Mapping riparian land use within agricultural zones: A case study in Skagit County

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Abstract

As part of Skagit County's salmon policy resolution, the GIS department was directed to map the land use in the riparian zones of Agriculture and Rural Natural resource lands. The analysis was performed using the time consuming method of heads-up digitizing from high-resolution aerial photos. Over 16,000 acres were digitized of which 8,000 acres were found to be within a standard buffer distance of 200' from Type 1 streams, 100' from Type 2 and 3 streams, and 50' from Type 4 streams. Within the standard buffer, 22% is in agricultural land use and 73% is forested, wetland or fallow. Of the agriculture land use, 42 acres are already protected, 75 acres are publicly-owned, and 64 acres are functionally separated from the watercourse—totaling 10% of the total agriculture land cover. Variations among regions of agriculture land use varied from 13% in the Sauk region to 35% in the Nookachamps region. The results of this study were compared to other land use analysis created using satellite data and found that those coarser studies overestimated agricultural land use by as much as 289%. While this approach is time-consuming, the information gathered is both useful and unique for assessing riparian land cover. This data will be useful in policy discussions and future planning of riparian protection programs.

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History of Skagit County debates

Background

Skagit County is required by the Washington State Growth Management Act to designate and protect critical areas—wetlands, aquifer recharge areas, fish and wildlife habitat conservation areas, frequently-flooded areas, and geologically hazardous areas. Fish and wildlife habitat areas and wetlands are especially important to healthy salmon populations, including the threatened Chinook species.

Many jurisdictions protect streams and other critical areas using mandatory buffers—strips of land bordering the stream where development or farming is not allowed. Like most jurisdictions, Skagit County requires riparian buffers for almost every zoning classification. But due to a lack of consensus between environmental agencies and farmers on the costs and benefits of buffers and because buffers can impose a heavy burden on agriculture, Skagit County currently does not require farmers to install riparian buffers on actively-farmed agricultural lands where the riparian area was legally cleared many years earlier. Instead, Skagit County requires agriculture to comply with watercourse protection measures designed to prevent harm to critical areas without buffers. Skagit County uses a monitoring and adaptive management approach to ensure its watercourse protection measures are effective. The county monitors streams for water and habitat quality and envisions modifying the protective measures if they fail to preserve existing habitat quality. The Washington State Supreme Court has upheld this approach, but not Skagit County's implementation of it.

Ruckelshaus Center SSB 5248 Process

In May 2007, the Legislature passed SSB 5248, creating a three-year "time out" to the ongoing controversy and litigation over riparian buffers on agricultural land. During the time-out, various stakeholders are participating in a collaborative process at the UW/WSU William D. Ruckelshaus Center, with the intent of creating a uniform and equitable plan for protecting riparian habitat in agricultural areas. Because Skagit County is squarely in the center of this statewide Growth Management Act dispute, the County has made the Ruckelshaus Center process a high priority.

Salmon Policy Resolution

On October 8, 2007, the Skagit County Commissioners approved Resolution R20070499, directing county departments to proactively pursue salmon recovery efforts. The resolution directs County departments to consider the Puget Sound Salmon Recovery Plan in all their actions, and pursue grant funds for salmon habitat enhancement. County departments must consider adoption of measures to implement their recommendations whenever reasonable. Such measures may include enhancing riparian habitat when it is reasonable while working on adjacent country roads and controlling drainage, training road crews in Best Management Practices, preventing spraying harmful pesticides near salmon streams, enhancing riparian habitat within county-owned lands, acquiring habitat

adjacent to county parks, and integrating education about salmon issues into interpretive centers and road signs. The resolution also requires county departments to report annually to the Board of Commissioners about the salmon recovery measures those departments have accomplished during the preceding year.

