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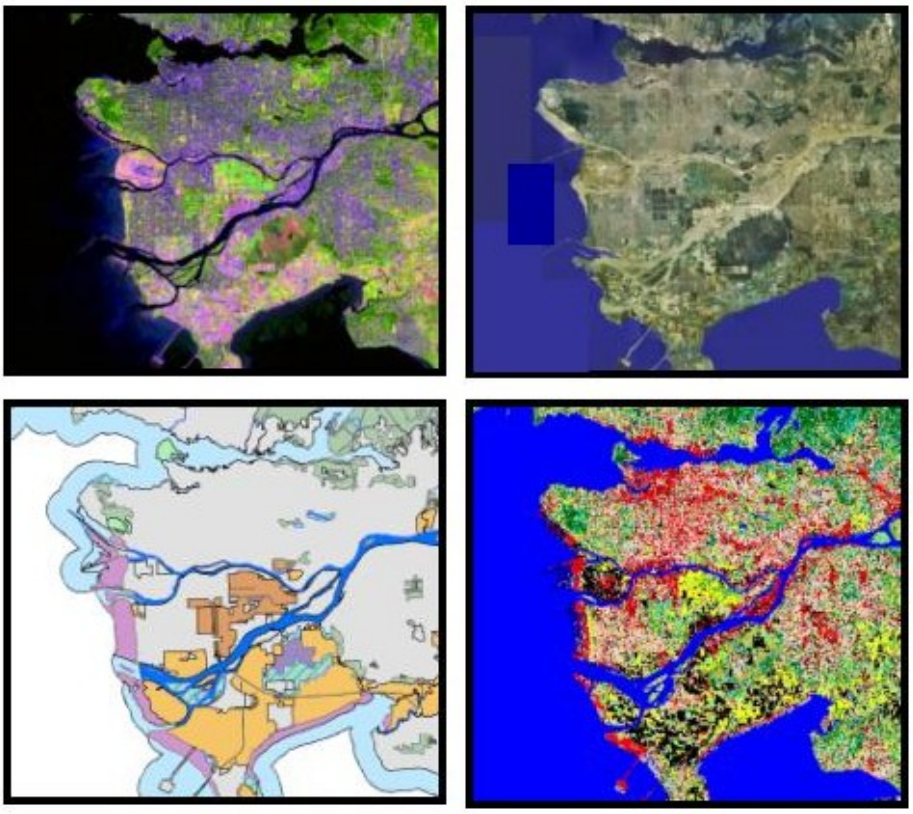
Land Cover and Land Use Change Mapping for the B.C. Lower Mainland



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GeoSpatial International Inc.

Timberline Forest Inventory Consultants

EXECUTIVE SUMMARY

Urbanization, deforestation, and loss of wetlands are three globally important issues that are drivers for this project. This report provides land use change and land cover change analysis and mapping products for the lower mainland region of British Columbia as defined by the Greater Vancouver Regional District (GVRD). Delivered with this project is a multi-temporal spatial database of land cover and land use for the GVRD, which can serve as a base for environmental, planning, land evaluation, and other applications.

Specific project objectives were:

- To monitor land cover and land use change over time for the Greater Vancouver Regional District area. Mapping of land use changes from 1986 to 2002 and land cover changes from 1986 to 2002 and deforestation mapping for 1998-2002 to be carried out using multi-temporal Landsat imagery. Deforestation mapping was to be according to the Kyoto definition[1].
- To integrate mapping to allow mapping and analysis of deforestation, wetlands and major land use and their changes over specified time periods.

The study area consists of the GVRD area plus a two kilometre buffer (with the exception of south of the U.S. border) including only areas above the salt water line as defined by the Terrain Resource Information Management Program (TRIM). The total area of the study area is 375,456 ha.

Land cover results from a complex mixture of natural and anthropogenic influences and is the composition and characteristics of land surface elements (Cihlar, 2000). Land use is characterized by economic uses of land and people's relationships with the environment (Avery and Berlin, 1992).

The period of 1986 to 1993 saw relatively little change in land use. Forests appear to have been cycling through old forest, harvest, and re-establishment to young forest. Most harvesting is not resulting in deforestation and urban use.

The period of 1993 to 1998 saw increased levels of change in land use. This included loss of wetlands, forests, and agriculture land to urbanization.

The period of 1998 to 2002 saw a return to lower levels of change in land use. Significant areas recently logged are re-established as young forest.

Land cover and land cover change is mapped for three distinct points in time 1986, 1998, and 2002.

Land cover change patterns are much as one would expect with forests declining and urban areas expanding.

Total wetlands lost in the study area between 1986 and 2002 is determined to be 1,115 ha.

Total area deforested in the study area is reported to be 563 ha between 1998 and 2002.

[1] Deforestation is defined as the conversion of forested land to non-forested land as a direct result of human activities (Natural Resources Canada, 2004).

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This document is distributed electronically. Electronic delivery provides complete access to the report, appendices, references, maps, and supporting documents. The CD has an auto-run feature, once loaded it will automatically present a menu interface for navigation through the project documents. Full access depends to some extent on the internet browser being used. *Acrobat Reader* is required.

1.0 INTRODUCTION AND BACKGROUND

Urbanization, deforestation, and loss of wetlands are three globally important issues that are drivers for this project. The dynamics of land use and land cover can be described by posing the following questions:

- Where and when did changes occur?
- What type of changes were they?
- Why did they occur?
- What are the consequences to the environment and biodiversity?

Canada's commitment to the Kyoto Protocol further enhances the need to map and monitor locations and extents of permanent deforestation and wetlands.

The B.C. Ministry of Sustainable Resource Management (MSRM) retained Timberline Forest Inventory Consultants Ltd. to produce land use change and land cover change analysis and mapping products for the lower mainland region of British Columbia as defined by the Greater Vancouver Regional District (GVRD). Timberline, and GeoSpatial International Inc. have produced this report and associated materials. Results represent a multi-temporal spatial database of land cover and land use for the GVRD, which can serve as a base for environmental, planning, land evaluation, and other applications.

The project objectives at the outset of the project were:

- To monitor land cover and land use change over time for the Greater Vancouver Regional District area. Mapping of land use and land cover changes from 1986 to 2002 and deforestation mapping for 1998-2002 to be carried out using multi-temporal Landsat imagery. Deforestation mapping was to be according to the Kyoto definition[2].
- To integrate mapping to allow mapping and analysis of deforestation, wetlands and major land use and their changes over specified time periods.

Land Cover vs. Land Use

Land cover and *land use* are terms often used interchangeably; however, they have different meanings. Land cover results from a complex mixture of natural and anthropogenic influences and is the composition and characteristics of land surface elements (Cihlar, 2000). Land use is characterized by economic uses of land and people's relationships with the environment (Avery and Berlin, 1992). For example, a land cover of forest, when considered as a land use, could be a park or a golf course. Residential area would qualify as urban land use while being classified as herb under land cover classification scheme.

[2] Deforestation is defined as the conversion of forested land to non-forested land as a direct result of human activities (Natural Resources Canada, 2004).

