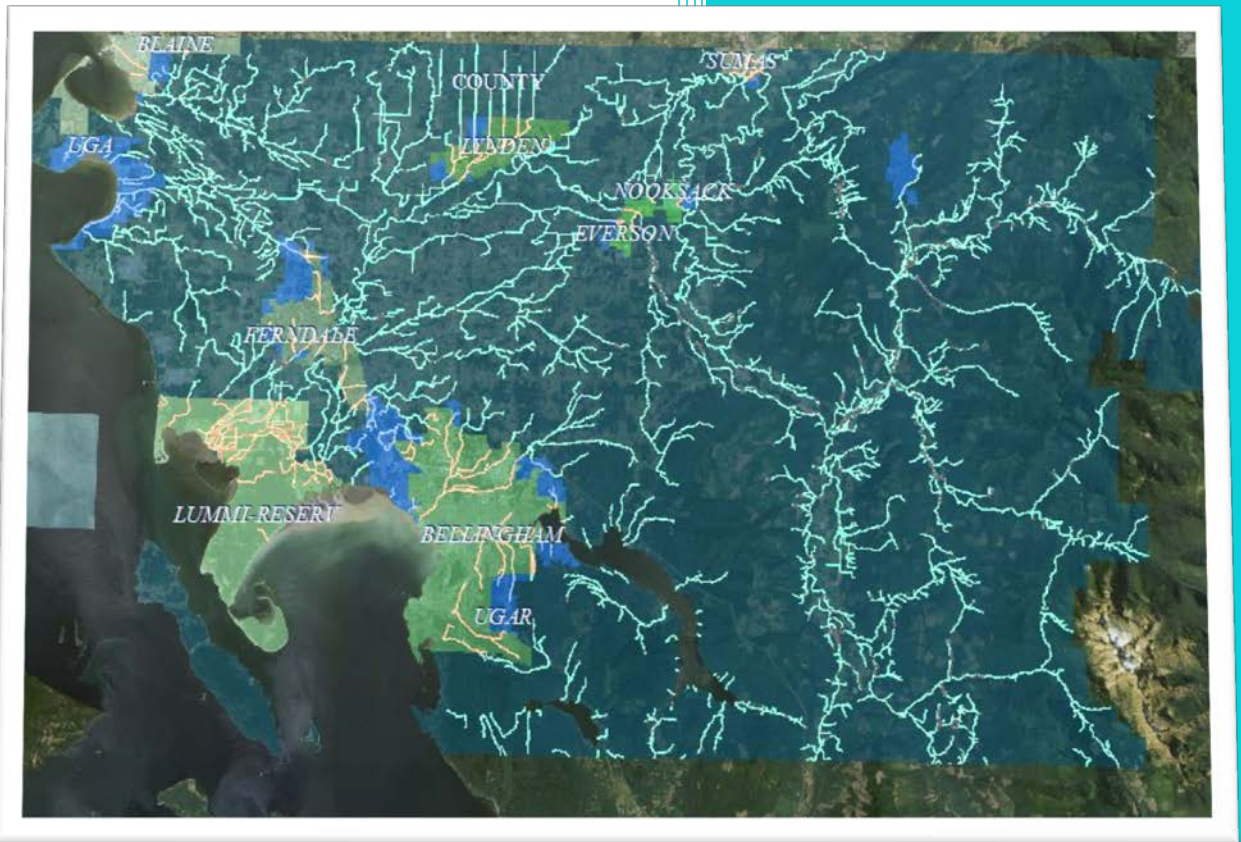


2006 to 2011

Whatcom County: Land Cover Change within Riparian Buffers



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Project Overview and Objectives

Land cover change in Whatcom County was quantified using the High Resolution Change Detection (HRCD) dataset developed by the Washington Department of Fish & Wildlife (WDFW). Based on comparing Washington statewide National Agricultural Imagery Program (NAIP) photography of two time periods, 2006 to 2009 and 2009 to 2011, images were separated into homogenous segments, automatically evaluated for probability of change then manually inspected for change and assigned attributes (i.e. initial land class, amount of change in polygon, and the change agent). The first iteration of the HRCD dataset, quantifying canopy loss and impervious surface increase within the Puget Sound watershed, a uniquely large scale, between 2006 and 2009 was completed in 2013. A pilot study has been initiated by WDFW to determine utility of the dataset for local partners to gauge interest for future HRCD time frames.