R20070499: Riparian Mapping Project : Section 3 *"…Geographic Information Systems shall, by June 1, 2008, assess riparian areas in the AG-NRL and RR-NRL zones to determine existing buffer type and width…"*

The Salmon Policy Resolution directed the county's Geographic Information Systems (GIS) department to undertake a large-scale mapping project of riparian areas on agricultural and natural resource lands within the Skagit River watershed (some 770 miles of watercourse). Titled the Skagit Watershed Ag/RRc-NRL Riparian Mapping Project, the resolution specifies that the project will determine the following:

1) existing riparian buffers
2) existing roads, buildings and structures that would preclude riparian buffers

Beyond its applications for the Ruckelshaus Center process, Skagit County intends to use the results of this project to evaluate the current status of riparian habitat in the Skagit River Basin, and to prioritize and focus efforts to protect and enhance riparian areas.

Methods

Study area

Skagit County is located in northwest Washington State and covers a varying landscape that includes marine areas in the Puget Sound to alpine areas along the Cascade Mountains crest. The county is roughly 1.2 million acres in size with the majority of its 116,000 people living in the western lowlands. Through the middle of the county runs the Skagit River, one of the largest rivers on the U.S. west coast. The Skagit watershed is over 3,000 square miles and draws from three counties and a portion of Canada (figure 1). On average the river discharges 16,540 cubic ft/sec of water, but during times of flooding discharge rates can be over 160,000 cubic ft/sec (USGS 2006).

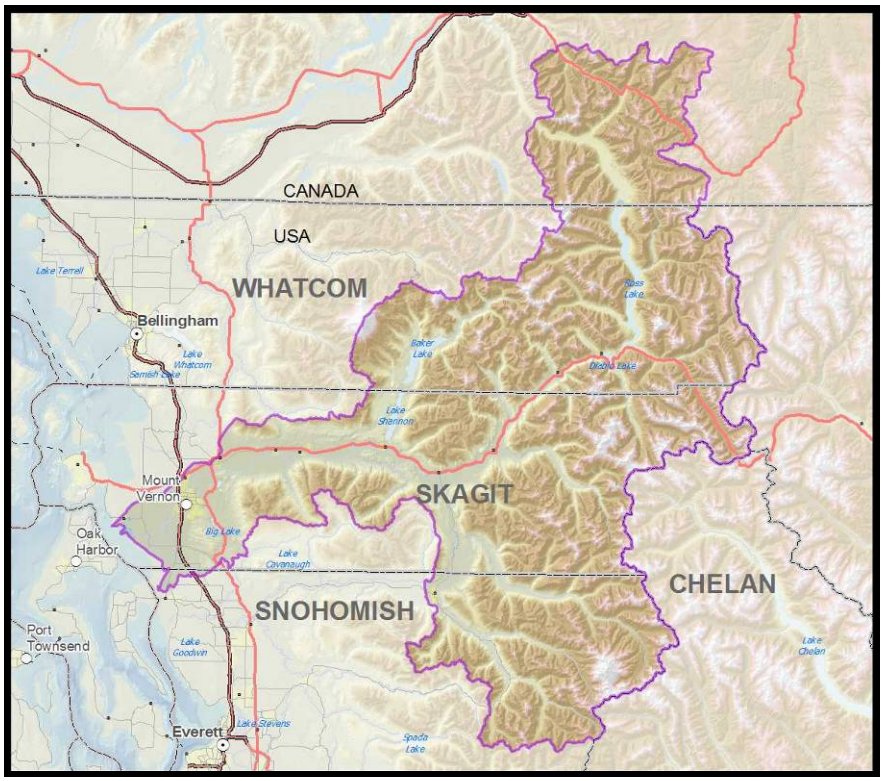


Figure 1. Skagit River watershed

The Skagit River is the only large river in Washington to have all five species of native salmon as well as two species of trout. While much of the upper watershed is undeveloped, the lower Skagit has experienced development pressures by increased population and retail services. The lower delta also has a long history of agricultural activity including tulips, seeds, potatoes and berries. The middle Skagit River between Sedro-Woolley and Marblemount is a mix of smaller farms that also include dairy and beef production, hay fields, and a large number of “hobby” farms with horses.