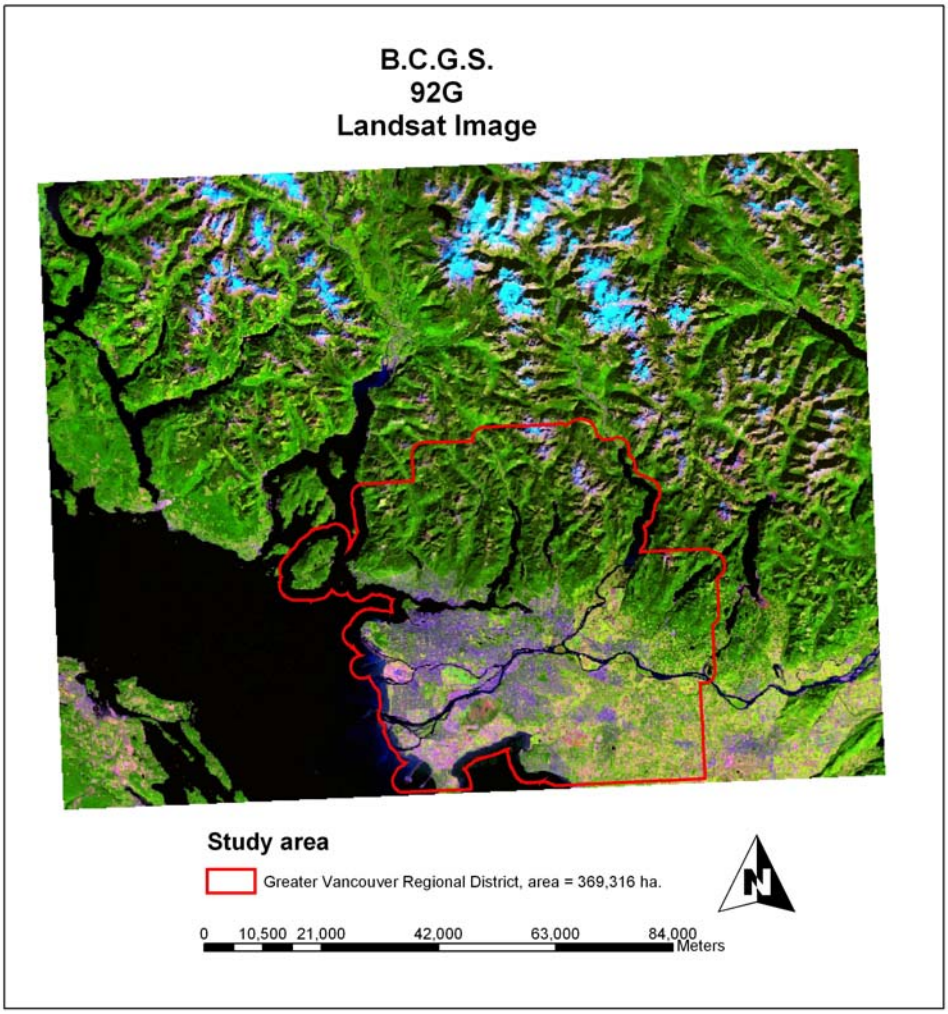


Figure 1.1 Study area

The study area consists of the GVRD area plus a two kilometre buffer (with the exception of south of the U.S. border) including only areas above the salt water line as defined by the Terrain Resource Information Management Program (TRIM). The total area of the study area is 375,456 ha.

Section 2.0 of this report presents land use and land use change, full methodology is available in Appendix II.

Section 3.0 presents land cover and land cover change, with full documentation in Appendix I.

Wetlands and lost wetlands are addressed in Section 4.0 and Appendix III.

Deforestation is reported in Section 5.0 and Appendix IV.

Appendix V presents the methods and results of the various quality assurance processes undertaken in the course of this project.

Appendix VI lists auxiliary data sources employed.

Appendix VII provides field notes and pictures from ground truthing of deforestation analysis.

2.0 LAND USE AND LAND USE CHANGE

Land use mapping (also referred to as baseline thematic mapping or BTM) and land use change mapping was produced for four specific points in time and change data reflecting a span of 16 years.

2.1 METHODOLOGY

Full methodology for preparation of the land use and land use change products can be found in Appendix II.

As described in Figure 2.1, the production of the land use mapping involves multiple input data sets such as satellite imagery and existing land use mapping of various vintages. In addition there are multiple information sources supporting the work. These include a composite wetlands map, digital ortho-photographs, hard copy air photos, and supplementary inventory data sets.

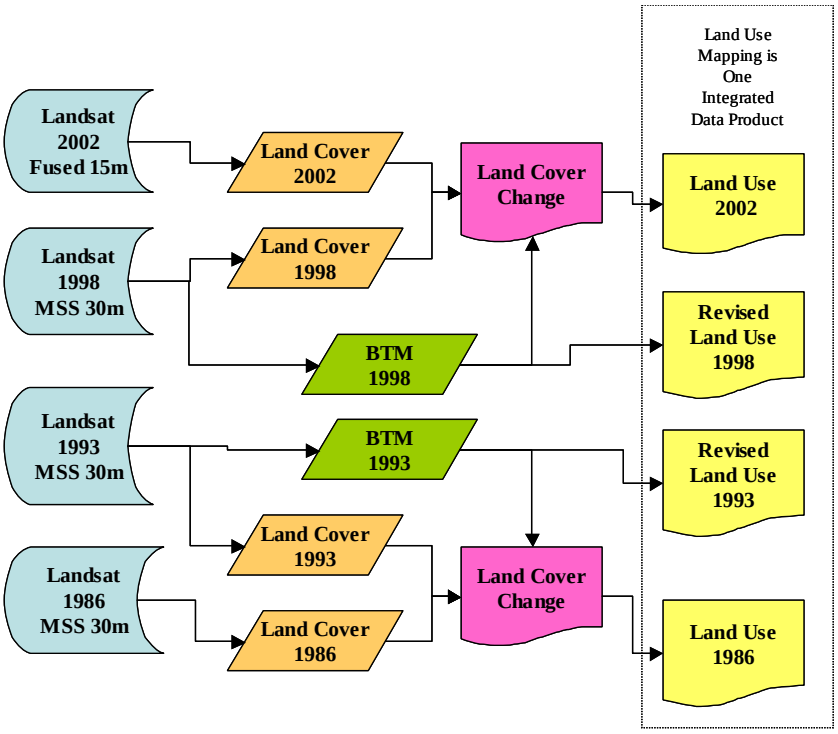


Figure 2.1 Project flow: land use

Previously completed BTM for 1993 and 1998 was upgraded to current specifications. Land cover change as defined by satellite imagery was used to "backdate" the 1993 BTM to 1986. The 1998 BTM is updated to 2002 using land cover change. The data product is stored as one file for all four BTM land use views.

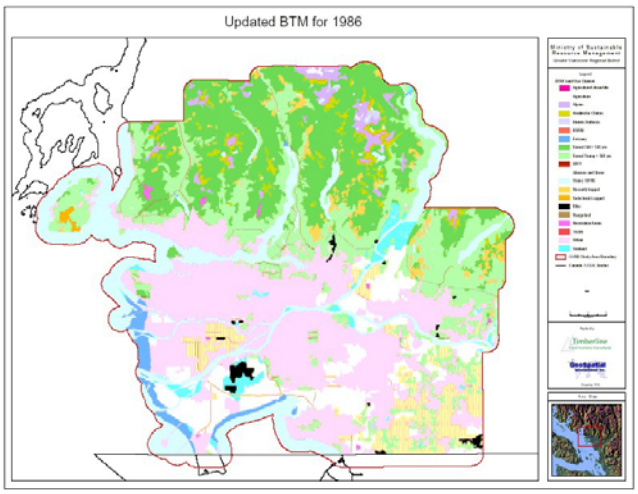
2.2 LAND USE MAPPING LEGEND

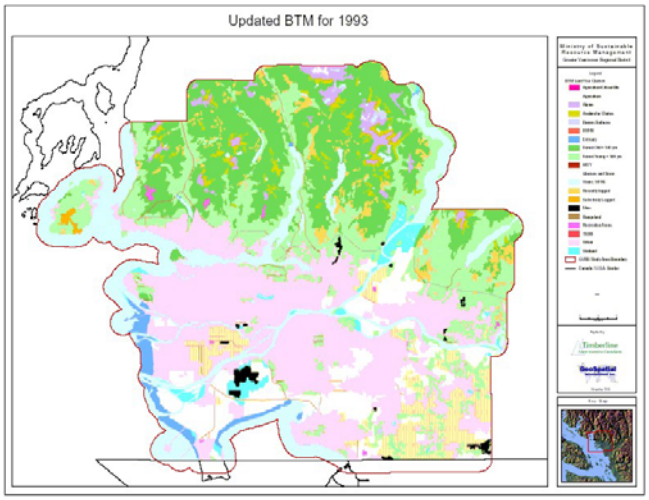
Presented in Figure 2.2 is the final land use legend and colour scheme as provided to us. Rivers and lakes are combined in the water (water, fresh) category.