In collaboration with Whatcom County Planning and Development Services, a pilot application investigating land cover change within riparian buffers was developed. Using the Statewide Washington Integrated Fish Distribution (SWIFD) riverine map developed as a joint effort by WDFW and NWIFC, fish bearing streams and rivers were buffered in ArcGIS, observed change was then quantified and compared across relevant jurisdictional borders. The objective of this exercise is to provide a glimpse into riparian critical area ordinance effectiveness; this report is not meant to draw final conclusions, rather offer an opportunity to ask deeper land-use management questions. Table 1 attempts to summarize and compare observed land change between the three primary areas of interest in this report, inside and outside of a 100' riparian buffer and Whatcom County at large.

Table 1 Land cover change in Whatcom County between 2006 and 2011.

<i>Jurisdiction</i>	<i>Acres of Change per 1000 acres of SWIFD 0-100' buffer per year</i>	<i>Acres of Change per 1000 acres of SWIFD 100-200' buffer per year</i>	<i>Acres of Change per 1000 acres of zoning area* per year</i>
<i>County NonUGA</i>	2.15	2.49	5.44
<i>County UGA</i>	3.05	2.83	2.38
<i>City/Lummi</i>	2.95	2.84	3.74
<i>Total</i>	2.26	2.54	5.20

**Jurisdictional zoning area includes the SWIFD buffers.*

Land cover change event segments have a minimum mapping unit of ~0.05 acres (~2,180 sq. feet). Change agents for this report are classified as anthropogenic (i.e. development, tree removal, water mitigation structures, and re-development), commercial forestry and natural (i.e. stream course change). Initial land class for this report aggregates the HRCD attributes to vacant (bare ground, forest, herb/shrub, and other-natural) and built (mixed and non-mixed permanent human use).

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Land Cover Change in Whatcom County

Section 1: Change by Jurisdiction

Using the “current zoning” GIS layer from the Whatcom County website areas were aggregated into three large zoning jurisdictions based on the “Jurisdiction” and “WCPlan” attributes, Whatcom County Jurisdiction UGA and Non-UGA and City/Lummi reservation (Figure 1.1). Because different jurisdictions utilize different land-use regulations in different ways, these areas can have profound impacts on observed land cover change and associated ecological effects. This section summarizes observed land cover change by jurisdiction between the available HRC time periods (2006 to 2009 and 2009 to 2011), assigns probable change agents, what type of areas (i.e. initial land class) have experienced the change and an approximation of imperviousness per new person within a selection of cities in Whatcom County.

