Final Report – 2003/04

Rare and Sensitive Ecosystem Inventory Pilot Project

Weyerhaeuser, West Island Timberlands

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Introduction

The purpose of Sensitive Ecosystems Inventory (SEI), as stated on the SEI website (http://srmwww.gov.bc.ca/cdc/sei/) "is to identify remnants of rare and fragile terrestrial ecosystems and to encourage land-use decisions that will ensure the continued integrity of these ecosystems." The first SEI project completed in BC was for east Vancouver Island and the Gulf Islands (Ward et al. 1998); another was done in the Central Okanagan (Iverson and Cadrin 2003). A third SEI project is underway for the Sunshine Coast. The projects were collaborations between various partners, including the BC Ministry of Environment, Land and Parks, the Canadian Wildlife Service, Regional Districts and others. All three study areas are in highly developed landscapes with a mixture of urban, rural and forested ownerships; consequently, there were no comprehensive inventories of ecosystems. Because of development pressures, these areas contain few remaining natural ecosystems and a high proportion of BC's rare plants, animals and plant communities. SEI in these areas will provide a tool for local governments, landowners, developers and others to identify sites of high biological value in land use planning and decision making.

The West Island Timberlands Advisory Group, formed as part of CSA Certification, recommended that Weyerhaeuser conduct SEI for the TFL 44. The model and objectives for SEI mapping on the TFL are somewhat different than previous SEI projects because there is a single tenure holder, an existing GIS with Terrestrial Ecosystem Mapping (TEM), forest cover and other relevant data, and regulations requiring reserves for some of the ecosystem types in previous SEI inventories (e.g., riparian, wetland, old forest). A steering committee was formed with advisory group members and Weyerhaeuser staff to oversee a pilot project. The committee concluded that a pilot GIS project would determine whether or not the SFM plan objectives for conserving rare or sensitive ecosystems can be met with existing data.

Definition

"Sensitive" was defined in earlier inventories (Ward et al. 1998) as having one or more of these attributes:

- Rarity – either due to limited natural occurrence or as a result of human activities
- Fragility – sensitivity to disturbance that could lead to decline or loss of ecosystem health or integrity
- High biodiversity – high species richness
- Specialized habitats – unique microhabitats; presence of rare or endangered species or communities

For this project, we used a combination of previous SEI project categories and those rare natural plant communities on the BC Conservation Data Centre tracking lists (Red and Blue) to define a single GIS map layer.

Objectives

1. To provide a single data source for use in planning that will ensure that rare or sensitive ecosystems are considered.
2. To meet the WIT SFM plan commitment to "complete an inventory of high conservation value areas".
3. To identify any gaps in the current inventory of rare and sensitive ecosystems that need to be filled with additional aerial photo or field work.
4. To help fulfill the SFM Objective (4) under the Conservation of Biological Diversity Criteria: "Maintain representative red- and blue-listed plants and plant communities".

Methods

A rare and sensitive "theme" was created in Weyerhaeuser's GIS for identifying areas with high conservation value. The layer was built by extracting data from existing GIS coverages. The primary data sources were:

1. **Terrestrial Ecosystem Mapping (TEM).** This mapping is now complete for all areas of TFL 44. All projects were done at 1:20 000 scale on the TRIM (NAD 83) base, and follow the provincial Resource Inventory Standards Committee (RISC) mapping and database standards (Survey intensity level 4). TEM maps show site series, site modifiers (e.g., shallow soil, cool aspect) and seral stage. Other products include: a terrain map showing surficial materials, slope class and drainage; a project report describing the ecosystems for the mapped area; and a plot database.
2. **Forest Cover (FC).** This coverage includes the age class and species composition of forested areas, rock outcrops, "swamps" and other sparsely vegetated features.
3. **BC Conservation Data Centre (CDC).** Tables listing the "red and blue lists" of threatened, endangered or vulnerable plant communities.

Procedures were developed in 2002/03 using a portion of TFL 44 for which TEM mapping was available (approximately 165k ha) to produce preliminary maps. We consulted with Carmen Cadrin at the CDC on methodology, and reviewed the draft standards (RISC 2002). Once the process for building the rare and sensitive ecosystem theme was documented and tested, we conducted field surveys in 2003 on four 1:20,000 map sheets. The results of field tested were used to revise the GIS procedures and update specific map units. Final maps were then produced for all of TFL 44 (over 277k ha).

Legend

We built a map of sensitive and rare features with an explanatory legend that includes categories from previous SEI projects (wetland, herbaceous, etc.) as well as Provincial and landscape rarity. We created a working legend that specifies the categories and sub-categories of ecosystem types, and identifies the data sources and specific attributes that were used to populate the category. The final legend is shown in Table 1. We used the more recent Sunshine Coast SEI category definitions, with some modifications from the C. Okanagan project and additional

units relevant to our study area (e.g., alpine, estuaries). Because the "old forest" category (areas where the average tree age is 250 years or more) used in previous SEI projects was already defined on both our TEM and FC layers, we displayed only old forest that occurred within red- and blue-listed ecosystems. For the Riparian category, we showed only low, medium and high bench floodplain ecosystems. The scale of mapping did not allow definition of all areas that are considered riparian (such as small streams, unmapped at 1:20 000).

Each category used the best available data in the current GIS. For example, for the wetland category we used a combination of ecosystems defined by TEM (such as buckbean-sedge fens) and undifferentiated wetland areas classified as "swamp" in the FC layer. Where there was overlap for a feature on the TEM and FC layers, we used the more specific detail to define a sub-category. The "classes of type" in the FC coverage were used to define some specific categories. For the initial pilot, we also used data from 1:5000 scale mapping, where it was available, to improve our identification of wetlands and sparsely vegetated ecosystems. As a result of field surveys we decided that it was inappropriate to mix the 1:5 000 data as part of the 1:20 000 SEI coverage.

Red- and Blue-listed Plant Communities

TEM units that correlated with the Conservation Data Centre Rare Plant Community Tracking List (vulnerable, threatened or endangered) were included in the Provincial rarity category. There are 40 Red-listed and 26 Blue-listed plant communities in the South Island Forest District. Specific locations of listed plants and plant communities will be kept on a separate layer where these data are available from the CDC or local naturalists. This will be particularly important for the 14 plant communities in the CDC listing that are not described as site series in the biogeoclimatic classification (Green and Klinka 1994), so they will not be shown in TEM.

