10%	6	0	Minor digitizing errors. Fragmentation rate approximately 7%, but '<6%' indicated.

Notes:

[1] Minor Errors include such problems as digitizing error that results in a change in polygon area of less than 0.4 ha. Such errors are not thought to cause significant change to the SEI results, and do not cause a failure of the Quality Assurance process.

[2] Critical Errors include misinterpretation of a polygon (*e.g.*, assigning it 'No Change' when it has been disturbed), or digitizing errors resulting in a change in polygon area greater than 0.4 ha. Such errors are considered to have serious consequences to the SEI results, and would cause the failure of the Quality Assurance process.

2.5 Concurrent Projects

Concurrent with the work described in this report, two tasks were performed by Ron Buechert, which affected the completed SEI database. Refer to Buechert (2004) for a full description of scope, methods and results for these tasks.

2.5.1 Remnant Assessment

Where some portion of a polygon was deleted due to disturbance, the remaining intact ecosystem is reduced in size. The remnant assessment process reviewed each ecosystem reduced by disturbance to ensure it remained viable. Ecosystems not considered viable due to size, shape or neighbouring disturbances were flagged in the database as Deleted due to Remnant Assessment (DR), and are not considered an SEI ecosystem.

2.5.2 Re-evaluation of Major Riparian Corridors and other Areas

The original SEI mapping of riparian ecosystems avoided areas showing recent human disturbance. However, the linear corridors formed by riparian ecosystems comprise a continuous ecological unit with very high conservation values overall. Major riparian corridors were re-evaluated to reflect these values and to encourage land use decisions that consider entire riparian ecosystems as well as the larger watersheds of which they are a part.

The riparian re-evaluation added 256 new riparian polygons in major corridors such as the Cowichan, Chemainus, Koksilah, Nanaimo, Englishman, Little Qualicum, Puntledge, Quinsam, Oyster, Tsolum and Trent River valleys. Where riparian ecosystems were identified within an existing non-riparian polygon, the riparian ecosystem code was added.

For consistency, the new air photo interpretation was conducted at a scale of 1:10,000. Since this scale was larger than some of the original 1990s photos (many of which were between 1:15,000 and 1:20,000), more accurate interpretation was possible. However, budget and time constraints did not allow for a comprehensive re-interpretation of the entire study area at this scale.

Where previously unidentified SEI ecosystems were noticed during the riparian re-evaluation, new polygons were added. Approximately 25 non-riparian polygons were identified, representing older forests, wetlands and seasonally flooded agricultural fields. A few older second growth forest polygons were also identified where they occurred adjacent to a sensitive ecosystem.

3 Project Summary

3.1 Project Results

This section provides a summary of change in the SEI in the period between the original inventory (1984 – 1992) and 2002. Loss of ecosystem area is calculated using those polygons identified as 'Deleted' (see the description of codes 'DD', 'DR' and 'DF' in Table 1). Loss due to fragmentation was not calculated due to the limitations discussed in Section 3.2.

Where loss by ecosystem is quantified, as with the original SEI summary of results (Ward et al. 1998), the primary ecosystem alone is used. This will tend to slightly underestimate ecosystem loss, since an ecosystem may be present in complexed ecosystems as the secondary ecosystem and thus not quantified in the summaries that follow.

Loss proportions were calculated using the original (1997) SEI area in order to maintain consistency. Therefore, the area occupied by new polygons created during the riparian re-evaluation (see above) was not considered in the area loss calculations summarized below.

Table 4 depicts the loss of both sensitive ecosystems (all ecosystems except Older Second Growth (SG) and Seasonally Flooded Agricultural Fields (FS)), and other important ecosystems (SG and FS) summarized by region. Loss of sensitive ecosystem area is relatively low in all regions, with the greatest loss occurring in the Nanaimo subunit. The greatest overall loss (including all ecosystem types) occurred in the Comox subunit. Loss to SG and FS ecosystems are dominated by the harvest of older second growth forests, primarily in the Comox-Strathcona and Nanaimo regions. The loss of SG and FS ecosystems in these two regions comprise the majority (53%) of all loss to SEI area, primarily as loss to SG ecosystems.

Table 4. Loss by Region

	Sensitive Ecosystems			Other Ecosystems (SG, FS)		
SEI Sub-Unit	Original SEI (Ha)	Loss (Ha)	% Loss	Original SEI (Ha)	Loss (Ha)	% Loss
Capital	8500.5	140.2	1.6%	11080.0	865.9	7.8%
Comox	8684.8	483.6	5.6%	9085.6	2649.3	29.2%
Cowichan	4416.9	205.5	4.7%	4066.5	306.4	7.5%
Islands	5128.8	223.6	4.4%	14751.8	1539.3	10.4%
Nanaimo	5779.2	411.3	7.1%	8685.3	2017.5	23.2%
Total	32510.1	1464.2	4.5%	47669.3	7378.4	15.5%

Table 5 shows the loss to the SEI by ecosystem unit. Again, loss is dominated by the harvest of older second growth forests. Of the sensitive ecosystems (all ecosystems except SG and FS), the majority of loss (62% of loss to sensitive ecosystems) is found in the Older Forest (OF) ecosystem unit.