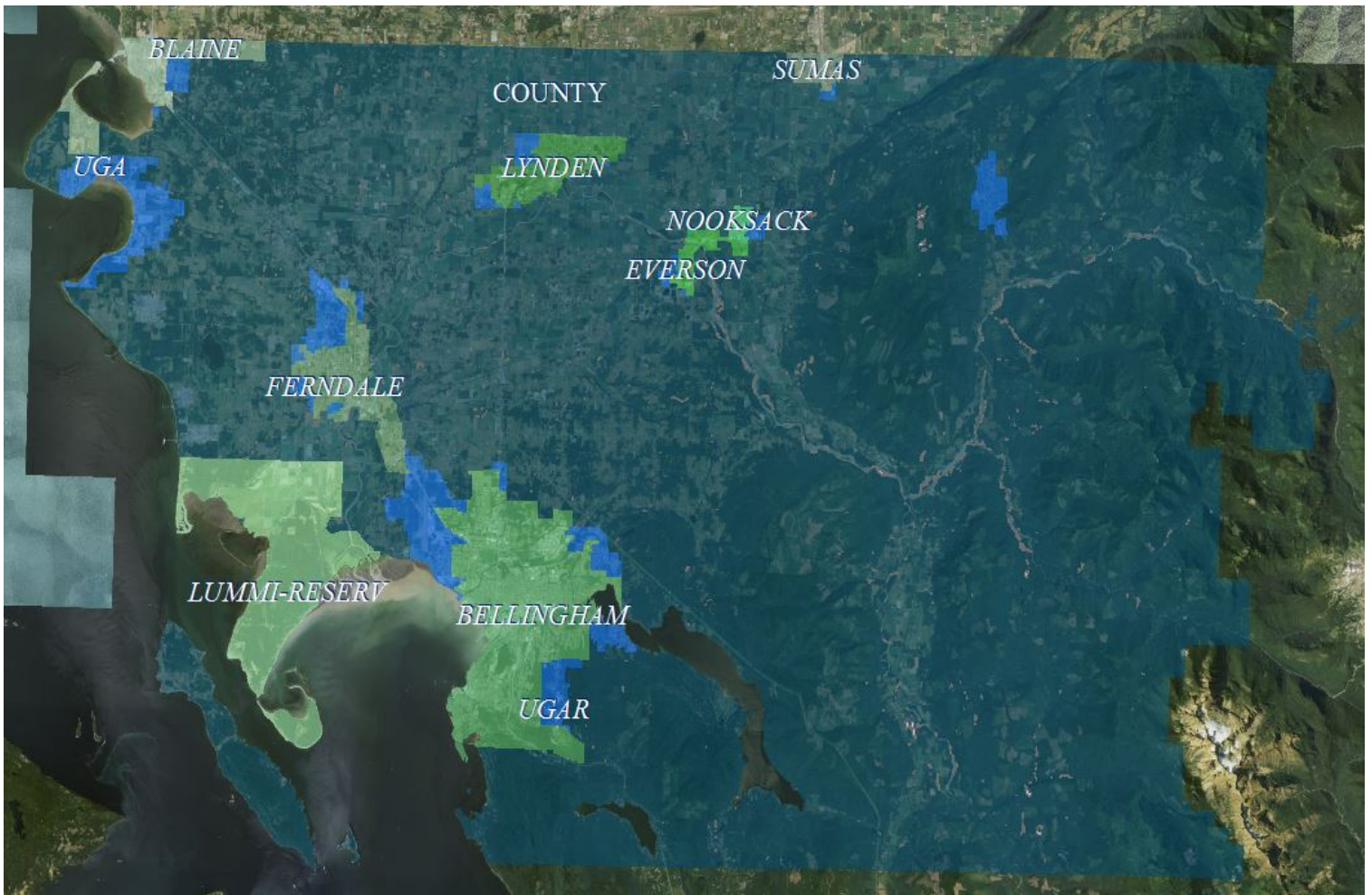


Figure 1.1 Extent of area examined for land cover change (Point Roberts not pictured but included for analysis). Whatcom County Non-UGA (steel blue), Whatcom County UGA (royal blue) and City and Lummi reservation (green).

Table 1.1 Land cover change events and area in Whatcom County observed within the two time periods of available HRCD data (2006 - 2009 and 2009 - 2011).

	Jurisdiction (acres)	Change Events	Total Change Area (acres)	Canopy Loss (acres)	Impervious Surface Increase (acres)	Change acres per 1000 acres of Jurisdictional Area per year
2006-2009		2199	5755.26	5603.02	148.16	3.81
County NonUGA	443635	1735	5025.92	4960.93	50.28	3.78
County UGA	14854	123	113.53	101.37	14.38	2.55
City/Lummi	45110	341	615.81	540.72	83.50	4.55
2009-2011		2727	7339.21	7068.85	191.57	7.29
County NonUGA	443635	1966	7047.88	6918.05	82.66	7.94
County UGA	14854	197	63.37	30.72	20.37	2.13
City/Lummi	45110	564	227.97	120.09	88.54	2.53
Grand Total	503599	4926	13094.47	12671.87	339.73	5.20

Table 1.2 Total Whatcom county land cover change between 2006 and 2011.

	Jurisdiction (acres)	Change Events	Total Change Area (acres)	Canopy Loss (acres)	Impervious Surface Increase (acres)	Change Acres per 1000 acres of Jurisdiction per year
County NonUGA	443,635	3,701	12,073.79	11,878.98	132.93	5.44
County UGA	14,854	320	176.90	132.09	34.76	2.38
City	45,111	905	843.78	660.81	172.04	3.74
BELLINGHAM	17,846	351	211.19	162.40	55.53	2.37
BLAINE	3,559	83	42.16	23.38	16.76	2.37
EVERSON	1,078	20	35.04	32.82	1.75	6.50
FERNDALE	4,553	157	137.39	88.16	45.29	6.04
LUMMI-RESERV	13,334	124	363.17	343.33	15.11	5.45
LYNDEN	3,374	137	41.37	9.18	28.87	2.45
NOOKSACK	435	11	2.69	0.22	1.92	1.24
SUMAS	932	22	10.77	1.30	6.81	2.31
Grand Total	548,711	4,926	13,094.47	12,671.87	339.73	4.77

Table 1.3 Total land cover change and canopy loss acreage between 2006 and 2011 broken down by likely change agent.