Zones and areas to be included in analysis

The focus of this study is limited by several factors. The first factor is the zoning area to be assessed. Only areas that are in the Comprehensive Plan zones of Agriculture (Ag-NrL) and Rural Resource (RRc-NRL) zoning will be evaluated. Riparian and critical areas in the other zones are already protected under the County’s critical areas ordinance (Skagit County Code 14.24). Agriculture zoning covers 87,688 acres and Rural Resource zoning covers 26,872 acres (figure 2).

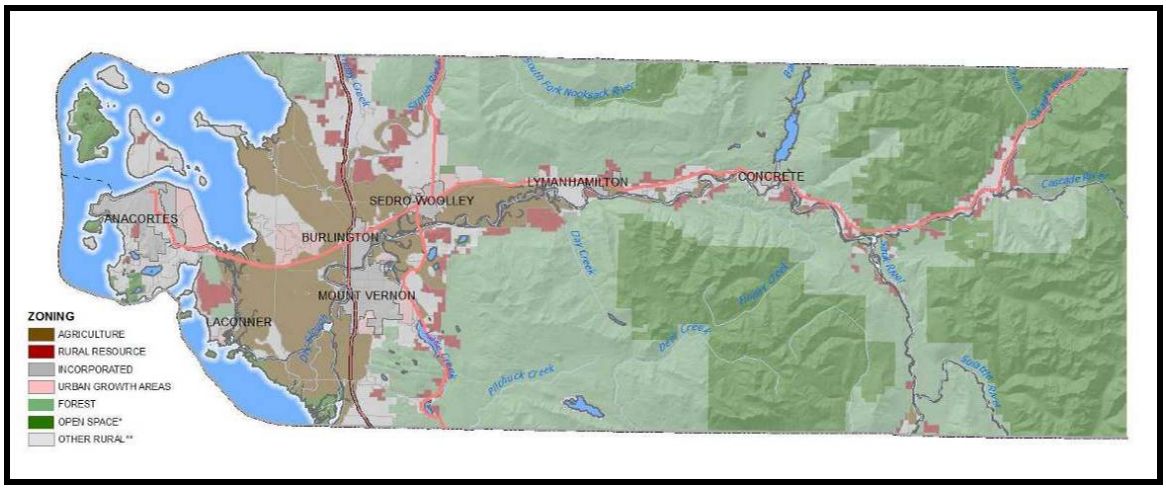


Figure 2. Comprehensive Plan Zones for Skagit County.

Other area to be examined include unincorporated areas, areas outside the Skagit Tidegate and Fish Initiative agreement, and watercourses that are not typed 1 through 4 by the Washington State Department of Natural Resources.

Table 1. Areas included in study.

Included Zone	Data Source
In Ag-Nrl or RRc-Nrl	Comprehensive Growth Plan
Unincorporated Skagit County (not cities)	Legal description of cities
Within 300' of watercourses typed 1 through 4	Buffer of counties hydro data
Outside drainage districts with a Fish and Wildlife agreement (Skagit Delta Tidegates and Fish Initiative).	Assessor database on special taxes paid for each property