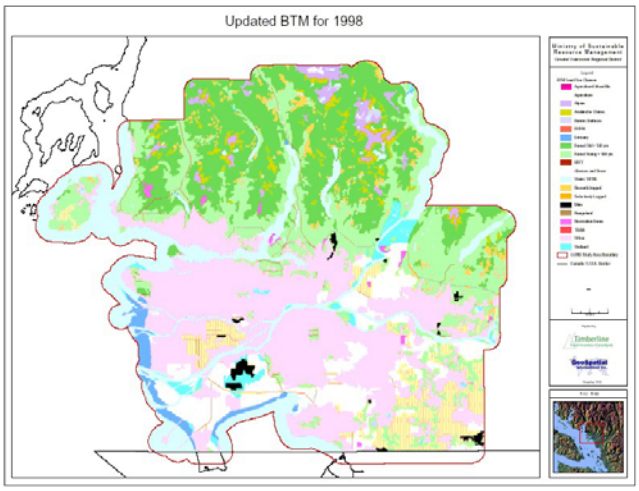
Figure 2.2 Land use mapping legend

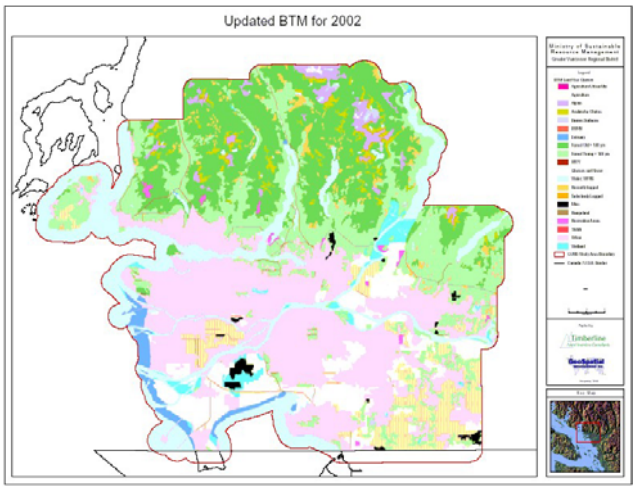
2.3 GVRD LAND USE MAPPING

Land use in the Greater Vancouver Regional District at four distinct points in time is presented below. Change areas are small and difficult to discern except at the full map scale. Double click each map for viewing or printing.









2.4 LAND USE SUMMARY - GVRD

Table 2.1 presents a land use and land use change area summary for the GVRD area.

Table 2.1 GVRD land use area summary (ha)

Land Use	1986	1993	Change '86 to '93	1998	Change '93 to '98	2002	Change '98 to '02
Agriculture/Urban Mix	16,511	16,511	0	17,430	919	17,393	-37
Agriculture	31,728	31,684	-44	31,712	29	31,733	21
Alpine	6,624	6,624	0	6,624	0	6,624	0
Avalanche Chutes	6,388	6,388	0	6,388	0	6,388	0
Barren Surfaces	659	659	0	659	0	659	0
Burn	0	0	0	0	0	0	0
Estuary	5,181	5,181	0	5,181	0	5,181	0
Forest Old (> 140 years)	70,245	68,691	-1,555	68,459	-231	68,436	-23
Forest Young	66,634	66,627	-6	66,772	145	67,399	627
Highway	458	458	0	457	-0	457	0
Glaciers and snow	247	247	0	247	0	247	0
Fresh Water	8,831	8,831	0	8,831	0	8,831	0
Recently Logged	7,499	8,760	1,261	6,530	-2,230	5,806	-724
Selectively Logged	559	559	0	0	-559	0	0
Mine	2,009	2,077	68	2,139	63	2,132	-7
Range Land	0	0	0	0	0	0	0
Recreation	707	707	0	1,182	475	1,178	-4
River	8,363	8,363	0	8,363	0	8,363	0
Transmission	835	835	0	835	0	835	0
Urban	93,660	93,936	276	95,761	1,826	95,910	149
Wetland	6,576	6,576	0	6,140	-435	6,140	0
Salt Water	35,602	35,602	0	35,602	0	35,602	0
Total	**369,316**	**369,316**		**369,316**		**369,316**	

Source: BTM data: ArcInfo polygonal coverage *btm_gvrd_utm* (UTM projection)

Tables 2.2, 2.3, and 2.4 report on the nature of the changes.

Table 2.2 GVRD land use change 1986 to 1993

Land Use Change From	To	Area (ha)
1986 to 1993		
Agriculture	Urban	44
Old Forest (> 140 years)	Recently Logged	1,555
Young Forest (< 141 years)	Recently Logged	108
	Mining	68
	Urban	232
Recently Logged	Young Forest (< 141 years)	402

Source: BTM data: ArcInfo polygonal coverage *btm_gvrd_utm* (UTM projection)

The period of 1986 to 1993 saw relatively little change in land use. Forests appear to have been cycling through old forest, harvest, and re-establishment to young forest. Most harvesting is not resulting in deforestation and urban use.

Table 2.3 GVRD land use change 1993 to 1998

Land Use Change From	To	Area (ha)
1993 to 1998		
Mixed Agriculture	Urban	257
Agriculture	Recreation Activities	179
	Urban	373
Old Forest (> 140 years)	Recently Logged	249
Young Forest (< 141 years)	Agriculture/Urban Mix	608
	Agriculture	299
	Old Forest (> 140 years)	18
	Recently Logged	267
	Mining	47
	Recreation Activities	265
	Urban	1,113
Recently Logged	Agriculture/Urban Mix	8
	Young Forest (< 141 years)	2,738
Selectively Logged	Agriculture/Urban Mix	559
Mining	Agriculture	91
Recreation Activities	Urban	68
Wetlands	Agriculture	191
	Forest Young	24
	Mining	106
	Recreation Activities	99
	Urban	15

Source: BTM data: ArcInfo polygonal coverage *btm_gvrd_utm* (UTM projection)

The period of 1993 to 1998 saw increased levels of change in land use. This included loss of wetlands, forests, and agriculture land to urbanization.

Table 2.4 GVRD land use change 1998 to 2002

Land Use Change From	To	Area (ha)
1998 to 2002		
Mixed Agriculture	Urban	39
Agriculture	Urban	12
Old Forest (> 140 years)	Recently Logged	19
	Urban	4
Young Forest (< 141 years)	Agriculture/Urban Mix	2
	Agriculture	33
	Recently Logged	107
	Urban	82
Recently Logged	Young Forest (< 141 years)	850
Mining	Urban	7
Recreation Activities	Urban	4

Source: BTM data: ArcInfo polygonal coverage *btm_gvrd_utm* (UTM projection)

The period of 1998 to 2002 saw a return to lower levels of change in land use. Significant areas recently logged are re-established as young forest.

These comparisons are based on multi-temporal data. Such an approach has limitations that must be considered when drawing conclusions. There are spectral differences between data sets, which introduce noise, as well as seasonal and year-to-year variations in ground conditions that introduce differences in between data sets.

2.4.1 Deforestation Based on Land Use Comparisons

Table 2.5 presents deforestation and potential deforestation based on land use (BTM) changes. Deforestation is defined as permanent land use change from forest land. A more specific and rigourous analysis of deforestation is presented in Section 5.0. The deforestation events are changes in land use, which will probably permanently remove the area from the forested land base. Potential deforestation events are those, which may be converted to non-forest land in the future (*e*.g. young forest which has been logged for future urban development).