Change Agents	Change Events	Change Area (acres)	Canopy Loss (acres)
Anthropogenic (non-forestry)			
<i>Development</i>	1289	435.54	150.90
<i>Tree Removal</i>	2051	2836.52	2823.29
<i>Redevelopment</i>	66	20.29	1.30
<i>Stormwater Pond</i>	26	41.84	6.57
<i>Other - NonNatural</i>	220	46.37	0.18
Forestry			
<i>Forestry</i>	726	9280.39	9263.57
Natural			
<i>Stream</i>	366	352.16	344.73
<i>Other -Natural</i>	182	81.35	81.35
Grand Total	4926	13094.47	12671.87

Table 1.4 Anthropogenic (non-forestry) land cover change in Whatcom County between 2006 and 2011 based on initial land class. Data is aggregated into two categories: vacant (bare ground, mixed-not human use, forest and herb/shrub) and built (permanent human use).

<i>Anthropogenic (non-Forestry)</i>	Change Area (acres)	Percentage of where change occurs
Vacant	3266.49	96.63%
Built	114.07	3.37%
Grand Total	3380.57	100.00%

Table 1.5 Based on population estimates from Washington Office of Financial Management (OFM), approximate value of new imperviousness per capita in select cities within Whatcom County. Cities were chosen based on available population data and relative population similarities.

	2006 Pop.	2009 Pop.	2006 to 2009 Pop. Increase	Impervious surface increase (sq. ft.)	Square feet of imperviousness per each new person
Bellingham	75,562	79,383	3,821	1,496,722	392
Ferndale	10,406	11,281	875	968,339	1107
Lynden	10,811	11,789	978	551,470	564

Section 2: Change within SWIFD buffers

Using ArcGIS, buffers were drawn on SWIFD reaches in Whatcom County, 0 to 100 feet and 100 to 200 feet (Figure 2.1). HRCD polygons were then overlaid and intersected with the buffers (Figure 2.2) to quantify total change, canopy loss and impervious surface increase. The intersection resulted in a total of 1,216 change event polygons across the , however this figure is misleading as many of these polygons are representing parts of the same event only arbitrarily divided by the buffer polygons. Considering this then, 399 change events span both the 0 – 100’ and 100 – 200’ buffers. In addition, 138 change events were completely contained within the 0 – 100’ buffer, 280 change events were observed within the 100 – 200’ buffer and independent of the interior buffer. Land cover change area presumably has a more direct ecological impact and is therefore presented in detail for this section. Land cover change, including canopy loss and impervious surface increase is described by jurisdictional change and change agent.



Figure 2.1 Extent of buffered (0 -100' and 100 - 200') SWIFD reaches observed for land cover change.