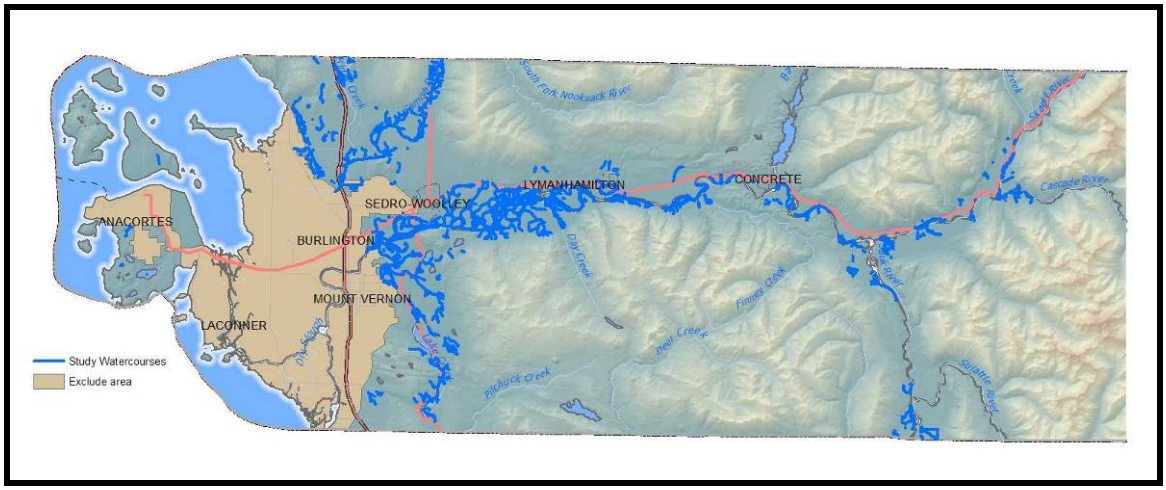


Figure 3. Watercourses evaluated in the study area with the exclusion of incorporated areas and drainage districts.

Hydrology data

The original source of the hydrology data was the Washington State Department of Natural Resources. Skagit County has been making corrections to the data and the data is now maintained in-house and is available to the public through the county's web site (see literature citations for exact address).

Watercourses that are in the study area were verified for location using 2007 aerial photography. Many of these watercourses were previously corrected using older photography and field verification. It was important for this project that the stream location and land cover were verified using the same photography so that the analysis between the two will match.

Typing definitions:
Water Type Code - refer to Washington Administrative Code (WAC 222-16-31)

- Type 1 - All waters, within their ordinary high-water mark, as inventoried as "shorelines of the state" under chapter 90.58 RCW.
- Type 2 - Segments of natural waters which are not classified as Type 1 Water and have a high fish, wildlife or human use.
- Type 3 - Segments of natural waters which are not classified as Type 1 or Type 2 Waters and have a moderate to slight fish, wildlife, or human use.
- Type 4 - All segments of natural waters within the bankfull width of defined channels that are perennial nonfish habitat streams. Perennial streams are flowing waters that do not go dry any time of a year of normal rainfall and include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow.
- Type 5 - All segments of natural waters within the bankfull width of defined channels that are not Type 1, 2, 3, or 4 Waters.
- Type 9 - Unclassified water feature.

In addition, typing updates were provided by Skagit River System Cooperative and were integrated with the DNR typings. This updating was only done in the watercourses that would be used for this analysis.

Aerial photo available

Skagit County acquired aerial photos in March and April of 2007 by contracting with Pictometry International. Pictometry flew the county with a set of digital cameras that take photos in the traditional straight down orientations as well as a 40-degree angle out the side of the airplane. These photos are georegistered using a combination of airborne GPS, IMU and a digital elevation model of the earth's surface. The resulting orthophotos are one foot color, and the oblique photos have variable resolution but are invaluable for determining land use and land class information.

Heads-up digitizing versus automatic classification

The technique of performing a land cover or land use classification falls into one of two main styles. Heads-up digitizing is the oldest method and requires a person to evaluate

photos and draw lines around the boundaries of the different classes. The accuracy of this approach will depend on the quality of the photos and the skill of the digitizer.

A newer technique is to use a computer to analyze the image and determine the classes or at least the boundaries of the classes. This automatic approach can often be faster and also more systematic and therefore easier to repeat. Computer derived classification is more common with lower resolution satellite images but software programs and techniques have been developed to assist in classifying higher resolution data.

Automated techniques were attempted to be used on the 2007 imagery that the county owns but the results were not accurate enough for this project. Boundaries tended to be very small in area, or covering multiple classes. The detail of classification required for this project required the use of the more time consuming heads-up digitizing approach. This approach also allowed the oblique photos to be used since there are not any software programs readily available that can use multiple oblique photos along with traditional orthophotos to classify land cover.