Table 2.5 GVRD deforestation based on BTM

Land Cover Change		Deforestation (ha)	Potential Deforestation (ha)
From	**To**		
1986 to 1993			
Old Forest (> 140 years)	Recently Logged		1,555
Young Forest (< 141 years)	Recently Logged		108
Young Forest (< 141 years)	Mining	68	
Young Forest (< 141 years)	Urban	232	
Total		**300**	**1,663**
1993 to 1998			
Old Forest (> 140 years)	Recently Logged		249
Young Forest (< 141 years)	Mixed Agriculture	608	
Young Forest (< 141 years)	Agriculture	299	
Young Forest (< 141 years)	Recently Logged		267
Young Forest (< 141 years)	Mining	47	
Young Forest (< 141 years)	Recreation Activities	265	
Young Forest (< 141 years)	Urban	1,113	
Recently Logged	Mixed Agriculture	567	
Total		**2,899**	**516**
1998 to 2002			
Old Forest (> 140 years)	Recently Logged		19
Old Forest (> 140 years)	Urban	4	
Young Forest (< 141 years)	Mixed Agriculture	2	
Young Forest (< 141 years)	Agriculture	33	
Young Forest (< 141 years)	Recently Logged		107
Young Forest (< 141 years)	Urban	82	
Total		**121**	**126**

Source: BTM data: ArcInfo polygonal coverage *btm_gvrd_utm* (UTM projection)

2.5 LAND USE FOR THE GREATER LOWER MAINLAND

Standard land use mapping consists of BTM mapped for large areas at a scale of 1:250,000. This mapping is produced on tiles such as UTM (Universal Trans Mercator) letter block 92G (see key map Figure 1.1).

Land use mapping for the entire area of the 92G letter block, including the GVRD area, has been prepared for the year 2002. Tacking advantage of existing BTM for 92G which reports on two time frames, 1993 and 1998, a composite product was produced for four points in time: 1986; 1993; 1998; and 2002. Figure 2.3 explains the process. New BTM for 2002 was produced in the same manner as for the GVRD area (see Section 2.1). The new BTM for the GVRD area as described in Section 2.1 was used to update that area within existing 1993 and 1998 BTM. As no 1986 BTM product for the letter block previously existed, the 1986 BTM presents the GVRD area only.

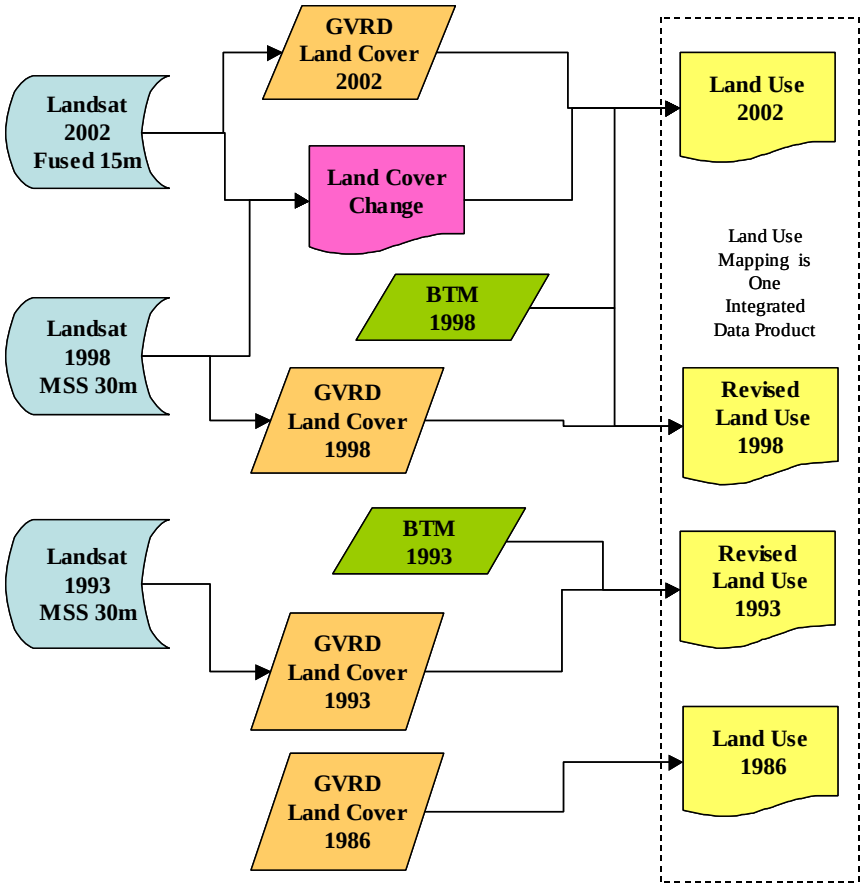
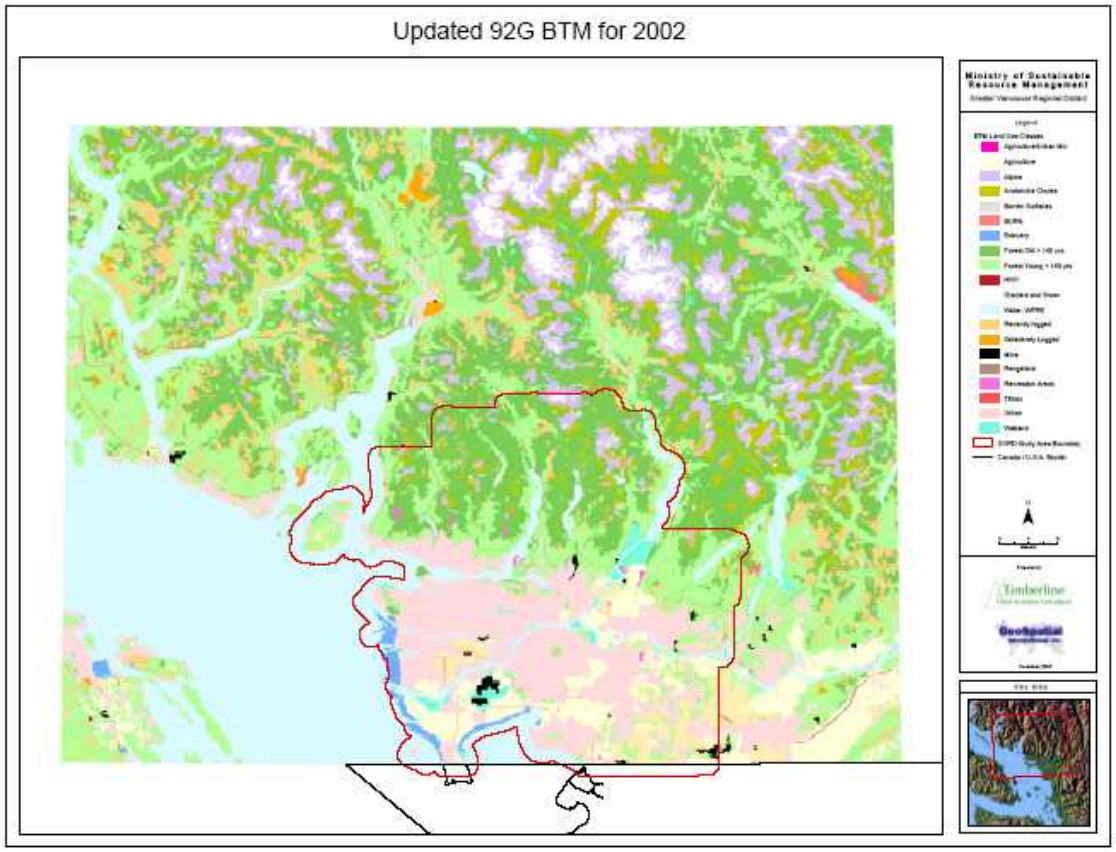


Figure 2.3 Letter block land use information flow

Land use in the 92G letter block in 2002 is presented below.