Landscape Rarity Classes

In addition to the Provincial Red- and Blue-listed plant communities, we created a local "landscape rarity" sub-category within the Rare Community (RC) category. Landscape rarity was defined as site series or other ecosystems that collectively represent 2% of the Defined Forest Area (DFA) of TFL 44. This amounted to 120 ecosystem units, each of which had a total area less than 210 ha. We subdivided these ecosystems into three rarity classes based on their total area as follows:

la 1 – less than 10 ha (51 units)
la 2 – 10 ha to 50 ha (30 units)
la 3 – 51 ha to 210 ha (39 units)

To put these rarity classes in perspective, within the 277k ha of TFL 44 there are 195 ecosystem units (excluding man-made features; lakes, rivers and beaches; and coding errors). The rare ecosystems occupying 2% of the landscape represent over 60% of the units. The 10 most common site series represent 61% of the TFL area, while the remaining 37% of the area consists of 65 ecosystem units, only four of which represent more than 2% of the area (2% = roughly 5,500 ha).

GIS Procedures

Detailed procedures that were used for creating the Sensitive Ecosystem Inventory are given in Appendix I, as revised after field surveys. The basic steps are summarized as follows:

1. Identify potential data sources for the Codes and Subcodes in the working legend.
2. Assemble and confirm source data (TEM, 1:20000 Forest Cover, Hydro, Slope).
3. Establish hierarchies for data presentation.
4. Develop AML programming to automate the assembly of data for the subcodes in each legend category.
5. Prepare the TEM component for overlay.
6. Prepare the 1:20000 forest cover component data for overlay using AML and manual procedures.
7. Prepare the Hydro component data (lakes and coastline buffers) for overlay using AML and manual procedures.
8. Prepare the Slope component data for overlay (reclassification and conversion of grid or raster data to polygon covers).
9. Compile the final SEI polygons.
10. Develop a thematic mapping template.
11. Document SEI cover metadata and procedures.

The detailed procedures in Appendix I will allow duplication of the process for creating the SEI coverage for other areas using existing TEM, Forest Cover and other GIS layers.

Field Surveys

The objectives of the field verification conducted by Shearwater Mapping in September 2003 were to:

- Confirm the map unit sub-categories for the sparsely vegetated, wetland and cliff polygons;
- Classify undifferentiated wetland polygons;
- Verify polygons containing red-listed or blue-listed site series that were not visited during TEM;
- Verify the site series classification for polygons in the landscape rarity classes.

Checking of SEI polygons consisted of a combination of air photo interpretation, ground visits and helicopter reconnaissance. Four 1:20,000 mapsheets were chosen for field work, two each in project areas done by C.E. Jones (Sproat-Great Central - 92F025, 92F035), and Shearwater Mapping (Klanawa-Sarita – 92C76, 92C085).

The contractor provided:

- A report describing methodology, results and recommendations (Appendix II – separate report);
- A spreadsheet identifying SEI polygons that require editing, showing existing data and proposed changes, and data for any proposed new units.
- Annotated hard copy maps or photos, clearly showing polygon boundary changes or new units.

Shearwater Mapping checked a total of 410 SEI polygons: 260 in the field, 111 with photo interpretation, and 39 with previous TEM plot data. Over 73% (301 polygons) of the SEI units assessed were deemed correct or required only minor modifications. Of the 95 polygons rejected, most were deemed too small to be captured on the 1:20 000 maps, or had classification errors.

To improve the final SEI coverage, we corrected the TEM (site series) labels for 33 of 143 polygons for which the original TEM polygon comprised the entire SEI polygon. We did not update TEM for those SEI units that represented only a portion of the original TEM unit because the entire TEM polygon was not visited in the field. Changing only a portion of the polygon could alter the proportions of the site series in rest of the original unit—potentially introducing errors. We omitted 1:5 000 Forest Cover source data from the final maps because it was deemed to be too detailed for the 1:20 000 planning scale. We also subdivided the herbaceous “hb” category into three subclasses based on the actual amount of rock outcrop within the polygon.

Results

This project completed SEI maps for 277,134 ha of TFL44 based on TEM mapping and forest cover. For ease of viewing without the need for ArcInfo software, PDF files were prepared of each map (see accompanying CD).

For ease of future updates, we did not incorporate data for known locations of red- and blue- listed species or ecosystems into the SEI coverage. This information will be maintained in the GIS as a separate coverage that can be updated annually with new data from the Conservation Data Centre.

The SEI coverage will be a useful addition to the GIS map base for operational planning. We did not incorporate any specific site information from local naturalists as originally planned. Local knowledge of rare or sensitive sites is an important addition to the SEI coverage that should be addressed as soon as possible.

Literature Cited

Green, R.N. and K. Klinka. 1994. A field guide to site identification oand interpretation for the Vancouver Forest Region. BC Min. Forests, Victoria, BC, 285 pp.

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Resources Information Standards Committee. 2002. Standards for Rare and Sensitive Terrestrial Ecosystem Mapping in British Columbia. Draft methodology, Victoria, BC.

Ward, P., G. Radcliffe, J. Kirkby, J. Illingworth and C. Cadrin. 1998. Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands 1993 - 1997. Volume 1: Methodology, Ecological Descriptions and Results. Technical Report Series No. 320, Canadian Wildlife Service, Pacific and Yukon Region, BC, 146 pp.