Table 5. Loss by Ecosystem

Primary Ecosystem	Original SEI Area (Ha)	Loss (Ha)	% Loss
Coastal Bluff	1042.9	1.2	0.1%
Terrestrial Herbaceous	4242.9	24.4	0.6%
Older Forest	10613.8	915.4	8.6%
Riparian	6712.3	310.8	4.6%
Sparsely Vegetated	325.6	4.5	1.4%
Woodland	2518.7	66.1	2.6%
Wetland	7053.9	141.8	2.0%
Total Sensitive Ecosystem Loss	32510.1	1464.2	4.5%
Seasonally Flooded Agricultural Field	2778.6	15.3	0.5%
Older Second Growth Forest	44890.6	7363.1	16.4%
Total Other Important Ecosystem Loss	47669.2	7378.4	15.5%
Total SEI Loss	80179.3	8836.7	11.0%

Table 6 shows the SEI loss summarized by disturbance type and region. Not surprisingly, the dominant disturbance type is 'Cleared/Logged', occurring primarily in Comox and Nanaimo regions. This reflects the significant harvest in older second growth and older forest ecosystem units.

Table 6. Loss by Disturbance Type and Sub-Unit

		Loss (Ha)					
Disturbance Type	**Ecosystem**	**Capital**	**Comox**	**Cowichan**	**Islands**	**Nanaimo**	**Total**
Agriculture	Sensitive	0.0	4.4	3.1	4.1	16.8	28.4
	Other	0.0	9.9	0.0	3.3	0.0	13.2
Cleared/Logged	Sensitive	89.7	376.5	168.3	202.6	338.8	1175.9
	Other	794.8	2329.5	299.4	1417.1	1992.4	6833.3
Industrial Use	Sensitive	3.2	6.1	0.6	0.0	0.2	10.2
	Other	2.0	0.0	0.4	0.0	0.0	2.4
Other	Sensitive	0.0	0.7	0.0	0.0	0.0	0.7
	Other	0.0	0.0	0.0	0.0	0.0	0.0
Road(s)	Sensitive	1.9	34.5	0.0	1.2	31.2	68.8
	Other	0.0	234.6	0.0	3.4	17.6	255.6
Rural Use	Sensitive	21.1	43.0	17.0	12.8	14.9	108.8
	Other	40.8	28.3	5.0	113.2	7.5	194.7
Trails/Recreation	Sensitive	0.0	0.0	0.0	1.4	0.4	1.8
	Other	6.9	0.0	0.0	2.3	0.0	9.2
Urban Use	Sensitive	24.2	18.3	16.5	1.6	8.9	69.5
	Other	21.3	47.0	1.6	0.0	0.0	70.0

Table 7 shows loss summarized by ecosystem unit and disturbance type for the entire study area. Tables 8 through 12 show the identical breakdown, summarized for each of the five regions. Tables 13 through 17 summarize loss by municipality for each subunit. Section 1.1 defines the ecosystem abbreviations used in the following tables.

Table 7. Loss by Disturbance Type and Primary Ecosystem: Study Area

	Loss (Ha)										
Disturbance Type	**CB**	**HT**	**OF**	**RI**	**WD**	**WN**	**SV**	**SE Total**	**FS**	**SG**	**OE Total**
Agriculture	0.0	0.0	0.6	2.5	0.0	25.4	0.0	28.4	0.9	12.2	13.2
Cleared/Logged	0.0	9.9	866.1	249.1	17.3	33.6	0.0	1176.0	0.0	6833.3	6833.3
Industrial Use	0.0	4.1	1.5	2.6	0.6	1.4	0.0	10.2	0.4	2.0	2.4
Other	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Road(s)	0.0	1.2	26.2	27.9	2.4	11.2	0.0	68.8	1.7	254.0	255.6
Rural Use	0.5	0.0	14.5	15.8	20.2	54.8	3.0	108.8	2.7	191.9	194.7
Trails/Recreation	0.0	0.4	0.0	0.0	0.0	1.4	0.0	1.8	2.3	6.9	9.2
Urban Use	0.7	8.2	6.6	12.9	25.5	14.1	1.5	69.5	7.2	62.8	70.0
Total	1.2	24.4	915.4	310.8	66.1	141.8	4.5	1464.2	15.3	7363.1	7378.4

Table 8. Loss by Disturbance Type and Primary Ecosystem: Comox Sub-unit

	Loss (Ha)										
Disturbance Type	**CB**	**HT**	**OF**	**RI**	**WD**	**WN**	**SV**	**SE Total**	**FS**	**SG**	**OE Total**
Agriculture	0.0	0.0	0.6	0.4	0.0	3.5	0.0	4.4	0.9	8.9	9.9
Cleared/Logged	0.0	2.3	219.5	142.9	0.6	11.3	0.0	376.5	0.0	2329.5	2329.5
Industrial Use	0.0	3.5	0.0	2.6	0.0	0.0	0.0	6.1	0.0	0.0	0.0
Other	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Road(s)	0.0	0.0	2.4	23.9	0.0	8.2	0.0	34.5	0.0	234.6	234.6
Rural Use	0.0	0.0	4.1	5.7	0.0	33.2	0.0	43.0	0.0	28.3	28.3
Trails/Recreation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban Use	0.0	0.0	0.0	9.7	5.9	2.7	0.0	18.3	5.6	41.4	47.0
Total	0.0	6.5	226.0	184.9	6.5	55.4	0.0	483.6	5.6	2633.8	2649.3