3.0 LAND COVER AND LAND COVER CHANGE

Land cover mapping from satellite imagery is produced for three points in time: 1986; 1998; and 2002. Land cover change mapping was carried out for the 1986-1998 and 1998-2002 time periods.

The Greater Vancouver Regional District is a complex and highly developed area with diversified land cover ranging from dense urban and industrial to old growth coastal forest. Elevation and slope gradients over the District are among the steepest in the world. Diverse terrain morphology in the valley bottom and coastal mountains creates a range of spectral signatures comprising land cover, sun elevation/slope and moisture characteristics of the terrain. The complexity of these factors makes consistent thematic mapping difficult.

3.1 METHODOLOGY

Full methodology for preparation of the land cover and land cover change products can be found in Appendix I. Figure 3.1 presents a simplified information flow used in the process. Major products are 30m resolution land classification (yellow), 30m land cover change (magenta), and 15m land cover classification (green). The 15m land cover and the land cover change maps are presented below.

In order to present land cover classification at 15m resolution for all time frames, the 2002 data is the base and land cover change is used to define classification in 1998 and 1986.

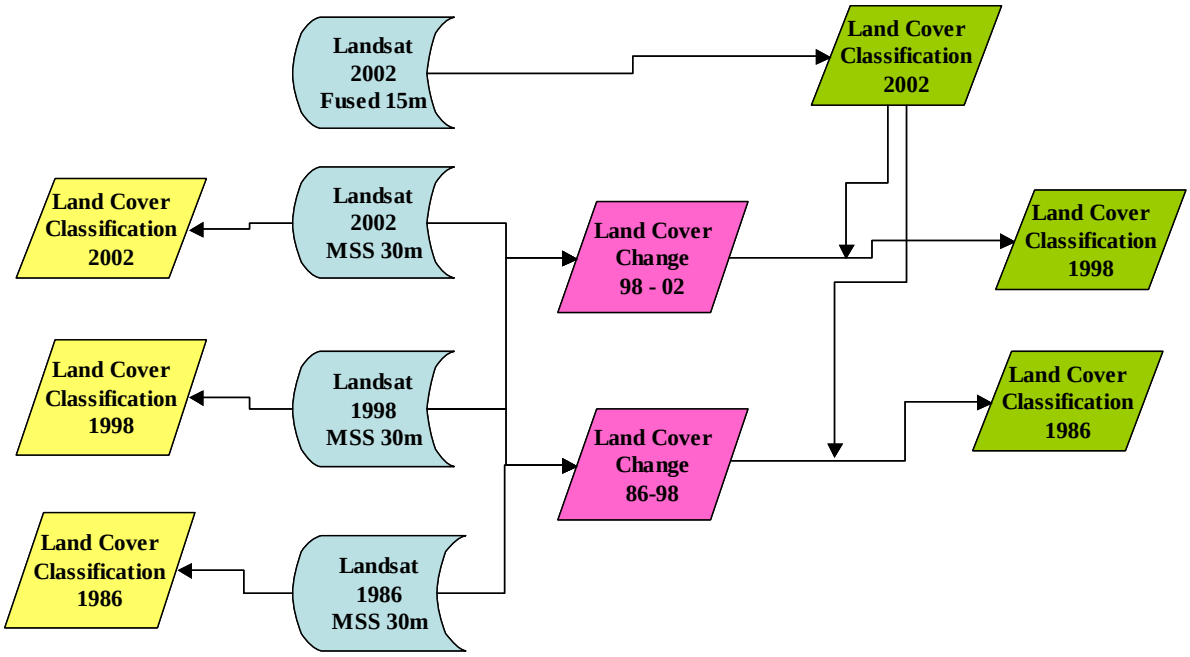


Figure 3.1 Project flow: land cover

3.1.1 Land Cover Classification Legend

The land cover classification legend is based on reviews of published land cover classification legends and is compatible with most national and provincial land cover programs. It is based on considerations of broad user base; resolution limitations of satellite data, simplicity and compatibility with other land cover programs.

3.1.2 Integrated Wetland Inventory

Available wetland inventories were used to stratify GVRD land cover into "potential wetlands". These included TRIM, Canadian Wildlife Service 1989 and 1999 wetland inventories, FREMP habitat and wetlands of 2002/03, and wetlands defined in vegetation resources inventory, the Langley land use inventory, and 1993 and 1998 BTM views.

3.1.3 Integration of Vegetation Resource Inventory

For the northern portion of the GVRD, existing vegetation resources inventory mapping was used to as a substitute in areas with forest spectral characteristics obscured by shadows. Matching (generalization) of VRI classes to those used in this project, and definition of when to substitute VRI attributes for classification, was done according to rules defined in Section 4.3 of Appendix I.

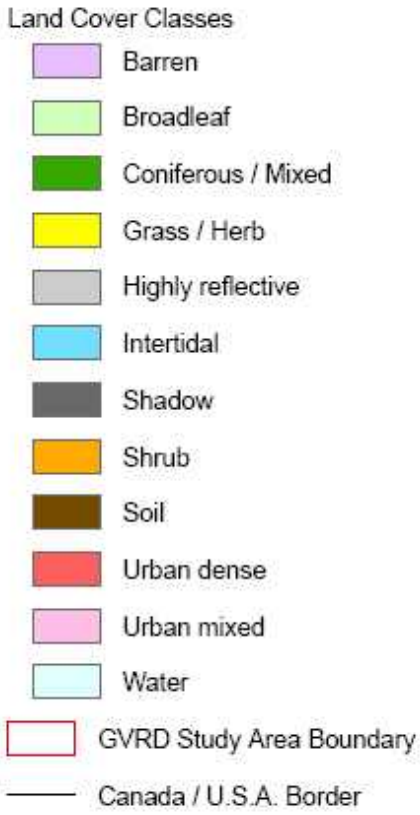
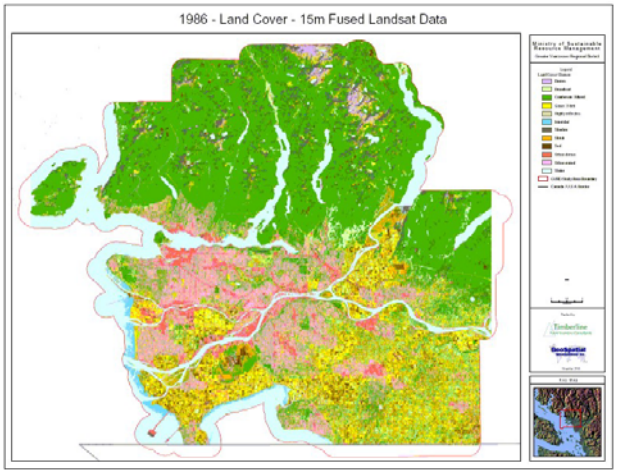


Figure 3.2 Land cover mapping legend

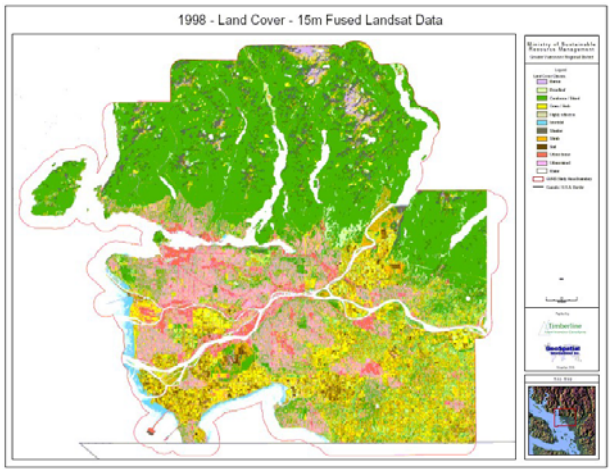
3.2 GVRD Land Cover Mapping

Land cover in the Greater Vancouver Regional District at three distinct points in time is presented below.