Table 1. Rare and Sensitive Ecosystem Categories - Legend

Category	Code	Subcode	Description	Data Source
Cliffs	CL		**Steep slopes, often with exposed bedrock.**	
		cc	coastal cliffs	Slope Grid, TEM
		ic	inland cliffs	Slope Grid
Sparsely Vegetated/ Herbaceous	SV/HB		**Non-forested ecosystems with <10% tree cover. Most have shallow soils and bedrock outcrops**	
		hb	Herbaceous: a mix of grasses and forbs as well as mosses and lichens	TEM, Forest Cover
		cs	Coastal herbaceous: windswept shorelines and slopes influenced by proximity to the ocean	TEM, Forest Cover
		sp	Spit: sand and gravel deposits with low to moderate cover of grasses and herbs	TEM
		du	Dunes: sand dunes with low cover of grasses and herbs	TEM
		sh	Shrub: shrubs account for more than 20% of the vegetation	TEM, Forest Cover
		ta	*Talus slopes*	TEM, Forest Cover
		ap	*Alpine*	TEM, Forest Cover
Wetland	WN		**Areas characterized by daily, seasonal or year- round water at or over the surface.**	
		bg	Bog	TEM
		fn	Fen	TEM
		ms	Marsh	Subcode not used
		sp	Swamp	TEM
		sw	Shallow water	TEM, Hydro
		wm	Wet meadow	Subcode not used
		es	*Estuary*	TEM
		un	*Undifferentiated wetland*	Forest Cover
Riparian	RI		**Streamside areas along creeks, streams, and larger floodplains**	
		fl	low bench: areas flooded at least once every 2 years for part of the growing season	TEM
		fm	medium bench: areas flooded every 1 - 6 years for short periods; usually deciduous or mixed	TEM
		fh	High bench: areas periodically and briefly inundated by high waters; typically conifer-dominated	TEM
		ff	Fringe: narrow, linear areas along open water bodies (rivers, lakes, ponds)	Subcode not used
		gu	Gully: watercourse in a steep V-shaped gully	Subcode not used
Woodland	WD		**Dry, open stands of woodland, generally with between 10 - 25% tree cover**	
		co	Conifer-dominated	Subcode not used (none ident.)
		mx	Mixed conifer - deciduous	TEM
Rare Communities	*RC*		***Rare plant communities in the CDC tracking list, or site series of rare occurrence within the DFA***	
		rl	*Red-listed*	TEM, CDC Red list
		bl	*Blue-listed*	TEM, CDC Blue list
		la	*Landscape rarity - within the DFA (TFL44)*	TEM, Rarity analysis

Categories follow the Sunshine Coast SEI definitions, with additions in italics For details on data sources and GIS procedures see Appendix I.

APPENDIX I

Weyerhaeuser
Sensitive Ecosystem Inventory
West Island Timberlands

GIS Procedures

prepared
for

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1. Introduction

As part of the CSA Certification process for West Island Timberlands, as decided by the West Island Timberlands Advisory Group, a Sensitive Ecosystem Inventory (SEI) pilot project was undertaken to develop a GIS data model to help identify rare and/or sensitive ecosystems within TFL 44. A key to the project was the use of existing Weyerhaeuser GIS data components as the source data for the inventory. These included: Terrestrial Ecosystem Mapping (TEM) data, 1:20,000 and resolution forest cover data, hydrology data, and reclassified slope grid data. Other data sources used included B.C. Conservation Data Centre rare listed plant communities in tabular format.

A working legend was first created to determine the SEI categories for the final data model (Table 1). More importantly for the GIS, classification criteria were also developed for each category to determine the data component for each and the spatial relationships among data components to be used. GIS procedures were used to analyze these complex spatial relationships with the intended result of a single data model and associated thematic mapping to help identify sensitive ecosystem areas.

This paper is intended to summarize the GIS data and procedures used in the SEI project and to provide a framework and critical discussion for GIS applications to similar projects in other areas. A full report on the SEI pilot project is available from Weyerhaeuser, Timberlands Services.

2. SEI Classification and Associated Source Data

This section will cover the process of selecting the GIS data for the project and its' use in the reporting of each SEI category; an outline of the categories followed by a description of the GIS data chosen will be discussed.

To determine the data to be used for the GIS element of the project it was first necessary to look at each category, its' components, and the data expected by the advisory group. The GIS technician met with the Weyerhaeuser forestry ecologist at Timberlands Services, to develop a clear understanding of the categories and how they may relate to existing GIS data sets. This also provided the forestry ecologist with a better understanding of the GIS components and their suitability in defining each category. As a result, criteria were developed for each category of the SEI that was then used as a basis for the construction of the final model.

The following sections provide a brief discussion of the SEI categories and the source data from which these categories would be derived.

2.1 Sensitive Ecosystem Inventory Classification

The following table outlines the categories of the SEI. Included is a description of each category and associated subcodes. The code is the general SEI category while the subcodes identify specific features that occur within each category. It should be noted that these categories and associated subcodes represent a complete list of possible features. Specific codes and subcodes will occur in the data for a given area depending upon the composition and availability of the source data for that area. For this pilot all categories and subcodes were not represented in the final data.

Table 2.1 shows the SEI categories along with description of each subcode that makes up that category.

Table 2.1
SEI Categories

Category	Code	Subcode	Description
Cliffs	CL		**Steep slopes, often with exposed bedrock.**
		cc	coastal cliffs
		ic	inland cliffs
Sparsely Vegetated / Herbaceous	SV/HB		**Non-forested ecosystems with <10% tree cover. Most have shallow soils and bedrock outcrops**
		hb	Herbaceous: a mix of grasses and forbs as well as mosses and lichens
		cs	Coastal herbaceous: windswept shorelines and slopes influenced by proximity to the ocean
		sg	Spit: sand and gravel deposits with low to moderate cover of grasses and herbs
		du	Dunes: sand dunes with low cover of grasses and herbs
		sh	Shrub: shrubs account for more than 20% of the vegetation
		ta	Talus slopes
		ap	Alpine
Wetland	WN		**Areas characterized by daily, seasonal or year-round water at or over the surface.**
		bg	Bog
		fn	Fen
		sp	Swamp
		sw	Shallow water
		es	Estuary
		un	Undifferentiated wetland
Riparian	RI		**Streamside areas along creeks, streams, and larger floodplains**
		fl	low bench: areas flooded at least once every 2 years for part of the growing season
		fm	medium bench: areas flooded every 1 - 6 years for short periods; usually deciduous or mixed
		fh	High bench: areas periodically and briefly inundated by high waters; typically conifer-dominated
Woodland	WD		**Dry, open stands of woodland, generally with between 10 - 25% tree cover**
		mx	Mixed conifer – deciduous
Rare Communities	RC		**Rare plant communities in the CDC tracking list, or site series of rare occurrence within the DFA**
		rl	Red-listed CDC

		bl	Blue-listed CDC
		la1/la2/la3	Landscape rarity - within the DFA (TFL44)

2.2 Source Data

The following is a summary of the GIS data that was selected as a component of the SEI categories as discussed in the previous section. All SEI polygons originated from existing Weyerhaeuser data used for operational and strategic planning. All covers are double precision NAD83 datum with an Alber's projection. Data sources within Weyerhaeuser may vary and are noted. A data dictionary is available from the GIS department documenting each of the standard Weyerhaeuser coverages discussed here.