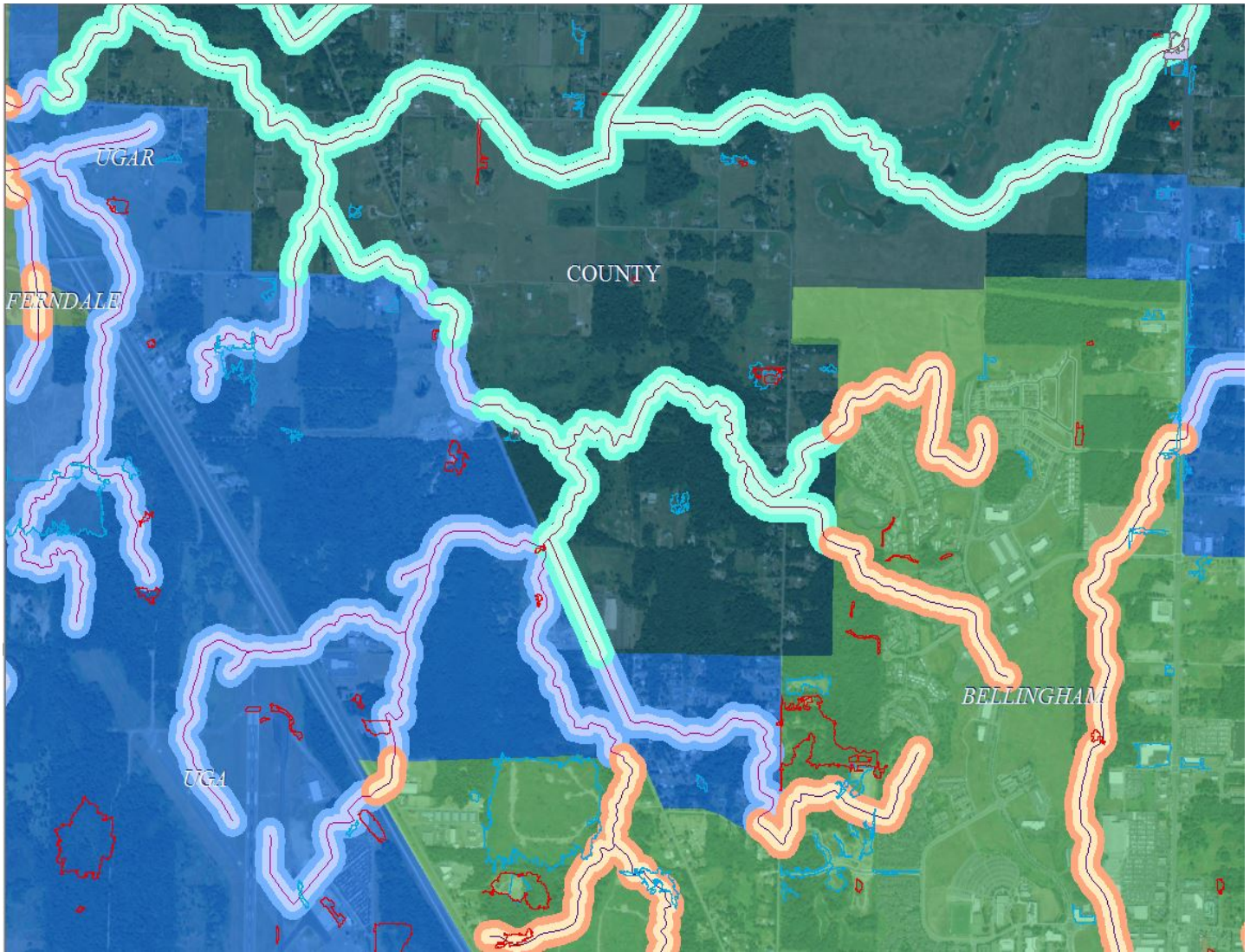


Figure 2.2 Example of drawn SWIFD buffers across some jurisdictional boundaries. Whatcom NonUGA (steel blue; teal SWIFD buffers), Whatcom UGAR (royal blue; purple SWIFD buffers) and City (green; orange SWIFD buffers). 2006 - 2009 change event locations are shown as blue polygons; 2009 to 2011 change event locations shown as red polygon.

Table 2.1 SWIFD buffer areas and total land cover change within Whatcom County SWIFD buffers.

	SWIFD Buffer Acreage		Change Area (acres)		Acres of Change per 1000 Acres of Buffer per Year	
	0 - 100'	100 - 200'	0 - 100'	100 - 200'	0 - 100'	100 - 200'
2006 - 2009			159.76	156.27	1.94	1.97
County Non-UGA	23656.88	22726.11	118.16	114.77	1.66	1.68
County UGA	906.02	954.14	7.44	8.56	2.74	2.99
City/Lummi	2850.40	2811.54	34.15	32.94	3.99	3.91
2009 - 2011			150.07	180.49	2.74	3.41
County Non-UGA	23656.88	22726.11	135.75	168.52	2.87	3.71
County UGA	906.02	954.14	6.37	4.95	3.51	2.60
City/Lummi	2850.40	2811.54	7.95	7.02	1.39	1.25
Grand Total	27413.29	26491.80	309.83	336.76	2.26	2.54

Table 2.2 SWIFD buffer areas and canopy cover loss within Whatcom County SWIFD buffers.

	SWIFD Buffer Acreage		Canopy Loss (acres)		Canopy Loss (acres) per 1000 Acres of Buffer per Year	
	0 - 100'	100 - 200'	0 - 100'	100 - 200'	0 - 100'	100 - 200'
2006 - 2009			154.18	151.65	1.87	1.91
County Non-UGA	23656.88	22726.11	114.46	112.19	1.61	1.65
County UGA	906.02	954.14	6.81	8.08	2.51	2.82
City/Lummi	2850.40	2811.54	32.91	31.37	3.85	3.72
2009 - 2011			144.68	169.49	2.64	3.20
County Non-UGA	23656.88	22726.11	133.20	162.75	2.82	3.58
County UGA	906.02	954.14	5.45	2.71	3.01	1.42
City/Lummi	2850.40	2811.54	6.04	4.03	1.06	0.72
Grand Total	27413.29	26491.80	298.86	321.14	2.18	2.42

Table 2.3 SWIFD buffer areas and impervious surface increase within Whatcom County SWIFD buffers.