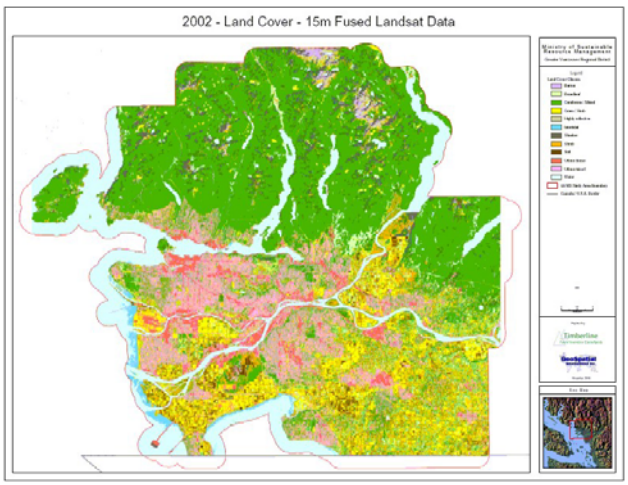
Post quality assurance data provided to Timberline had been clipped to the GVRD boundary rather than the study area boundary, resulting in the small area on the eastern edge that lacks coverage.



1986



1998



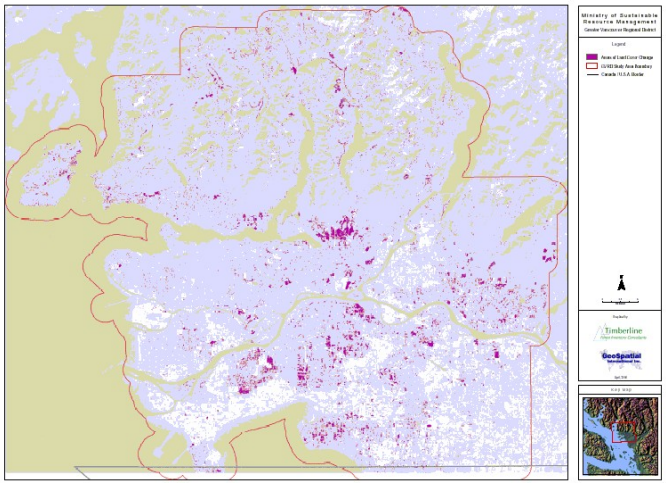
2002

3.3 LAND COVER CHANGE

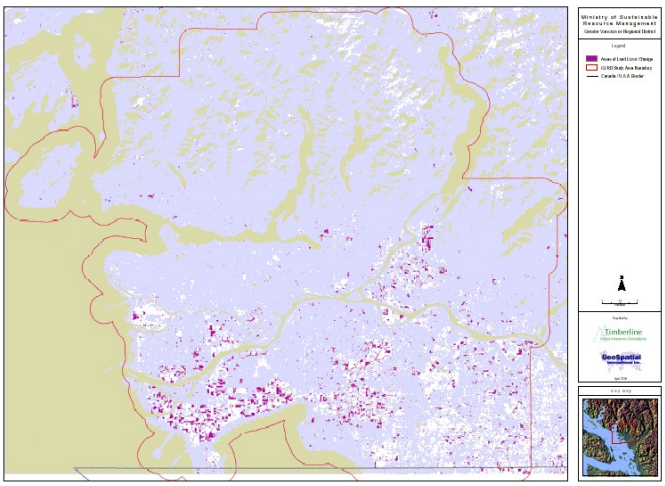
Classification of Landsat data using available bands 2,3,4,5 of 1998 and 2,3,4,5,7 of 1986 coverage was carried out to define land cover classes present in areas that underwent change from 1986-1998 and 1998-2002. Training areas defined for the fused data at 15m resolution were re-projected to 30m and modified to accommodate different resolution limits (*e.g.*, small training areas resolved at 15m were not resolvable at 30m), different extents of shadows presence of shadows (seasonal sun illumination difference) and exclusion possible presence of mixed pixels. Results were fused to determine the nature of land cover change.

Land cover change in the Greater Vancouver Regional District during two periods defining the land cover provided above is presented below.

1986 - 1998 Land Cover Change

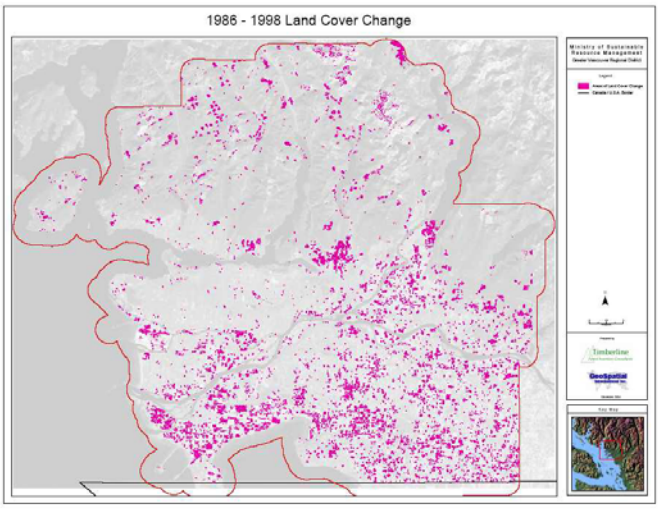


1998 - 2002 Land Cover Change



3.4 FINDINGS AND DISCUSSION

Land cover change as presented in Section 3.3 is change as defined by differences in satellite imagery. The change in land cover as defined by the final land cover product is presented in the following maps and tables.



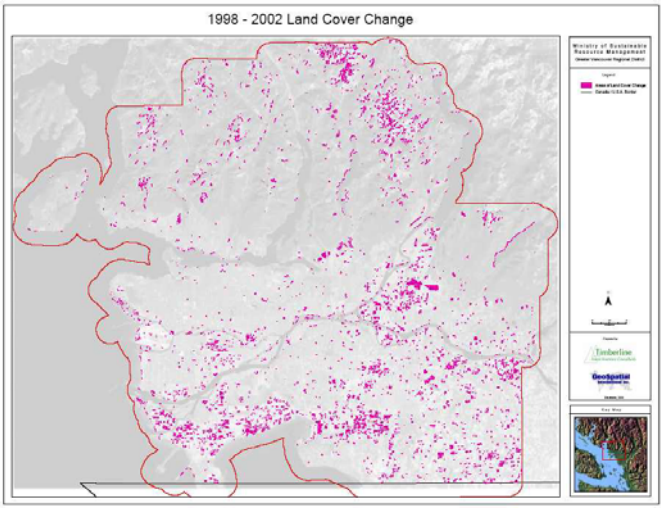


Table 3.1 presents a land cover and land cover change area summary for the GVRD area.

Table 3.1 GVRD land cover area summary

	Area (ha)				
Land Cover	**1986**	**1998**	**Change 1986 to 1998**	**2002**	**Change 1998 to 2002**
Barren	2,696	2,702	5	2,368	-334
Broadleaf	20,204	18,451	-1,753	18,712	261
Coniferous Mixed	150,847	150,286	-561	150,700	414
Grass Herb	40,531	42,090	1,560	43,470	1,380
Highly reflective	729	873	145	1,019	146
Intertidal/Sandbar	3,227	3,229	2	3,243	14
Shadow	11,341	11,668	327	11,839	171
Shrub	20,675	21,138	464	21,623	485
Soil	14,214	12,682	-1,533	10,369	-2,313
Urban dense	12,348	12,966	618	13,208	242
Urban mixed	35,375	36,533	1,158	36,196	-336
Urban shadow	488	126	-362	9	-118
Water	51,000	50,932	-68	50,919	-13

Source: BTM data: ArcInfo grid coverage lc_gvrd_utm (UTM projection)

Tables 3.2 and 3.3 reports on the nature of the changes. Patterns are much as one would expect with forests declining and urban expanding.