As mentioned, the SEI component data consisted of Terrestrial Ecosystem Mapping (TEM) polygons, 1:20,000 resolution forest cover polygons, hydrology polygons, and reclassified slope grid polygons. Other data components included B.C. Conservation Data Centre rare listed plant communities in tabular format, and buffer zones generated along coastlines. All data sets were clipped to the project boundary, in this case TFL 44. No spatial data falling outside the project area was used.

As only specific spatial features from each source data set were needed, each of these components was prepared separately. Once the components for each of the source data were set, all were combined and coded based on their relationships set out in accordance with the criteria developed for the SEI features.

The following sections include further detail on the source data used and provide supporting information to the selection of this data for use in the SEI project. Table 2.2 summarizes the spatial source data used, the SEI subcodes that each source feature is a component of and the location of the source data within Weyerhaeuser.

Table 2.2
Spatial Source Data Summary

Data	Type	SEI Subcodes	Location
TEM	SDE	cc, hb, cs, sg, du, sh, ta, ap, bg, fn, sp, sw, es, un, fl, fm, fh, rl, bl, la	BCCGSDE
1:20000 Forest	SDE	un	BCCGSDE
Hydro	SDE	cc	BCCGSDE
Slope	ArcInfo GRID	cc, ic, cs	\\nanagissvr01\stat\grid_20k

It should be noted that while the final data recognizes sensitive ecosystems, the only source data that actually contains identifiable ecosystems is the TEM data. The ecosystems can be identified by the combination of the biogeoclimatic zone, sub zone and variant in combination with the site series or map code values in the TEM database.

2.2.1 TEM

All of the SEI categories, except for 'inland cliffs' utilized the TEM biogeoclimatic zones, site series, and mapcodes as a component. Especially dependant on this data set is the 'Rare Communities' category. This includes the CDC red and blue listed sub codes as well as the landscape rarity sub codes all of which are derived directly from the TEM biogeoclimatic zone and site series classifications.

Currently, the TEM data for TFL 44 covers mainly the western portion - Sproat Operation with limited data available for eastern areas – Franklin Operation. Mapping for the remaining areas is in progress and when available will have a definite impact on the SEI data. There is currently no red list, blue list areas in the SEI data for these missing portions and the landscape rarity analysis is based strictly upon the existing TEM data. The SEI should be regenerated once this new mapping is received

Due to the stratified composition of the TEM data (up to three different ecosystems features per polygon) this data had to be approached with a different strategy than other components. It was necessary to select the ecosystem with the highest representation within the polygon that satisfied the SEI criteria for any specified sub code. For example, if both the first and second strata in a selected TEM polygon satisfied the criteria for two different sub codes, the strata, in this case the first, representing the highest proportion of that polygon would be used. The proportion of each ecosystem in a TEM polygon is determined by the SDEC_1, SDEC_2, and SDEC_3 attributes in the TEM database.

As the rare community subcodes were deemed to be of utmost importance, it was decided that a hierarchy of the subcodes would also have to be implemented for those TEM polygons that contained rare community ecosystems in one of the strata. For example, if one of the strata of the TEM polygon satisfied the criteria for a red listed plant community but was representative of only 10% of the polygon it was still classified as a red list subcode instead of the higher proportion subcode not in the rare communities. The hierarchy was determined to be red list, blue list, landscape rarity within the rare communities and then any other subcode that made up the highest proportion of the TEM polygon.

To ascertain the rare landscapes within TFL 44, a landscape rarity analysis was performed on the TEM information. This was done by looking at each unique ecosystem occurring within the TEM data and totaling the area for those ecosystems. Grouping the ecosystems with the least representation across the study area developed three landscape rarity classifications.

While not specifically spatial data, red list, blue list, and rare landscapes were compiled into lookup tables to assist in the coding of the TEM data. Due to the extensive list and the dynamic nature of these rare and endangered plant communities/ecosystems it was necessary to have these lookup tables as additional source of information for the TEM component of the SEI classification.

It should be noted that red and blue listed plant communities with a site unit of '00', while included in the lookup table, could not be identified from the TEM

data. This is due the fact these '00' codes have no associated map codes in the TEM data.

2.2.2 Forest Cover - 1:20,000 Resolution

This component was used for the collection of undifferentiated wetland features. It was also a key component of the red and blue listed feature of the SEI. Only ecosystems identified on the CDC list that occur within 'old growth' forest are considered for the red and blue list.

The STANDS database associated with this cover was necessary for determining areas of old growth forest. This database contains detailed information (e.g. species, age, etc.) for each polygon in the forest cover. This database was joined with the spatial component before the data was used in the analysis. As the last inventory on the 1:20,000 forest cover was performed in 1995, it was necessary to update the age to reflect the current year of the SEI.

In association with the age updates, harvested stand areas from 1995 – 2004 were removed to reflect current landscape conditions to more accurately identify the red and blue list classifications.

2.2.3 Hydro

The hydro cover component was used for determination of coastal features within the SEI. A buffer was established along coastal shoreline using the coastal shoreline line work from this data source. Coupled with the slope data this information was used for the inland cliff ('ic') and coastal cliff ('cc') classifications.

2.2.4 Slope

The slope component of the SEI was used as a quick way to determine ecosystems that are unique due to their topography. These included areas such as cliffs and certain slopes adjacent to coastal waters.
As the other data components were in vector format, this data it was necessary to reclassify it to match the SEI criteria and convert to polygons to allow for overlay with the other source components.

3. Source Data Procedures

This section discusses the preparation of the GIS data for the Sensitive Ecosystem Inventory. As mentioned, the approach was to generate preliminary data from the individual source components of the SEI that encompass features necessary to determine the subcode classifications. Once prepared these components were then combined, their relationships analyzed, and the SEI features coded based upon those relationships.

To accomplish this, AML programming was undertaken to automate the process as much as possible to reproduce the data quickly if changes to the criteria were necessary. Table 3 lists these AML programs and the data they are intended for. Each program contains comments to help determine the program flow and any additional requirements or information specific to that AML. Several programs are listed that were not developed specifically for this project but were used in support of the processing.