	SWIFD Buffer Acreage		Impervious Surface Increase (acres)		Impervious Increase (acres) per 1000 Acres of Buffer per Year	
	0 - 100'	100 - 200'	0 - 100'	100 - 200'	0 - 100'	100 - 200'
2006 - 2009			3.87	4.30	0.05	0.05
County Non-UGA	23656.88	22726.11	2.09	1.87	0.03	0.03
County UGA	906.02	954.14	0.59	0.15	0.22	0.05
City/Lummi	2850.40	2811.54	1.20	2.28	0.14	0.27
2009 - 2011			2.31	7.42	0.05	0.16

County Non-UGA	23656.88	22726.11	1.39	4.66	0.77	2.44
County UGA	906.02	954.14	0.28	1.09	0.05	0.19
City/Lummi	2850.40	2811.54	0.64	1.67	0.01	0.03
Grand Total	27413.29	26491.80	6.19	11.72	0.05	0.09

Table 2.4 Land cover change within SWIFD buffers (all jurisdictions) by likely change agent.

2006-2009			
	0 - 100'	100 - 200'	Total Change within Buffers
Anthropogenic (non-forestry)			
<i>Development</i>	27.75	35.63	63.38
<i>Tree Removal</i>	82.07	116.60	198.68
<i>Redevelopment</i>		1.00	1.00
<i>Stormwater Pond</i>	1.75	1.75	3.50
<i>Other - NonNatural</i>	0.75	2.50	3.25
Forestry			
<i>Forestry</i>	6.94	19.35	26.29
Natural			
<i>Stream</i>	78.12	76.87	154.98
<i>Other - Natural</i>	9.22	10.22	19.43
2006 – 2009 Total	206.59	263.91	470.51
2009-2011			
	0 - 100'	100 - 200'	Total Change within Buffers
Anthropogenic (non-forestry)			
<i>Development</i>	20.50	38.88	59.38
<i>Tree Removal</i>	41.55	57.30	98.85
<i>Redevelopment</i>	1.50	1.50	3.00
<i>Stormwater Pond</i>	2.00	4.50	6.50
<i>Other - NonNatural</i>	9.00	11.25	20.25
Forestry			
<i>Forestry</i>	21.75	29.22	50.97
Natural			
<i>Stream</i>	67.24	72.20	139.44
<i>Other - Natural</i>	6.50	7.25	13.75
2009 - 2011 Total	170.04	222.10	392.13

Appendix

Table A.1. 2006 – 2011 change in acres within SWIFD buffers in Whatcom County Non-UGA areas.

Buffer Distance	0 - 100'			100 - 200'		
Buffer Acreage	23656.88			22726.11		
County Non-UGA	Total Change	Canopy Loss	Impervious Surface Increase	Total Change	Canopy Loss	Impervious Surface Increase
Anthropogenic (non-forestry)	77.83	71.77	3.33	106.63	98.51	6.24
Forestry	56.54	56.35	0.16	90.01	89.78	0.30
Natural	119.54	119.54	0.00	86.65	86.65	0.00
Grand Total	253.92	247.65	3.49	283.29	274.94	6.53

Table A.2 2006 – 2011 change in acres within SWIFD buffers in Whatcom County UGA areas.

Buffer Distance	0 - 100'			100 - 200'		
Buffer Acreage	906.02			954.14		
County UGA	Total Change	Canopy Loss	Impervious Surface Increase	Total Change	Canopy Loss	Impervious Surface Increase
Anthropogenic (non-forestry)	13.72	12.17	0.87	13.06	10.35	1.24
Natural	0.09	0.09	0.00	0.45	0.45	0.00
Grand Total	13.81	12.26	0.87	13.51	10.80	1.24

Table A.3 2006 - 2011 change in acres within SWIFD buffers in City and Lummi jurisdictional areas.

Buffer Distance	0 - 100'			100 - 200'		
Buffer Acreage	2850.40			2811.54		
City/Lummi	Total Change	Canopy Loss	Impervious Surface Increase	Total Change	Canopy Loss	Impervious Surface Increase
Anthropogenic (non-forestry)	38.97	35.82	1.83	38.54	34.13	3.88
Forestry	0.00	0.00	0.00	0.22	0.07	0.07
Natural	3.13	3.13	0.00	1.19	1.19	0.00
Grand Total	42.10	38.95	1.83	39.95	35.40	3.95