Land use classes

All areas within the study area were classed into one of the following categories:

Agricultural Land use

- Crop/Dirt Field
- Forested Pasture
- Mowed/Grazed Field

Non-Agricultural Land Use

- General Wetland
- Grassland/Field
- Low Shrub/Tree
- Deciduous Trees
- Mixed Trees
- Evergreen Trees
- Residential
- Commercial
- Building
- Road
- Timber Harvest
- Open Water
- Dike
- Dirt

Class Descriptions

Crop/Dirt Field – Agricultural activities that have disturbed the soil for planting a crop.

Figure 4. Example of Crop/Dirt Field land use

Forested Pasture – Areas that have trees but also evidence of grazing by cattle or horses which would be considered agricultural use. This is a difficult category to determine from the aerial photos that are snap shot in time. But in the cases where it seemed clear that the area had grazing under the trees this category was selected.

Figure 5. Example of Forested Pasture land use .

Mowed/Grazed Field- Areas that have been mowed for what appears to be agricultural activities. Alternatively, areas that have been mowed and are large enough that they would require a tractor to be mowed would also be in this group. This category also includes grazing of livestock. Differentiating between this category and the non-agriculture Grassland/Field category can be difficult but is usually determined by lack of senescent grasses, occurrence of ground patterns from tractors or animals, and in some cases enrollment in the open space agriculture program.

Figure 6. Example of Mowed/Grazed Field land use

General Wetland – A broad category that would include standing water that has vegetation in it, or several small open water areas that are not individually large enough to count as open water.

Figure 7. Example of General Wetland land use.

Grassland/Field – Open grass areas that are not being used for agricultural purposes or have any annual disturbance from mowing. This class is very similar to the Agricultural Mowed/Grazed Field class. The main difference visually is the presence of senescent grasses, occasional small shrubs or blackberries. This class can also include grass areas such as along roads which are mowed but not being used for agricultural purposes.

Figure 8. Example of Grassland/Field class.

Low Shrub/Tree – Areas that have a predominance of shrubs or small trees. Usually not 100% cover of shrubs and is therefore a mix of some classes in many examples. This class can contain mature trees but usually only individual trees that are surrounded by a mixture of grass and shrubs. There are many examples of this class in areas that are no longer being mowed regularly and natural succession has occurred allowing blackberries and small trees to establish. This class also includes small planted trees that are being planted for conservation buffers such as the CREP program.

Figure 9. Example of Low Shrub/Tree classes. The two on the left are more natural shrubs and the one on the right is an example of a planted conservation project.

Deciduous Trees - Areas that have only deciduous trees that are over 10-15' tall and cover more than 50% of the area.

Figure 10. Example of Deciduous Trees class.

Mixed Trees – Forested areas that have a tree density of over 50% and trees that are taller than 10 to 15 feet tall but contain a mix of deciduous and evergreen trees. The actual proportion of deciduous to evergreen can vary greatly but does not contain only one or the other. The boundary of this class can be subjective and often blends with low shrub.

Figure 11. Example of Mixed trees.

Evergreen Trees - Forested areas that have a tree density of over 50% and trees that are taller than 10 to 15 feet tall with predominantly evergreen trees visible.

Figure 12. Example of Evergreen Trees class

Residential – This class is a catch all for the land use types associated with residential homes. Cover types can include driveways, houses, accessory dwellings, lawns and personal gardens and small orchards. These varied land uses fall under a different portion of the Counties Critical Ordinance than the Agriculture regulations and so the exact details of the residential land uses were not separated from each other. In some cases a field that may be mowed for residential uses but the field is larger than what would be mowed with a residential mower, than the field would be classed as *grassland/field*.

Figure 13. Example of residential class.

Commercial – Activities that are more intense use of the land than residential although some of the properties may not be commercial in terms of a business. Large numbers of out buildings, access roads, abandoned vehicles or excessive paved areas would be grouped into this class. Some overlap with *residential class* and in some cases the commercial class does include a residence.

Figure 14. Example of commercial class

Building – Buildings that are mostly freestanding and not a part of a residential or commercial activity. Often these are barns in fields or storage sheds separated from other activities. The extent of the class covers only the structure of the building and not paths, driveways or access for the building.

Figure 15. Example of Building land class.