Table 9. Loss by Disturbance Type and Primary Ecosystem: Nanaimo Sub-unit

	Loss (Ha)										
Disturbance Type	**CB**	**HT**	**OF**	**RI**	**WD**	**WN**	**SV**	**SE Total**	**FS**	**SG**	**OE Total**
Agriculture	0.0	0.0	0.0	0.6	0.0	16.2	0.0	16.8	0.0	0.0	0.0
Cleared/Logged	0.0	3.8	237.2	79.5	0.0	18.3	0.0	338.8	0.0	1992.4	1992.4
Industrial	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Road(s)	0.0	0.0	22.6	4.0	1.7	2.9	0.0	31.2	1.7	16.0	17.6
Rural Use	0.5	0.0	0.3	8.7	0.0	5.5	0.0	14.9	1.5	5.9	7.5
Trails/Recreation	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Urban Use	0.0	0.8	0.0	1.6	0.0	6.5	0.0	8.9	0.0	0.0	0.0
Total	0.5	5.0	260.1	93.7	1.7	33.5	0.0	411.3	3.2	2014.3	2017.5

Table 10. Loss by Disturbance Type and Primary Ecosystem: Cowichan Sub-unit

	Loss (Ha)										
Disturbance Type	**CB**	**HT**	**OF**	**RI**	**WD**	**WN**	**SV**	**SE Total**	**FS**	**SG**	**OE Total**
Agriculture	0.0	0.0	0.0	1.5	0.0	1.6	0.0	3.1	0.0	0.0	0.0
Cleared/Logged	0.0	1.9	128.9	24.8	11.0	1.8	0.0	168.3	0.0	299.4	299.4
Industrial Use	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.6	0.4	0.0	0.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Road(s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rural Use	0.0	0.0	2.0	0.0	0.0	15.0	0.0	17.0	1.2	3.7	5.0
Trails/Recreation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban Use	0.0	2.3	0.0	0.9	10.1	3.2	0.0	16.5	1.6	0.0	1.6
Total	0.0	4.9	130.9	25.7	21.1	19.9	0.0	205.5	3.3	303.2	306.4

Table 11. Loss by Disturbance Type and Primary Ecosystem: Capital Sub-unit

	Loss (Ha)										
Disturbance Type	**CB**	**HT**	**OF**	**RI**	**WD**	**WN**	**SV**	**SE Total**	**FS**	**SG**	**OE Total**
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cleared/Logged	0.0	0.8	82.9	1.7	3.3	1.1	0.0	89.7	0.0	794.8	794.8
Industrial Use	0.0	0.0	1.5	0.0	0.6	1.1	0.0	3.2	0.0	2.0	2.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Road(s)	0.0	0.0	1.3	0.0	0.7	0.0	0.0	1.9	0.0	0.0	0.0
Rural Use	0.0	0.0	0.0	1.4	18.5	1.2	0.0	21.1	0.0	40.8	40.8
Trails/Recreation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	6.9
Urban Use	0.7	5.1	6.6	0.7	9.5	0.0	1.5	24.2	0.0	21.3	21.3
Total	0.7	5.9	91.2	3.8	32.6	3.5	1.5	140.2	0.0	865.9	865.9

Table 12. Loss by Disturbance Type and Primary Ecosystem: Islands Sub-unit

	Loss (Ha)										
Disturbance Type	**CB**	**HT**	**OF**	**RI**	**WD**	**WN**	**SV**	**SE Total**	**FS**	**SG**	**OE Total**
Agriculture	0.0	0.0	0.0	0.0	0.0	4.1	0.0	4.1	0.0	3.3	3.3
Cleared/Logged	0.0	1.1	197.6	0.3	2.5	1.1	0.0	202.6	0.0	1417.1	1417.1
Industrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Road(s)	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.2	0.0	3.4	3.4
Rural Use	0.0	0.0	8.1	0.0	1.7	0.0	3.0	12.8	0.0	113.2	113.2
Trails/Recreation	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.4	2.3	0.0	2.3
Urban Use	0.0	0.0	0.0	0.0	0.0	1.6	0.0	1.6	0.0	0.0	0.0
Total	0.0	2.3	205.7	0.3	4.3	4.1	3.0	223.6	2.3	1537.0	1539.3