Table 3
SEI AML Programs

Name	Source Data	Comment
append.aml*	Slope GRID	Appending individual covers – slope, 1:5000 forest polygons
buffer_coast.aml	Hydro	Buffer coastline features
grid_sei_all.aml	Slope GRID	AML that feeds list to grid_sei_operation.aml
grid_sei_operation.aml	Slope GRID	Reclassifies GRIDs and exports to polygon
prep_20k.aml	1:20000 Forest	Creates cover containing 1:20000 forest components coded for overlay
prep_sei.aml	All Sources	Generates final SEI polygons coded from component layers
prep_tem.aml	TEM	Creates cover containing TEM polygon components coded for overlay
stand_age.aml*	1:20000 Forest Stand Database	Updates forest stand ages based upon current year and inventory year
tem_rarity.aml	TEM	Summarizes each unique ecosystem for use in the landscape rarity analysis within the study area

* Not project specific

The following sections will describe the procedures used in the preparation of the component data. The descriptions are intended for GIS technicians and will describe the operations performed using GIS terminology. All commands associated with the data processing will not be described in this section but can be found in the associated AMLs. It is assumed that these AMLs will serve as a basis for, and be applied to, any further SEI data preparation.

ArcInfo covers, databases, INFO files, look-up tables, AMLs and attributes will be typed in bold to help identify these items in the procedures. All of the source data was kept in its' original format by copying to working covers before any structural changes occurred. These working covers are not described but their use and purpose is documented in each AML program.

3.1 TEM

Two separate procedures were developed for preparing the TEM data for use in the SEI. The first involves developing the list of rare ecosystems within the TEM landscape and the second is using that list to identify, code and separate the TEM polygon components to be used in the SEI. The **tem_rarity.aml** and **tem_prep.aml** were created to accomplish this task.

The following procedures were used to prepare the TEM component for overlay:

1) The **tem_rarity.aml** was run to summarize the area of each unique ecosystem (identified by the combination of **bgc_zone**, **bgc_subzon**, **bgc_vrt** and site series component within each **ecp_dbase** record as mentioned in Section 2.2) within the TFL 44. The results were tabulated and grouped into three landscape rarity classes of 0-10 hectares, 11-50 hectares, and 51-210 hectares combined of the total study area. The **rarity.xls** contains a listing of these unique ecosystems;

2) These results were then manually combined with the CDC list of red and blue listed plant community ecosystems. Any duplicates were removed. Added to this list were the TEM ecosystems identified in the SEI component criteria (see Appendix 1 for the more details). Each ecosystem was then given a SEI sub code that would be used to later identify to which SEI category the ecosystem belonged. The resulting **tem_component.dbf** was used as the lookup table for the TEM coding. As noted, there were CDC red and blue list ecosystems with '00' site units that could not be accounted for in the TEM data. This was due to the fact that they could not be given the two letter map code values for '00' site units as they were unrecognized ecosystems and lack government identified map codes.

3) Using the **tem_prep.aml**, this layer and associated **ecp_dbase** table were exported from BCCGSDE into an ArcInfo cover and INFO file respectively. The **bgc_vrt** field from the database was defined from binary integer to integer to help facilitate concatenation as will be explained in the following procedures. The database was then joined to the cover using the **ecp_mb** attribute item. The **tem_component.dbf** was converted to INFO;

4) Additional attributes were then added to the polygon attribute table, **.pat**, to structure the data in preparation for overlay and SEI coding. The items, definition and descriptions are as follows:

```
vrt     1 1 c 0
variant1    10 10 c 0
variant2   10 10 c 0
variant3   10 10 c 0
subcode1   3 3 c 0
subcode2   3 3 c 0
subcode3   3 3 c 0
tem_subcode  10 10 c 0
source_tem   10 10 C 0
```

The **vrt** attribute was used to store the **bgc_vrt** value. If the **bgc_vrt** were left as binary integer it could not be copied to the **vrt** attribute and still used in concatenation. The **vrt** attribute needs to be blank for '0' values after concatenation to link to the look-up table containing the CDC and rare ecosystems, so it is present to store a character value for '0' which can then be changed to a null character field thus eliminating the '0' value in the concatenation process. If not done, those records with a bgc_vrt of '0' would not relate to the look-up table values.

The **variant1**, **variant2**, and **variant3** attributes were added to place the ecosystem values from the **ecp_dbase** (concatenation of the **bgc_zone**, **bgc_subzon**, **bgc_vrt** and **sitemc_s<n> or site_s<n> value**); the **subcode1**, **subcode2**, and **subcode3** attributes to store each ecosystem's SEI sub code. The **tem_subcode** attribute was made available to store the dominant TEM sub code value as mentioned in Section 2.2.1 and the **source_tem** attribute the value of 'TEM' to help identify TEM component polygons after the final component overlay;

5) The population of the added 'variant' attributes were performed in INFO through concatenation and the **source_tem** attribute coded with 'TEM';

6) The TEM data was clipped to the TFL 44 boundary that corresponded with the study area boundary. The clip cover was called **ten_bndry** and was the TFL 44 boundary used in the Management Plan 4;

7) Each unique ecosystem identified in the **tem_component.dbf** was compared to the TEM data 'variant' attribute ecosystems. Matching ecosystems in the TEM data were given a 'sub code' attribute value from the **tem_component.dbf** corresponding to that ecosystem. These 'sub code' attributes were then compared within each record to determine the dominant TEM sub code. This dominant sub code was then placed in the **tem_subcode** attribute;

8) Polygons within the TEM data coded as SEI component ecosystems were then copied to a TEM component cover and extraneous attribute items were removed. The cover was then cleaned to build polygon topology. The final component cover was called **tem_sei**.