Table 3.2 GVRD land cover change (area in ha) 1986 to 1998

	Land Cover 1998											
Land Cover 1986	Barren	Broad-leaf	Coniferous-mixed	Grass-herb	Highly reflective	Inter-tidal	Shadow	Shrub	Soil	Urban dense	Urban mixed	Water
Barren		7	46	10	25	0	36	2	1	3	10	0
Broadleaf	14		144	1,100	22		23	334	596	115	386	0
Coniferous-mixed	17	466		545	21		23	180	117	36	251	0
Grass-herb	30	110	121		15		31	350	1,149	100	118	1
Highly reflective	728	1										
Inter-tidal												
Shadow	16	7	15	71	18	0		18	26	81	97	1
Shrub	3	52	113	308	10	0	10		135	62	110	1
Soil	56	339	622	1,532	31	1	144	380		165	288	11
Urban dense												
Urban mixed	8	0	1	18	3	0	5	2	12	56		1
Water	1	0	32	1		0	42	1	0	0	4	

Source: BTM data: ArcInfo grid coverage lc_gvrd_utm (UTM projection)

Table 3.3 GVRD land cover change (area in ha) 1998 to 2002

	Land Cover 2002											
Land Cover 1998	Barren	Broad-leaf	Coniferous-mixed	Grass-herb	Highly reflective	Inter-tidal	Shadow	Shrub	Soil	Urban dense	Urban mixed	Water
Barren		26	21	265	62	2	19	20	28	10	10	3
Broadleaf			17	148	1		1	9	55	5	14	0
Coniferous-mixed	4	32		91	10		21	60	33	12	30	1
Grass-herb	5	124	313		23	1	60	155	388	46	152	4
Highly reflective	0	1	23	3			2	2	2	6	8	
Inter-tidal												
Shadow	15	2	26	17	11	1		1	5	45	15	1
Shrub		0	0	2					0		0	
Soil	18	308	244	1,859	31	1	43	204		48	127	3
Urban dense												
Urban mixed	87	16	53	264	54	8	43	31	57	69		12
Water	3	1	10	4	1		5	6	6	1	1	

4.0 WETLANDS MAPPING AND LOST WETLANDS

This section provides the results of a wetlands mapping, reporting, and change analysis process.

A comprehensive wetlands map for the GVRD area was compiled from multiple data sources for input to both land use and land cover mapping. This wetlands mapping is also the basis for analysis of lost wetlands.

4.1 MAPPING

This section provides the methodology for mapping of wetlands as input to land cover mapping of the GVRD.

The intent is to add wetland attribution to both the land use and land cover classification. At the same time, raster land cover classification results can aid determining the loss of wetlands.

Wetland inventories contain various degrees and detail of wetland attributes. In the context of this project, only a general "wetland" modifier will be added as another land cover class attribute.

All vector polygon data sets available for the project were used to stratify land cover into “potential wetlands”. All data sources were considered as equally valid. Satellite-based land cover classification served as the source of land cover data.

Data sets providing wetlands mapping were:

- Baseline thematic mapping (BTM);
- Terrain resource information management (TRIM);
- Vegetation resources inventory (VRI);
- Langley land use inventory;
- Canadian Wildlife Service 1989 wetlands;
- Canadian Wildlife Service 1999 wetlands; and
- Fraser River Estuary Management Program (FREMP) habitat and wetlands inventories 2002/03 (circa 1987).

An aggregation, or super-set, of wetlands was created from the data sets listed above. Wetland classification was undertaken for three distinct time periods 1986, 1998 and 2002.

4.2 LOST WETLANDS

Wetland polygons were used to stratify the GVRD land base and detailed land cover analysis carried out in wetland areas. Land cover and land cover change were found as insufficient indicators of wetland loss. Detailed wetland loss was mapped from ortho-photographs in land cover change-targeted areas.

A full methodology for lost wetlands can be found in Appendix III. Figure 4.2 presents the flow of information to a photo-interpreter who delineates the wetlands deemed to be lost.

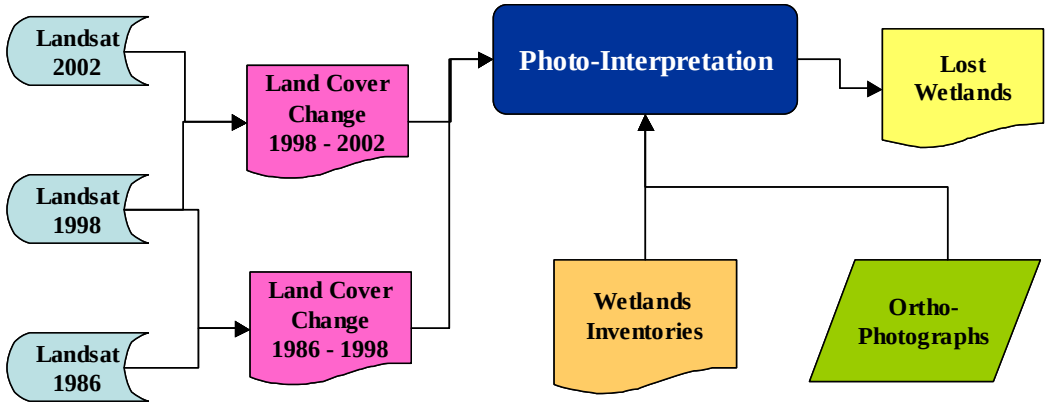
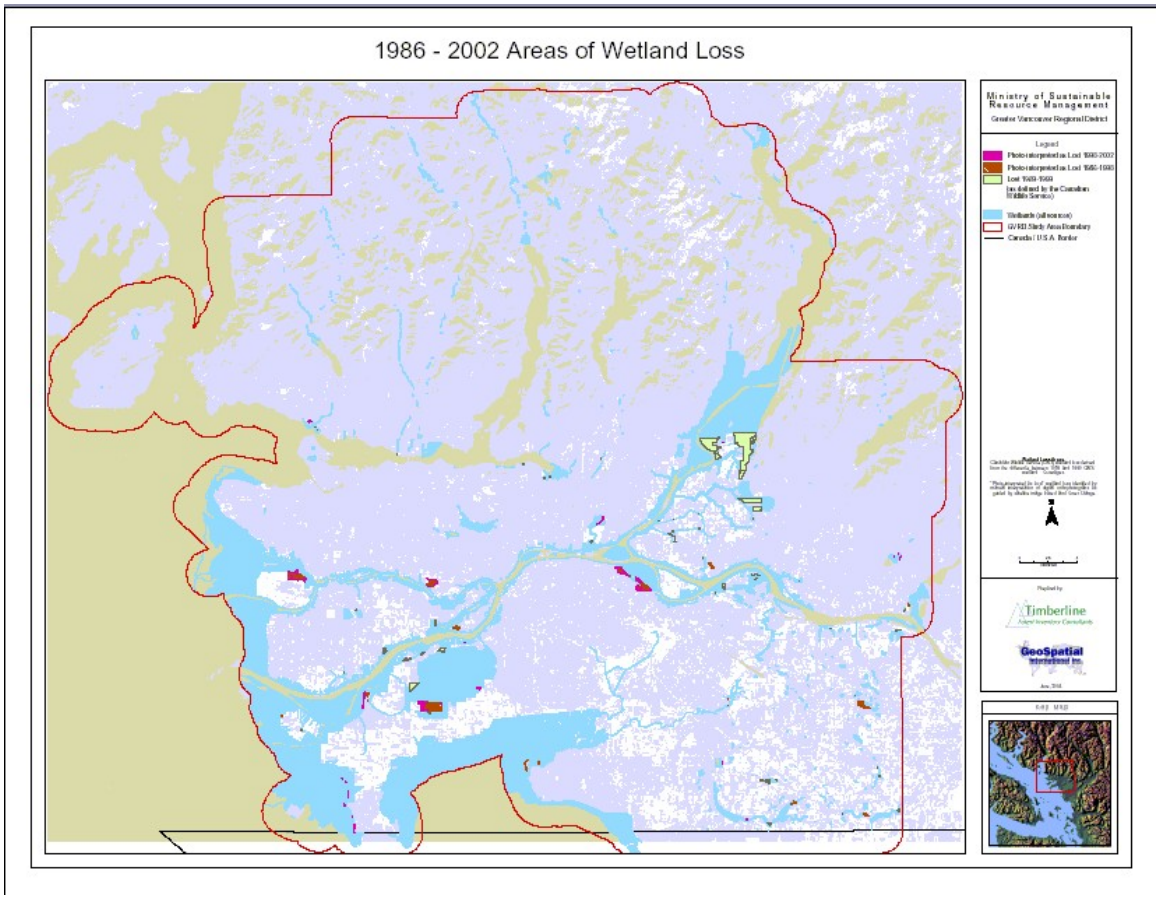


Figure 4.2 Project flow: lost wetlands

The composite wetlands mapping and lost wetlands in the GVRD are presented below.