Figure 3. Comox Sub-unit

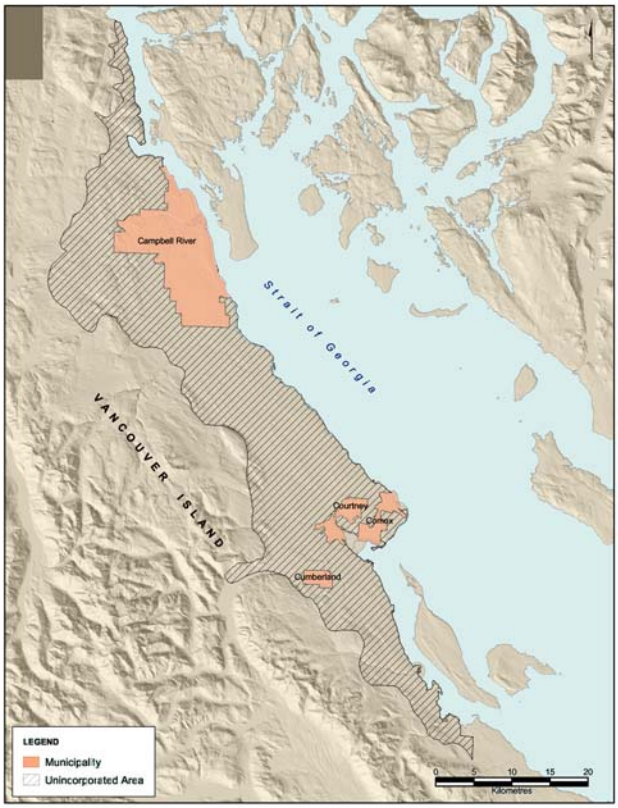


Table 13. Loss by Municipality: Comox Sub-unit

Comox		Sensitive Ecosystems								Other Ecosystems			All
		CB	HT	OF	RI	SV	WD	WN	Total	FS	SG	Total	Total
Campbell River	Original SEI (ha)	0.0	102.8	70.6	344.9	19.1	0.0	425.8	963.3	0.0	436.0	436.0	1399.3
	Loss (ha)	0.0	0.0	34.5	21.1	0.0	0.0	6.7	62.4	0.0	71.4	71.4	133.7
	% Loss (ha)	0.0%	0.0%	48.9%	6.1%	0.0%	0.0%	1.6%	6.5%	0.0%	16.4%	16.4%	9.6%
Comox	Original SEI (ha)	0.0	0.5	5.6	0.0	1.2	0.0	15.6	22.9	0.0	90.8	90.8	113.7
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	8.1	8.1	8.7
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.4%	2.3%	0.0%	9.0%	9.0%	7.6%
Courtenay	Original SEI (ha)	0.0	0.0	0.0	20.3	0.0	18.5	13.1	51.9	6.0	96.5	102.6	154.5
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	6.5	0.0	6.5	5.6	71.1	76.7	83.2
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	34.8%	0.0%	12.4%	92.9%	73.7%	74.8%	53.8%
Cumberland	Original SEI (ha)	0.0	0.0	0.02	7.3	0.0	0.0	58.1	65.4	0.0	121.5	121.5	187.0
	Loss (ha)	0.0	0.0	0.02	3.2	0.0	0.0	0.0	3.2	0.0	78.1	78.1	81.3
	% Loss (ha)	0.0%	0.0%	100.0%	43.3%	0.0%	0.0%	0.0%	4.9%	0.0%	64.2%	64.2%	43.5%
Unincorporated Areas	Original SEI (ha)	34.1	1223.9	1040.7	2445.4	72.4	5.8	2758.8	7581.2	485.4	7849.3	8334.6	15915.9
	Loss (ha)	0.0	6.5	192.1	161.0	0.0	0.0	51.6	411.0	0.9	2414.1	2415.0	2826.1
	% Loss (ha)	0.0%	0.5%	18.5%	6.6%	0.0%	0.0%	1.9%	5.4%	0.2%	30.8%	29.0%	17.8%
Total	Original SEI (ha)	34.1	1327.3	1116.9	2818.0	92.7	24.3	3271.4	8684.8	491.4	8594.2	9085.6	17770.4
	Loss (ha)	0.0	6.5	226.6	185.3	0.0	6.5	58.8	483.6	6.5	2642.8	2649.3	3132.9
	% Loss (ha)	0.0%	0.5%	20.3%	6.6%	0.0%	26.5%	1.8%	5.6%	1.3%	30.8%	29.2%	17.6%