Dirt – Areas that have exposed dirt that is not being used for agricultural purposes are classed as *dirt*. Determining how a dirt area is being used it based on observation of a lack of indicators typically found in agricultural practices. These indicators include: rows and paths from plowing, proximity of barns, overall size, and open space taxation program enrollment.

Figure 16. Example of dirt class.

Road – Road classes include public and private roads that are paved and if dirt are significant in size and construction so as to make the relocation of the road an expense. The area of road "disturbance" is included (shoulder and pull outs) and not any additional right of way property. Driveways that are a part of residential area are not always included in road classes. Road class can also include railroad tracks and larger maintained trails.

Figure 17. Example of road class.

Timber Harvest – Areas that have clear timber harvest evidence and not much regrowth. Once the planted area has established, these areas are often classed as Low Shrub/tree. Typical land cover is bare and disturbed soils with down and dead wood debris.

Figure 18. Example of Timber Harvest class

Open Water – Waterbodies wider than 40' are classed as open water. The photo being used were taken in late March and Early April when there is more free standing water on the ground. In some cases the open water areas may diminish or disappear altogether by August. If grass is seen in the water body it would not be considered open water since the grass could not grow with continuous water cover. In some cases the open water is part of the buffer area if there was not a perimeter line used on the water body (figure 21). The preferred alternative is to have the perimeter of the waterbody in the Hydrology dataset so that the buffer is made from the edge of the water and not the centerline of the waterbody (figure 22).

Figure 19. Example of open water class.

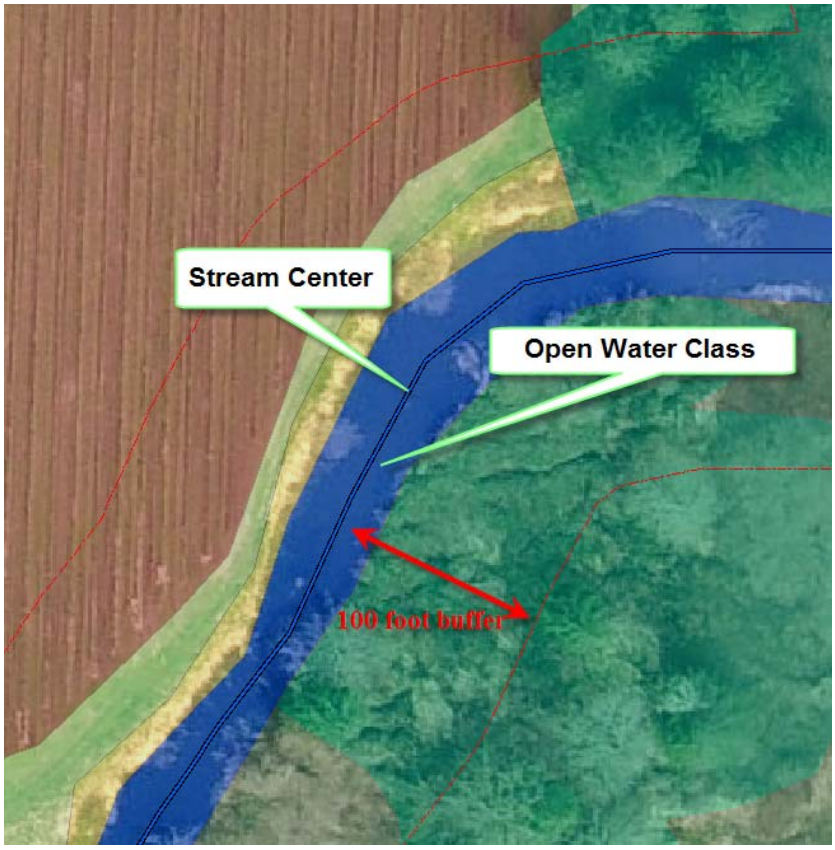


Figure 21. Snapshot of classes showing how some of the area within the buffer of a stream without a perimeter line (most of those less than 40' wide) can actually be the open water of the stream. Optimally the edge of the watercourse would have been mapped and extend the buffer from the perimeter of the watercourse and not the center.