4.3 FINDINGS AND DISCUSSION

Table 4.1 presents a wetlands and lost wetlands area summary for the GVRD area.

Table 4.1 GVRD wetlands area summary

	Total area (ha)	Area uniquely labeled (ha)
Wetland area reported	33,115	
Lost between 1986 and 1998	345	(177 ha unique)
Lost between 1998 and 2002	62	(30 ha unique)
CWS specified loss	908	(708 ha unique)
Total Wetland Loss	1,115	
Total Wetlands 2002	32,000	

Note: total wetland loss = unique 86_98 + unique 98_02 + total CWS specified

Total wetlands lost between 1986 and 2002 is determined to be 1,115 ha.

A comprehensive wetlands inventory was not undertaken by this project. Change as detected by satellite imagery is the basis for evaluation of lost wetlands and for this reason, the results include a conservative bias; that is, the area of lost wetlands is likely underestimated.

5.0 DEFORESTATION ANALYSIS

Deforestation is defined as the conversion of forested land to non-forested land as a direct result of human activities (Natural Resources Canada website: www.carbon.cfs.nrcan.gc.ca/definitions_e.html).

5.1 METHODOLOGY

The methodology used to map deforestation and land cover change between 1998 and 2002 followed general principles described in the *Deforestation Interpretation Guide (Version 2.0), Appendix C*. Different satellite image band combinations, computer screen layouts and image enhancements were tested. Delineation from 1998 digital ortho-imagery overlayed with 1998-2002 land cover change data at tested opacity thresholds was found as the optimal method. A second monitor showing various single date images was used as a reference. Due to the level of detail of used ortho-maps (0.5m), the confidence level of mapped deforestation events is high. Results are characterized by relatively small size of deforestation events for the given time period.

Figure 5.1 provides a simplified flow of information, which culminated in the deforestation analysis.

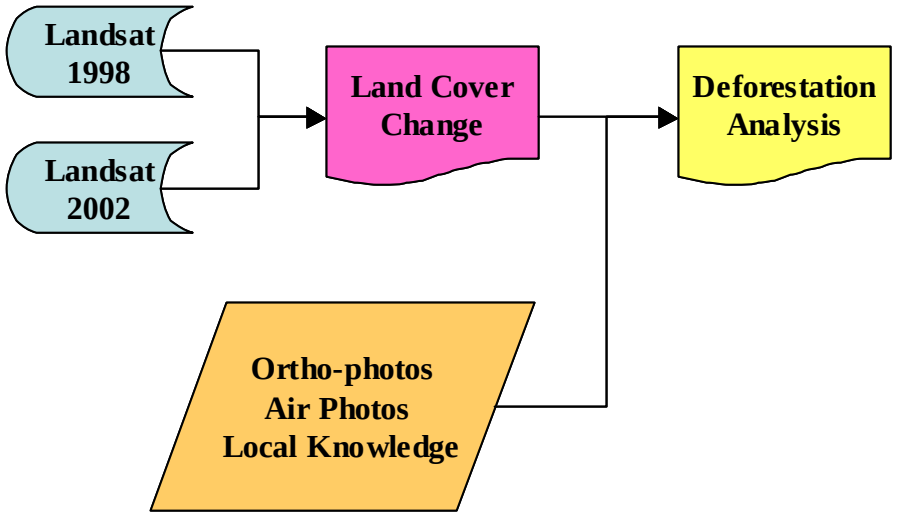
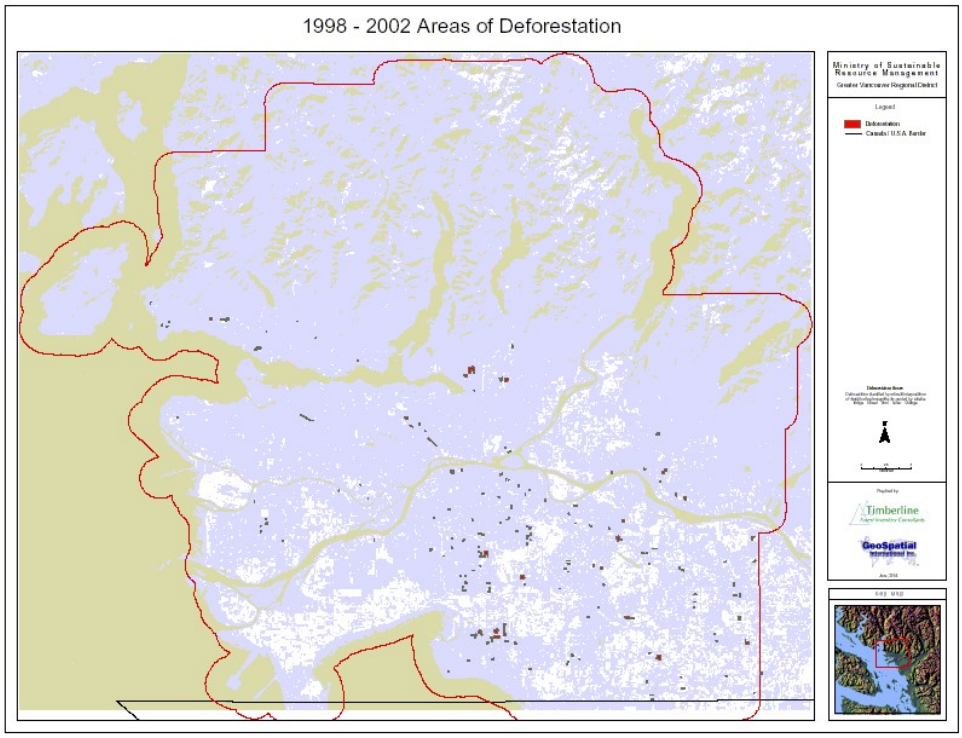


Figure 5.1 Project flow: deforestation analysis

Deforestation in the GVRD is presented below.



1998 to 2002

5.2 FINDINGS AND DISCUSSION

Table 5.1 presents summary for the GVRD area of deforestation.

Table 5.1 GVRD 98-02 deforestation area summary

From (Forest Type)	To (Land Use)	Area (ha)
Broadleaf	Agricultural use	59
Broadleaf	Corridors/right of way	13
Broadleaf	Open field	3
Broadleaf	Industrial	37
Broadleaf	Soil disturbance	26
Broadleaf	Urban/suburban residential	81
Coniferous	Agricultural use	4
Coniferous	Industrial	12
Coniferous	Recreational	5
Coniferous	Soil disturbance	3
Coniferous	Urban/suburban residential	40
Mixed	Agricultural use	35
Mixed	Open field	5
Mixed	Industrial	6
Mixed	Soil disturbance	19
Mixed	Urban/suburban residential	215
Total		**563**

Total area deforested is reported to be 563 ha.

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