Figure 4. Nanaimo Sub-unit

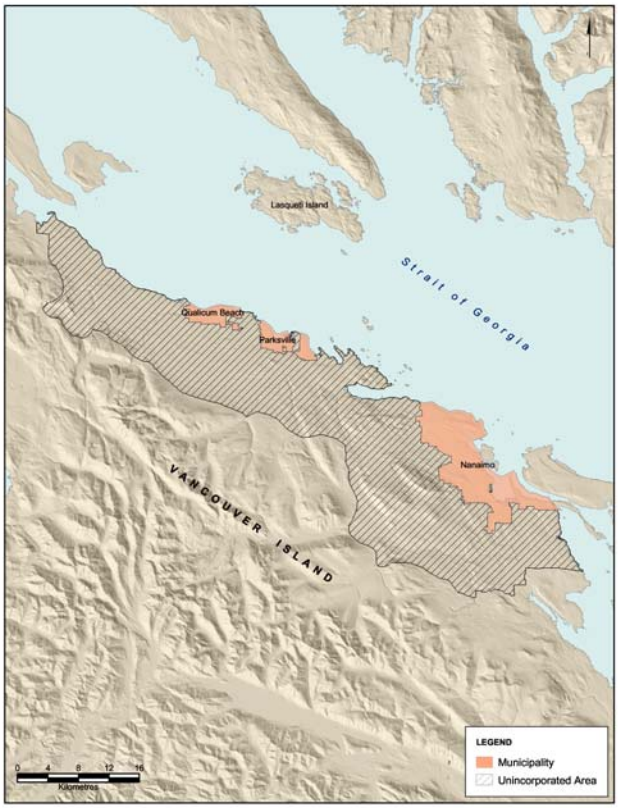


Table 14. Loss by Municipality: Nanaimo Sub-unit

Nanaimo		Sensitive Ecosystems								Other Ecosystems			All
		CB	HT	OF	RI	SV	WD	WN	Total	FS	SG	Total	Total
Nanaimo	Original SEI (ha)	9.1	18.9	20.9	114.6	4.0	43.0	258.1	468.6	71.6	201.8	273.3	741.9
	Loss (ha)	0.0	0.0	2.8	0.2	0.0	1.7	7.9	12.6	1.3	42.2	43.5	56.1
	% Loss (ha)	0.0%	0.0%	13.2%	0.2%	0.0%	3.9%	3.1%	2.7%	1.8%	20.9%	15.9%	7.6%
Parksville	Original SEI (ha)	0.0	3.6	0.0	42.4	0.0	0.0	31.0	77.0	0.1	43.6	43.8	120.8
	Loss (ha)	0.0	0.4	0.0	1.4	0.0	0.0	1.7	3.4	0.0	0.0	0.0	3.4
	% Loss (ha)	0.0%	10.1%	0.0%	3.2%	0.0%	0.0%	5.4%	4.4%	0.0%	0.0%	0.0%	2.8%
Qualicum	Original SEI (ha)	0.0	0.0	16.4	54.1	0.0	0.0	3.0	73.5	0.0	33.8	33.8	107.3
Beach	Loss (ha)	0.0	0.0	0.0	12.2	0.0	0.0	0.0	12.2	0.0	0.0	0.0	12.2
	% Loss (ha)	0.0%	0.0%	0.0%	22.6%	0.0%	0.0%	0.0%	16.6%	0.0%	0.0%	0.0%	11.4%
Unincorporated	Original SEI (ha)	26.4	423.6	1426.1	1941.4	38.9	39.1	1264.7	5160.1	885.1	7449.3	8334.4	13494.5
Areas	Loss (ha)	0.5	4.6	257.3	80.5	0.0	0.0	40.1	383.1	1.9	1972.1	1974.0	2357.1
	% Loss (ha)	1.9%	1.1%	18.0%	4.1%	0.0%	0.0%	3.2%	7.4%	0.2%	26.5%	23.7%	17.5%
Total	Original SEI (ha)	35.5	446.0	1463.3	2152.5	42.9	82.0	1556.9	5779.2	956.8	7728.5	8685.3	14464.5
	Loss (ha)	0.5	5.0	260.1	94.3	0.0	1.7	49.7	411.3	3.2	2014.3	2017.5	2428.8
	% Loss (ha)	1.4%	1.1%	17.8%	4.4%	0.0%	2.1%	3.2%	7.1%	0.3%	26.1%	23.2%	16.8%