3.2 Forest Cover - 1:20,000 Resolution

This section describes the procedures to prepare the 1:20000 forest cover component of the SEI inventory. The following outlines those procedures:

1) The **prep_20k.aml** was run to first extract the 1:20000 forest inventory from the BCCGSDE layer **forest20k**. It was discovered that the **forest20k** layer could not be directly extracted using the SDE commands for ArcInfo, due probably to the setup of the layer in the geodatabase, so this step had to bypassed and the layer exported manually to a cover through ArcCatalogue. The resulting cover was then joined to the **stands** database, also exported from BCCGSDE, using the **ind** item;

2) Additional attributes were then added to the polygon attribute table, **.pat**, to structure the data in preparation for overlay and SEI coding. The items, definition and descriptions are as follows:

```
age_cur   2 5 b 0
subcode_20k 3 3 c 0
type_forest  10 10 C 0
source_20k   10 10 C 0
```

The **subcode_20k** attribute was added to store each feature's SEI sub code, while the **type_forest** attribute was added to store a description of the features (i.e. the attribute = 'SWAMP', etc.) The **source_20k** attribute stored the value of 'FOREST_20K' to help identify 1:20,000 polygonal forest cover component polygons after the final component overlay, and the age_cur field was used to calculate both current stand ages for identifying 'Old Growth' forest critical to the capture of red and blue listed SEI polygons;

3) The **stands_age.aml** was run on the component data to update the **age** attribute to **age_cur** which reflected the stand age based on the current year not the age at inventory;

4) The data was then clipped to the TFL 44 boundary that corresponded with the study area boundary. The clip cover was called **ten_bndry** and was the TFL 44 boundary used in the Management Plan 4;

5) Using the **class** and **age_cur** attributes, each feature component matching the SEI criteria, was copied to the final 1:20,000 forest component cover. The following is a list of the **class** and **age_cur** values chosen to represent the features from this cover:

```
class = 30     /* Swamp
age_cur ge 251 /* Old Growth
```

6) These features were then coded in INFO with the appropriate SEI sub code using the **subcode_20k** attribute and **source_20k** attribute coded with 'FOREST_20K'. The **type_20k** attribute was coded to store a description of the component features (i.e. **type_20k** = 'OLD GROWTH', 'SWAMP', etc.);

7) This information was then clipped using the depletion layer (harvested blocks from 1995 – 2004) to quickly update the forest inventory to reflect current landscape conditions.

8) Extraneous attribute items were removed. The final 1:20,000 forest cover polygon component was called **for20k_sei**.

3.3 Hydro

This section describes the procedures to prepare the hydro component of the SEI inventory. The hydro component consisted of buffered linear coastline features. The coastal buffers were generated through a combination of the buffer_coast.aml and manual procedures.

The following were the procedures used to create the coastline buffers:

1) Polygons from the **hydro** cover with a **hydro_type** = 2 (saltwater) were selected and copied to the cover **coast**;

2) Using the **buffer_coast.aml**, these coastal features were then buffered for line by 10m;

3) The resulting buffer data was then erased using the original saltwater polygon cover **coast** to remove portions of the buffer overlapping coastal waters;

4) An additional attribute, **type_buffer** was then added to the polygon attribute table, **.pat**, to structure the data in preparation for overlay and SEI coding. Areas that had a value of **inside** = 100 were then given a value of 'COAST' for the **type_buffer** attribute.

3.4 Slope

As mentioned, the production of the slope component of the SEI involved the reclassification and conversion grid, or raster data, to polygon covers for overlay with the other polygon components. The **grid_sei_all.aml** was used to pass a map sheet list to the **grid_sei_operation.aml** containing the necessary commands to process the data. The procedures used to prepare the slope component of the SEI inventory were as follows:

1) Each individual slope percentage grid (**slopep**) was first reclassified to satisfy the SEI criteria. The percentage values were grouped into 0-30, 31-173, and 174 and greater and given **grid-code** values of 1,2, and 3 respectively.
2) The grids were then converted to polygon covers.
3) Additional attributes were then added to the polygon attribute table, **.pat**, to structure the data in preparation for overlay and SEI coding. The items, definition and descriptions are as follows:

```
type_slope   3 3 c 0
source_grid  10 10 C 0
```

   The **type_slope** attribute was added to store a description of the features (i.e. **type_slope** = '0-30 PCT'). The **source_grid** attribute stored the value of 'GRID_20K' to help identify grid component polygons after the final component overlay;

4) Each grid was appended into the **slopep_cls** cover that was then cleaned for polygon, and dissolved.
5) The data was then clipped to the TFL 44 boundary that corresponded with the study area boundary. The clip cover was called **ten_bndry** and was the TFL 44 boundary used in the Management Plan 4;

4. Sensitive Ecosystem Inventory – Final Preparation

The final preparation of the SEI dataset will be discussed in this section. The procedures outlined here are all contained in the **prep_sei.aml**. The final data set is comprised of a combination of all the SEI component data discussed in the previous sections. This resulted in a data set where the SEI criteria for a specific area may have been met by several component layers.

The relative importance of the input components as well as their relationship to each other was used in final definition of the SEI features. For example, while several components may be represented in one area, the SEI sub code and final source information was dictated by the most relevant/important component within that area. Information on the lesser component was maintained in the data as it was deemed useful if refinement of the data or additional analysis were necessary.

The following procedures were performed for the compilation of the final SEI polygons:

1) The first step was to overlay all of the source component covers to one data set. These included: **for20k_sei, slopep_cls**, **coast_b**, **tem_sei**;
2) Because of the hierarchical structure of the classes, duplicate variants were removed when compiling the lookup table **tem_component.dbf** (see Section 3.1) where landscape rarity class variants were the same as those for the red and blue listed ecosystems. These codes needed to be introduced back into the data after determining where the 'Old Growth' forest was present (a requirement for the red and blue list). This was done by comparing the **rarity.dbf** variants with variants in the TEM data that fell outside the 'Old Growth' areas. In polygons where the **variant1**, **variant2**, or **variant3**

attributes matched the appropriate rarity variant in the **rarity.dbf** the landscape rarity subcode were entered into the **subcode1**, **subcode2** or **subcode3** attribute. These 'sub code' attributes were then compared within each record to determine the dominant TEM sub code. This dominant sub code was then placed in the **tem_subcode** attribute;

3) Additional attributes were then added to the polygon attribute table, **.pat**, to structure the data in preparation for the final SEI coding. The items, definition and descriptions are as follows:

```
sei_variant 10 10 c 0
code      5 5 c 0
subcode   3 3 c 0
source  10 10 c 0
```

The **sei_variant** attribute was used to store the dominant **TEM** ecosystem value from the **variant1**, **variant2**, and **variant3** attributes of that source data. Polygons not from a **TEM** source will have this attribute left unpopulated. The **code** and **subcode** attributes were used to store one of the coded values of the six SEI categories and the sub code values within those six categories as shown in Table 2.1. The **source** attribute stored the source values of the component data;