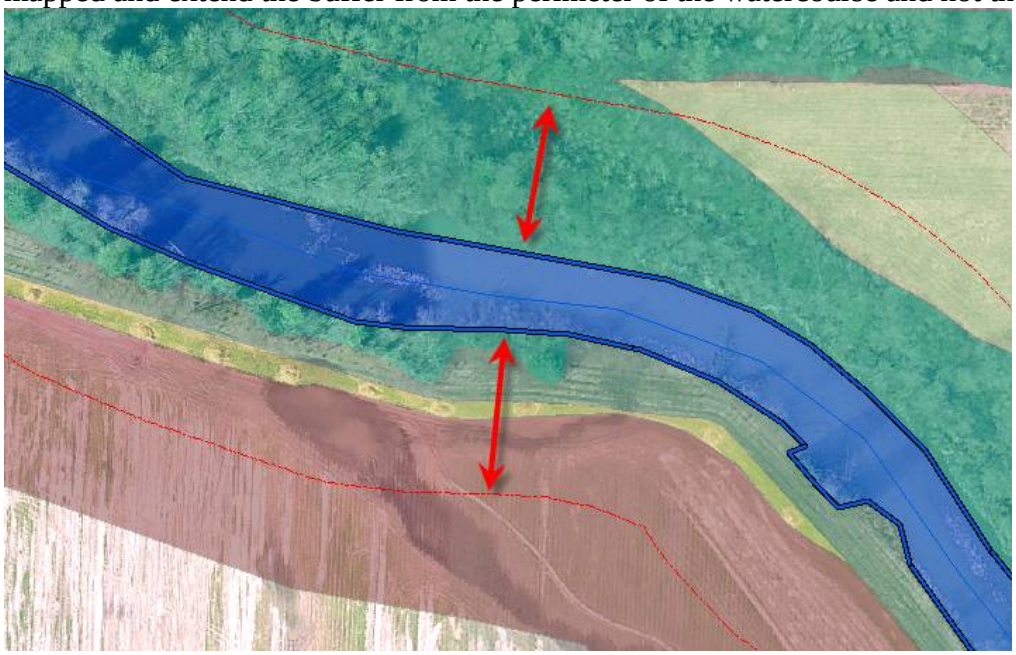


Figure 22. Buffer distances when the hydrology dataset includes a perimeter line.

Dike – Areas where the land has been elevated to control water flow or to protect against flooding. These areas are often mowed as part of the annual maintenance. Almost all the dikes in the study area for this project are outside the official dike district areas and are mostly

Figure 23. Example of *dike* class.

Study Regions

To assess the variability of land cover results in the study, regions were created based on natural breaks in topography and zoning (figure 23). These regions divide the study area into seven discrete areas that are essentially watershed-oriented. Land cover within each of the regions was analyzed separately to see if patterns are consistent for the entire area or if there are regional differences.