Figure 5. Cowichan Sub-unit

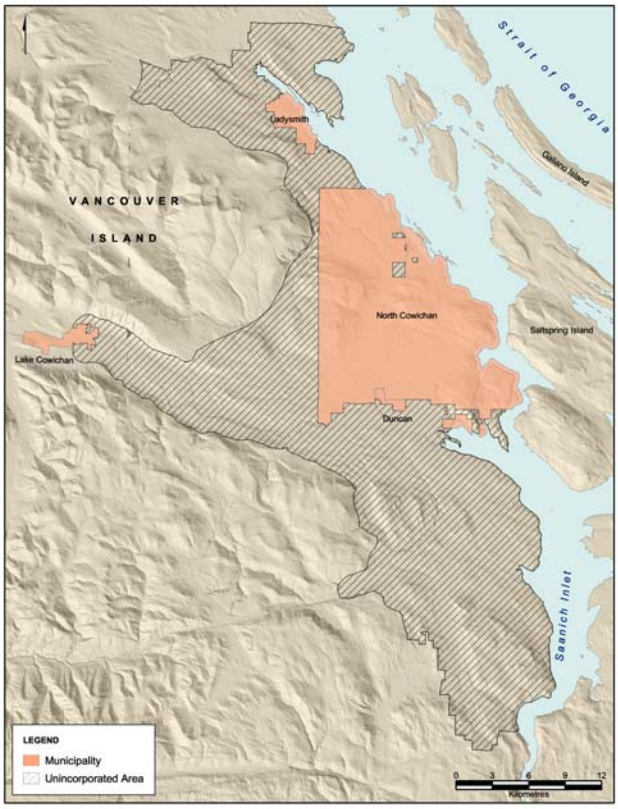


Table 15. Loss by Municipality: Cowichan Sub-unit

Cowichan		Sensitive Ecosystems								Other Ecosystems			All
		CB	HT	OF	RI	SV	WD	WN	Total	FS	SG	Total	Total
Duncan	Original SEI (ha)	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.2
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ladysmith	Original SEI (ha)	0.0	0.0	0.0	54.3	0.0	0.0	3.3	57.6	0.0	0.0	0.0	57.6
	Loss (ha)	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1
	% Loss (ha)	0.0%	0.0%	0.0%	2.1%	0.0%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	2.0%
Lake	Original SEI (ha)	0.0	0.0	0.0	0.0	0.0	0.0	13.1	13.1	2.5	0.0	2.5	15.6
Cowichan	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
North	Original SEI (ha)	18.9	296.9	96.8	193.4	3.6	219.4	427.7	1256.7	540.2	1230.7	1771.0	3027.7
Cowichan	Loss (ha)	0.0	2.3	53.3	1.8	0.0	16.5	17.8	91.7	1.0	42.5	43.5	135.1
	% Loss (ha)	0.0%	0.8%	55.1%	0.9%	0.0%	7.5%	4.2%	7.3%	0.2%	3.5%	2.5%	4.5%
Unincorporated	Original SEI (ha)	22.9	447.0	632.9	1075.9	21.0	137.8	751.7	3089.3	229.7	2063.3	2293.1	5382.3
Areas	Loss (ha)	0.0	2.6	77.6	24.2	0.0	4.6	3.8	112.8	2.3	260.7	263.0	375.8
	% Loss (ha)	0.0%	0.6%	12.3%	2.2%	0.0%	3.3%	0.5%	3.7%	1.0%	12.6%	11.5%	7.0%
Total	Original SEI (ha)	41.8	744.0	729.7	1323.8	24.6	357.2	1195.9	4416.9	772.4	3294.1	4066.53	8483.5
	Loss (ha)	0.0	4.9	130.9	27.1	0.0	21.1	21.6	205.6	3.3	303.2	306.5	512.1
	% Loss (ha)	0.0%	0.7%	17.9%	2.1%	0.0%	5.9%	1.8%	4.7%	0.4%	9.2%	7.5%	6.0%

Figure 6. Capital Sub-unit

Table 16. Loss by Municipality: Capital Sub-unit

Capital		Sensitive Ecosystems								Other Ecosystems			All
		CB	HT	OF	RI	SV	WD	WN	Total	FS	SG	Total	Total
Central Saanich	Original SEI (ha)	9.5	17.2	17.4	19.3	22.8	7.3	6.5	100.0	200.8	68.5	269.3	369.3
	Loss (ha)	0.0	0.8	0.0	1.4	0.0	1.2	0.5	3.9	0.0	6.4	6.4	10.3
	% Loss (ha)	0.0%	4.4%	0.0%	7.2%	0.0%	16.5%	8.3%	3.9%	0.0%	9.4%	2.4%	2.8%
Colwood	Original SEI (ha)	0.9	3.4	131.7	26.6	0.0	20.4	15.9	198.9	0.0	87.2	87.2	286.0
	Loss (ha)	0.0	0.0	1.9	0.0	0.0	0.0	0.0	1.9	0.0	8.1	8.1	9.9
	% Loss (ha)	0.0%	0.0%	1.4%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	9.2%	9.2%	3.5%
Esquimalt	Original SEI (ha)	4.5	7.6	4.2	0.0	0.0	14.2	0.0	30.5	0.0	0.0	0.0	30.5
	Loss (ha)	0.0	1.3	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.3
	% Loss (ha)	0.0%	17.5%	0.0%	0.0%	0.0%	0.0%	0.0%	4.3%	0.0%	0.0%	0.0%	4.3%
Highlands	Original SEI (ha)	1.9	184.5	134.9	14.7	0.6	343.9	55.1	735.5	7.1	1642.7	1649.8	2385.3
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.4	0.0	19.1	19.1	20.5
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.2%	0.0%	1.2%	1.2%	0.9%
Langford	Original SEI (ha)	0.0	109.4	162.7	62.0	0.0	286.7	34.7	655.4	0.0	1007.7	1007.7	1663.1
	Loss (ha)	0.0	1.0	0.0	0.0	0.0	11.6	1.5	14.1	0.0	106.4	106.4	120.4
	% Loss (ha)	0.0%	0.9%	0.0%	0.0%	0.0%	4.0%	4.4%	2.1%	0.0%	10.6%	10.6%	7.2%
Metchosin	Original SEI (ha)	73.7	230.3	657.8	52.1	3.4	149.7	49.8	1216.8	0.0	1511.5	1511.5	2728.4
	Loss (ha)	0.0	1.3	2.0	0.0	0.0	0.0	0.0	3.3	0.0	2.5	2.5	5.8
	% Loss (ha)	0.0%	0.6%	0.3%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	0.2%	0.2%
North Saanich	Original SEI (ha)	0.0	0.5	39.0	8.7	3.1	16.2	8.6	76.2	0.0	207.6	207.6	283.8
	Loss (ha)	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.0	2.0	2.0	2.6
	% Loss (ha)	0.0%	0.0%	0.0%	6.2%	0.0%	0.0%	0.0%	0.7%	0.0%	1.0%	1.0%	0.9%
Oak Bay	Original SEI (ha)	21.3	10.7	4.1	3.6	0.0	29.0	0.0	68.6	0.0	0.0	0.0	68.6
	Loss (ha)	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.7
	% Loss (ha)	3.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	1.0%
Saanich	Original SEI (ha)	26.7	53.8	334.1	19.5	1.7	198.9	98.9	733.6	110.3	393.7	504.0	1237.6
	Loss (ha)	0.0	0.8	2.7	0.0	1.5	16.9	0.7	22.5	0.0	12.2	12.2	34.8
	% Loss (ha)	0.0%	1.4%	0.8%	0.0%	93.0%	8.5%	0.7%	3.1%	0.0%	3.1%	2.4%	2.8%
Sidney	Original SEI (ha)	0.0	0.0	0.0	2.6	0.0	0.0	0.0	2.6	0.0	0.0	0.0	2.6
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sooke	Original SEI (ha)	0.0	16.7	5.9	15.6	0.0	0.0	16.4	54.6	0.0	313.0	313.0	367.6
	Loss (ha)	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.3	0.0	4.1	4.1	5.4
	% Loss (ha)	0.0%	0.0%	0.0%	8.1%	0.0%	0.0%	0.0%	2.3%	0.0%	1.3%	1.3%	1.5%
Victoria	Original SEI (ha)	4.9	18.1	2.7	0.0	0.0	21.8	1.3	48.8	0.0	0.0	0.0	48.8
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
View Royal	Original SEI (ha)	1.8	27.0	388.0	7.4	0.0	21.1	33.3	478.7	7.0	138.3	145.3	623.9
	Loss (ha)	0.0	0.0	4.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	4.0
	% Loss (ha)	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.6%
Unincorporated Areas	Original SEI (ha)	166.8	363.4	3149.4	149.6	6.5	47.2	217.5	4100.4	0.0	5384.5	5384.5	9484.9
	Loss (ha)	0.0	0.8	81.7	0.6	0.0	1.5	0.8	85.3	0.0	705.0	705.0	790.3
	% Loss (ha)	0.0%	0.2%	2.6%	0.4%	0.0%	3.2%	0.3%	2.1%	0.0%	13.1%	13.1%	8.3%
Total	Original SEI (ha)	312.1	1042.6	5031.8	381.7	38.0	1156.4	537.9	8500.5	325.2	10754.8	11080.0	19580.4
	Loss (ha)	0.7	5.9	92.2	3.8	1.5	32.6	3.5	140.2	0.0	865.9	865.9	1006.0
	% Loss (ha)	0.2%	0.6%	1.8%	1.0%	4.1%	2.8%	0.6%	1.6%	0.0%	8.1%	7.8%	5.1%