4) Each stratified component cover polygon was then classified into the appropriate SEI using INFO, based upon the relative importance of all the source data for that polygon. Using reselections, the source was determined, and the SEI **subcode** and **source** data values were populated using the chosen component information (e.g. the **subcode_20k**, **source_20k** values if the 1:20,000 data fulfilled the SEI criteria for that specific polygon, etc.). The **code** attribute was then populated based on the associated **subcode** value. The following is the reselection code from the **prep_sei.aml** used to determine the final SEI polygon coding and is highlighted here to show the hierarchical structure of the source data s it relates to the SEI features:

```
/* Bulk populate of basic subcodes, source
SEL TEMP_SEI.PAT
 RESEL TEM_SUBCODE = 'rl1' OR TEM_SUBCODE = 'rl2' OR
TEM_SUBCODE = 'rl3' OR TEM_SUBCODE = 'bl1'~
 OR TEM_SUBCODE = 'bl2' OR TEM_SUBCODE = 'bl3' AND
TYPE_FOREST = 'OLD GROWTH'
MOVE TEM_SUBCODE TO SUBCODE
MOVE SOURCE_TEM TO SOURCE
ASEL
RESEL SUBCODE = ''
RESEL TEM_SUBCODE = 'la1' OR TEM_SUBCODE = 'la2' OR
TEM_SUBCODE = 'la3'
MOVE TEM_SUBCODE TO SUBCODE
MOVE SOURCE_TEM TO SOURCE
ASEL
RESEL SUBCODE = ''
RESEL GRID-CODE = 3 AND TYPE_BUFFER = ''
MOVE 'ic' TO SUBCODE
```

```
MOVE SOURCE_GRID TO SOURCE
ASEL
RESEL SUBCODE = ''
 RESEL TEM_SUBCODE = 'ro' AND GRID-CODE = 2 OR GRID-
CODE = 3 AND TYPE_BUFFER = 'COAST'
MOVE 'cc' TO SUBCODE
MOVE 'DERIVED' TO SOURCE
ASEL
RESEL SUBCODE = ''
RESEL TEM_SUBCODE = 'ro' AND GRID-CODE = 1 AND
TYPE_BUFFER = 'COAST'
MOVE 'cs' TO SUBCODE
MOVE 'DERIVED' TO SOURCE
ASEL
RESEL SUBCODE = ''
RESEL TEM_SUBCODE = 'sg' AND TYPE_BUFFER = 'COAST'
MOVE 'sg' TO SUBCODE
MOVE 'DERIVED' TO SOURCE
ASEL
RESEL SUBCODE = ''
RESEL TEM_SUBCODE NE ''
RESEL TEM_SUBCODE NE 'rl1'
RESEL TEM_SUBCODE NE 'rl2'
RESEL TEM_SUBCODE NE 'rl3'
RESEL TEM_SUBCODE NE 'bl1'
RESEL TEM_SUBCODE NE 'bl2'
RESEL TEM_SUBCODE NE 'bl3'
MOVE TEM_SUBCODE TO SUBCODE
MOVE SOURCE_TEM TO SOURCE
ASEL
RESEL SUBCODE = ''
RESEL SUBCODE_20K NE ''
MOVE SUBCODE_20K TO SUBCODE
MOVE SOURCE_20K TO SOURCE
/* Populate CODE
ASEL
RESEL SUBCODE = 'cc' OR SUBCODE = 'ic'
MOVE 'CL' TO CODE
ASEL
 RESEL SUBCODE CN 'hb' OR SUBCODE = 'cs' OR SUBCODE =
'sg' OR SUBCODE = 'du' OR SUBCODE = 'sh' OR SUBCODE =
'ta' OR SUBCODE = 'ap'
MOVE 'SV/HB' TO CODE
ASEL
 RESEL SUBCODE = 'bg' OR SUBCODE = 'fn' OR SUBCODE =
'sp' OR SUBCODE = 'sw' OR SUBCODE = 'es' OR SUBCODE =
'un'
MOVE 'WN' TO CODE
ASEL
RESEL SUBCODE = 'fl' OR SUBCODE = 'fm' OR SUBCODE =
'fh'
MOVE 'RI' TO CODE
ASEL
```

```
RESEL SUBCODE = 'mx'
MOVE 'WD' TO CODE
ASEL
RESEL SUBCODE = 'rl1' OR SUBCODE = 'rl2' OR SUBCODE =
'rl3'
MOVE 'RC' TO CODE
ASEL
RESEL SUBCODE = 'bl1' OR SUBCODE = 'bl2' OR SUBCODE =
'bl3'
MOVE 'RC' TO CODE
ASEL
RESEL SUBCODE = 'la1' OR SUBCODE = 'la2' OR SUBCODE =
'la3'
MOVE 'RC' TO CODE
```

5) Extraneous attribute items were removed and the final cover, called **sei**, was then dissolved to simplify and clipped to the TFL 44 boundary;
6) For polygons with a **source** = 'TEM', the **sei_variant** value was then populated using the dominant ecosystem value as discussed in Section 3.1.

To satisfy the requirements of the project, a thematic mapping template called **sei_wit,mxt** was created to display the resulting SEI data and any associated features of interest such as TEM project boundaries, etc. Because the resulting SEI polygons were very small in some instances and the attributes abundant it was necessary to create a cover dissolved by the sub code value to help generalize the data thus reducing the number of labels to be generated for the mapping product.

The structure of the final SEI dataset and detailed description has been created in the **sei** cover metadata and can be accessed through ArcCatalog.

All prepared GIS data including source and final data sets, AMLs, look-up tables, and supporting documentation are located in the Weyerhaeuser project 20030605 at Timberlands Services in Nanaimo.

5. Conclusion

This section will highlight the conclusions drawn from the Sensitive Ecosystem Inventory for the West Island Timberlands Advisory Group, GIS component, including observations from this study, and suggestions/recommendations for additional inventory assessments.

Overall the GIS methodology and procedures developed were adequate in developing the final Sensitive Ecosystem Inventory for West Island Timberlands. A key aspect to the inventory satisfied, was the strict use of available Weyerhaeuser GIS data.