Figure 7. Islands Sub-unit

Table 17. Loss by Municipality: Islands Sub-unit

Islands		Sensitive Ecosystems								Other Ecosystems			All
		CB	HT	OF	RI	SV	WD	WN	Total	FS	SG	Total	Total
Denman	Original SEI (ha)	24.6	26.9	290.4	11.4	0.0	0.0	170.7	524.0	64.1	1094.4	1158.4	1682.4
	Loss (ha)	0.0	0.0	106.8	0.0	0.0	0.0	4.1	110.9	0.0	717.9	717.9	828.8
	% Loss (ha)	0.0%	0.0%	36.8%	0.0%	0.0%	0.0%	2.4%	21.2%	0.0%	65.6%	62.0%	49.3%
Gabriola	Original SEI (ha)	9.6	3.8	0.0	0.0	0.4	4.4	28.9	47.1	43.1	218.2	261.3	308.4
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0	34.0	34.0	34.8
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	1.7%	0.0%	15.6%	13.0%	11.3%
Galiano	Original SEI (ha)	8.7	14.8	36.8	0.0	1.3	151.0	48.0	260.7	5.1	1283.8	1288.9	1549.6
	Loss (ha)	0.0	0.0	2.7	0.0	0.0	0.0	0.0	2.7	0.0	184.1	184.1	186.8
	% Loss (ha)	0.0%	0.0%	7.2%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	14.3%	14.3%	12.1%
Hornby	Original SEI (ha)	2.1	26.6	104.6	0.0	15.1	16.6	1.0	166.0	14.5	572.6	587.2	753.1
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Jedediah	Original SEI (ha)	23.2	9.8	146.0	0.0	0.0	0.0	0.0	179.0	0.0	46.1	46.1	225.1
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Kuper	Original SEI (ha)	5.2	1.6	0.0	0.0	0.0	2.1	2.8	11.7	3.7	0.0	3.7	15.4
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Lasqueti	Original SEI (ha)	126.0	104.4	293.5	14.9	0.0	41.5	56.8	637.0	0.5	1506.8	1507.2	2144.3
	Loss (ha)	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	1.0	1.0	1.3
	% Loss (ha)	0.0%	0.0%	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%
Mayne	Original SEI (ha)	2.4	5.8	154.6	0.0	1.0	48.9	1.2	213.9	2.4	696.7	699.0	912.9
	Loss (ha)	0.0	0.0	11.3	0.0	0.0	1.4	0.0	12.7	0.0	61.3	61.3	74.0
	% Loss (ha)	0.0%	0.0%	7.3%	0.0%	0.0%	2.9%	0.0%	5.9%	0.0%	8.8%	8.8%	8.1%
Moresby	Original SEI (ha)	9.0	4.6	0.0	0.0	0.0	11.9	0.0	25.6	0.0	476.0	476.0	501.7
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%
Pender,	Original SEI (ha)	10.6	13.0	71.0	0.0	23.0	119.4	9.2	246.1	7.0	654.5	661.5	907.6
N&S	Loss (ha)	0.0	0.0	7.1	0.0	3.0	0.0	0.0	10.1	0.0	38.0	38.0	48.2
	% Loss (ha)	0.0%	0.0%	10.1%	0.0%	12.9%	0.0%	0.0%	4.1%	0.0%	5.8%	5.8%	5.3%
Portland	Original SEI (ha)	17.0	6.1	3.5	0.0	0.0	5.4	0.0	32.0	0.0	177.5	177.5	209.5
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Prevost	Original SEI (ha)	4.7	6.7	282.0	0.0	0.0	35.7	0.9	330.0	0.0	203.4	203.4	533.5
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	4.9	4.9
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	2.4%	0.9%
Saltspring	Original SEI (ha)	38.0	261.0	530.3	1.8	7.2	185.8	85.3	1109.4	85.4	4185.1	4270.6	5380.0
	Loss (ha)	0.0	1.2	14.8	0.0	0.0	2.5	1.6	20.2	2.3	266.9	269.2	289.4
	% Loss (ha)	0.0%	0.4%	2.8%	0.0%	0.0%	1.4%	1.9%	1.8%	2.7%	6.4%	6.3%	5.4%
Saturna	Original SEI (ha)	12.4	134.2	65.7	2.9	0.0	79.8	7.5	302.5	0.0	932.8	932.8	1235.3
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	13.0	13.0
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	1.4%	1.0%
Sidney	Original SEI (ha)	6.1	19.4	26.0	0.0	53.4	9.4	8.0	122.3	0.0	373.1	373.1	495.3
	Loss (ha)	0.0	0.0	26.0	0.0	0.0	0.0	0.0	26.0	0.0	73.7	73.7	99.6
	% Loss (ha)	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	21.2%	0.0%	19.8%	19.8%	20.1%
Thetis	Original SEI (ha)	8.6	0.9	2.1	0.0	0.0	7.8	24.3	43.6	7.1	11.5	18.6	62.3
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.3
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	4.3%	0.0%	0.8%	0.0%	0.0%	0.0%	0.5%
Valdes	Original SEI (ha)	32.1	5.6	22.0	5.5	0.1	1.5	16.8	83.8	0.0	855.4	855.4	939.1
	Loss (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	131.8	131.8	131.8
	% Loss (ha)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.4%	15.4%	14.0%
Other	Original SEI (ha)	278.9	37.6	234.8	0.0	34.7	177.6	30.3	793.9	0.0	1231.2	1231.2	2025.1
Islands	Loss (ha)	0.0	1.1	37.0	0.0	0.0	0.0	1.6	39.7	0.0	10.0	10.0	49.7
	% Loss (ha)	0.0%	2.9%	15.7%	0.0%	0.0%	0.0%	5.4%	5.0%	0.0%	0.8%	0.8%	2.5%
Total	Original SEI (ha)	619.3	683.0	2263.2	36.5	136.2	898.8	491.6	5128.8	232.9	14519.0	14751.8	19880.6
	Loss (ha)	0.0	2.3	205.7	0.3	3.0	4.3	8.2	223.6	2.3	1537.0	1539.3	1762.9
	% Loss (ha)	0.0%	0.3%	9.1%	0.8%	2.2%	0.5%	1.7%	4.4%	1.0%	10.6%	10.4%	8.9%