There were aspects of the GIS component that may yet be improved upon or altered in order to refine the resulting data or improve upon procedures. These aspects are covered in the following key observations and suggestions:

- Originally the B.C. Conservation Data Center's GIS polygon data for known locations/areas of rare and/or endangered species were to be incorporated into the spatial analysis. However upon review of the data, the format and representation of these locations were not suitable for inclusion in the final dataset;
- The ecosystems identified on the B.C. Conservation Data Centre – Rare Natural Plant Community Red and Blue List with a site unit of '00' have not been captured as there are no associated map codes from the TEM data for these to draw upon;
- As the final SEI is destined for storage in the Nanaimo geodatabase there will have to consultation with the geodatabase manager to ensure that the cover meets all the specified management criteria of data entering the geodatabase and any changes to the data to meet those criteria are performed.
- Review and correction of the TEM variant and mapcode data to account for errors in the original capture of this component of the TEM database.
- The final data set has not been cleaned for any sliver polygons that may be present from the overlay procedures. It would be useful to decide on a certain minimum size (ha) for polygons to be included in the data. Anything less than the minimum size would be eliminated.

While extensive review of notes taken during the project and the data involved, provide a basis for this document, some details may not have been taken into account here. As mentioned previously, all data and any supporting documentation can be found in the project – 20030605 should it be necessary. It is intended that the information provided in this document will assist in additional inventories and to further develop the GIS procedures and methodology.

Table 1. Sensitive Ecosystem Categories - Working Legend

Category	Code	Subcode	Description	Data Source	Type	Procedure
Cliffs	CL		**Steep slopes, often with exposed bedrock.**			
		cc	coastal cliffs	Slope contours, proximity to coast TEM - sitemc_s<n> = 'RO', 'SC' & slope 30% plus, within 10m of shoreline	Derived	Generate slope cover from GRID\DEM that meets SEI criteria. Buffer distance from shoreline and use areas that fall inside buffer.
		ic	inland cliffs	Slope contours, proximity to coast 173% degree slope or greater	Derived	Generate slope cover from GRID\DEM that meets SEI criteria. Buffer distance from shoreline and use areas that fall outside buffer.
Sparsely Vegetated / Herbaceous	SV/HB		**Non-forested ecosystems with <10% tree cover. Most have shallow soils and bedrock outcrops**			
		hb1,hb2, hb3	Herbaceous: a mix of grasses and forbs as well as mosses and lichens	TEM = 'RO', 'SC'; 1:20K (C/T) = 27 (rock), 31 (grassland); 1:5K = FCODE, MAP_LABEL	TEM, Forest Cover 1:5K & 1:20K	Select from existing data. Forest cover information takes precidence over TEM. Buffer from coastline - select outside.

		cs	Coastal herbaceous: windswept shorelines and slopes influenced by proximity to the ocean	1:20K = 27 (rock, + proximity to coast); TEM = sitemc_s<n> = 'RO', 'SC' & slope less than 30% , within 10m of shoreline	TEM, Forest Cover 1:5K & 1:20K	Select from existing data. Forest cover information takes precidence over TEM. Buffer from coastline - select intside.
		sp	Spit: sand and gravel deposits with low to moderate cover of grasses and herbs	TEM = 'GB' (Gravel bar) and within 10m of shoreline	Weyerhaeuser - TEM	Select from existing data. Buffer from coastline - select intside.
		du	Dunes: sand dunes with low cover of grasses and herbs	TEM = 'BE' (Beach)	Weyerhaeuser - TEM	Select from existing data.
		sh	Shrub: shrubs account for more than 20% of the vegetation	TEM = 'SA', 'MS'	Weyerhaeuser - TEM, Forest Cover 1:20K	Select from existing data. Forest cover information takes precidence over TEM.
		ta	*Talus slopes*	TEM = 'TA'	Weyerhaeuser - TEM, Forest Cover 1:20K	Select from existing data.
		ap	*Alpine*	TEM = 'AT'	Weyerhaeuser - TEM, Forest Cover 1:20K	Select from existing data.
Wetland	WN		**Areas characterized by daily, seasonal or year-round water at or over the surface.**			
		bg	Bog	TEM = Pl-sphagnum & associated site series	Weyerhaeuser - TEM	Select from existing data.

		fn	Fen	TEM = 'BS' (buckbean-sedge), 'CA' & associated site series;	Weyerhaeuser - TEM	Select from existing data.
				TEM = HG (hardhack-sweet gale) & associated site series	Weyerhaeuser - TEM	Select from existing data.
		sp	Swamp	TEM = skunk cabbage & associated site series	Weyerhaeuser - TEM	Select from existing data.
		sw	Shallow water	TEM = PD (pond)	Weyerhaeuser - TEM	Select from existing data.
		es	*Estuary*	TEM = HP (hairgrass-plantain) & associated site series	Weyerhaeuser - TEM	Select from existing data.
		un	*Undifferentiated wetland*	FC = 'Swamp' (1:5K), 30 (1:20K - C/T)	Forest Cover 1:20K	Select from existing data.
Riparian	RI		**Streamside areas along creeks, streams, and larger floodplains**			
		fl	low bench: areas flooded at least once every 2 years for part of the growing season	TEM = Low bench Site Series, and soils FA units (fluvial-active)	Weyerhaeuser - TEM	Select from existing data.
		fm	medium bench: areas flooded every 1 - 6 years for short periods; usually deciduous or mixed	TEM = Med bench Site Series	Weyerhaeuser - TEM	Select from existing data.

		fh	High bench: areas periodically and briefly inundated by high waters; typically conifer-dominated	TEM = High bench Site Series	Weyerhaeuser - TEM	Select from existing data.
Woodland	WD		**Dry, open stands of woodland, generally with between 10 - 25% tree cover**			
		co	Conifer-dominated	N/A	N/A	N/A
		mx	Mixed conifer - deciduous	TEM = Arbutus types (CDFmm/02; CWHxm/02); Garry oak, known occur.	Weyerhaeuser - TEM	Select from existing data.
Rare Communities	*RC*		***Rare plant communities in the CDC tracking list, or site series of rare occurrence within the DFA***			
		rl1, rl2, rl3	*Red-listed*	TEM units in red list	Weyerhaeuser - TEM	Select from existing data.
		bl1, bl2, bl3	*Blue-listed*	TEM units in blue list	Weyerhaeuser - TEM	Select from existing data.
		la1, la2, la3	*Landscape rarity - within the DFA (TFL44)*	TEM units defined as rare (Landscape Rarity Analysis)	Weyerhaeuser - TEM	Select from existing data.

Categories follow the Sunshine Coast SEI definitions, with additions in italics

APPENDIX II. (separate report)

Clement, Chris. 2003. Rare and sensitive ecosystem inventory pilot project: summary report on field verification. Shearwater Mapping Ltd., November 2003, 9 p. + Appendices.