3.2 Limitations

In a small number of cases, photo quality issues or missing photographs caused situations where polygon disturbance could not be rigorously evaluated. Where the new imagery was missing or of insufficient quality, 'No Change' was assumed, and the fact that a thorough assessment was not possible was noted in the disturbance comments for that polygon. This was the case with 22 polygons. Where the original photo was unavailable or of poor quality, it was impossible to determine if disturbance present in the 2002 imagery was also present when the polygon was originally delineated. Assumptions were made regarding the state of the polygon in 1992 based on the nature, appearance and extent of the disturbance in 2002. In most cases, a conservative approach was taken and the assumption was made that the disturbance was new. Polygons were then categorized as 'Fragmented' or 'Disturbed' as appropriate. Polygons with small encroaching disturbances (such as trails or rural houses) may have been assumed to be 'No Change'. A total of 54 polygons were assessed in the absence of original photos.

The assessment of disturbance was done with two very distinct imagery sets. The majority of the study area was assessed using black and white 1:10,000 scale imagery, but a small area surrounding and including Lasqueti Island was assessed using colour imagery. It is possible that the polygons in the Lasqueti Island area were assessed more rigorously with respect to loss from fragmentation – as houses and cabins in forested areas were more readily detectable with the colour imagery. However, with respect to other more common and obvious forms of disturbance, such as clearcut logging, there were no perceived differences in identification ability between the two image types.

Where the disturbance areas were too small to be digitized, or were spread throughout a larger polygon, the polygon was classified with the degree of fragmentation (<6%, 6-25%), and notes were made regarding the type and extent of disturbance. No re-digitizing was done to these polygons. Polygons with >25% fragmentation were marked for deletion, and thus are included in the results figures. However, because no re-digitizing was done to the polygons showing <6% or 6-25% fragmentation, they are not included in the results figures. The 1521 fragmented polygons comprise almost 48% of the SEI study area. Although we cannot make concrete statements regarding area lost due to fragmentation, the fact that almost half of the ecosystems identified have some level of fragmentation suggests significant impact. These fragmentation figures help to illustrate the incremental but escalating degradation and loss of remaining natural areas. The area of disturbance may be relatively small, but the cumulative effects of incremental ecosystem loss must be considered.

4 References

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