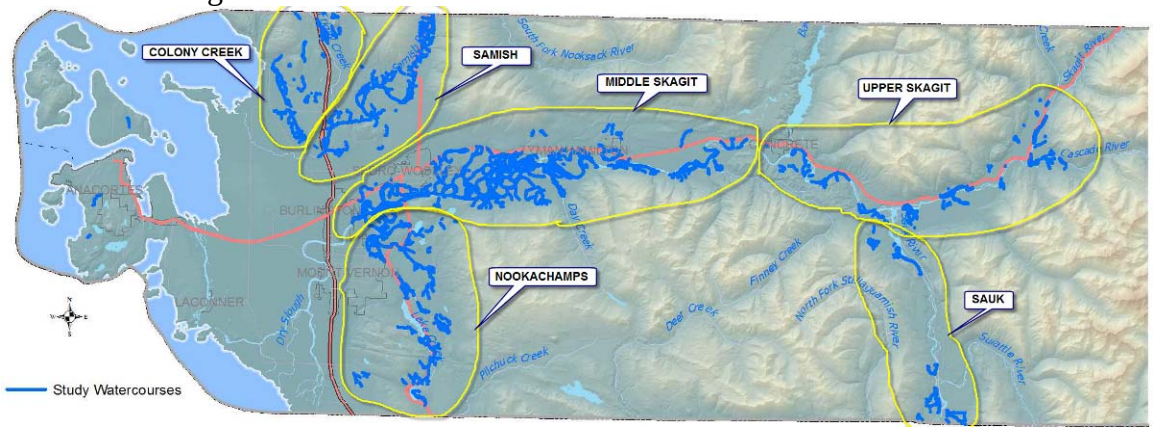


Figure 23. Six regions that are created to assess variations within the study area.

No Functions or Values

The Skagit County planning department has an allowance for areas that are physically separated from the watercourse as having “no –functions or values”. These areas can be on the far side of a road, behind existing dwellings, or other pre-existing development that would restrict the major benefits that a protected buffer could provide to a watercourse. These areas are determined on a case by case basis and use many factors before a determination is made by the building official. An estimate of how much non-functional area exists will be useful when determining both available buffer areas as well as any future prioritization of buffer acquisition programs.

Buffers

Buffers have a definition regarding riparian areas but also a slightly different meaning in terms of GIS analysis. A buffer zone in GIS analysis refers to an area of a specified width drawn around a map element (Aronoff 1989). In this analysis the buffer zones were drawn around the stream lines to find the land areas that are in specified distances from the streams. These distances can vary by stream type as shown in figure 24, and can also have multiple distances as shown in figure 25.

Figure 24 Example of buffers created at varying widths based on stream type.

Both distance types of buffering analysis were performed. The varying width buffers were created with distances to match current county regulations with the exclusion of Type 5 streams. SCC 14.24.530.

Table 2. Distances used from watercourse as “standard buffer”

STREAM TYPE	DISTANCE
Type 1 & 2	200 feet
Type 3	100 feet
Type 4	50 feet
Type 5	Not measured

The multiple buffer distance technique was made with buffers that were 25, 50, 75, 100, 150 feet from all watercourses in the study area (Types 1-4).

Figure 25. Example of multiple buffer distances around a single watercourse to assess how land cover changes with increasing distance from the watercourse.

Protected and Public Properties

Skagit County has a variety of organizations that have been working on protecting properties from development. In addition there are many properties that are owned by public organizations. Public lands seem to be an obvious priority for riparian improvements since they would have little impact on an individual land owner. Some have argued that there are a lot of public lands inside these buffer zones so a quantitative analysis of these public lands is an important part of the riparian discussion.

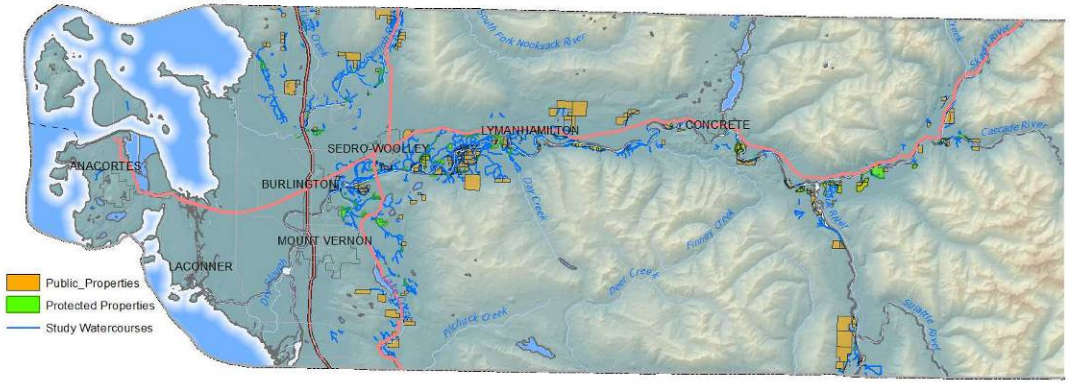


Figure 26. Protected and Public Owned properties in the study area.

Results

This process took about 1,000 hours of fairly tedious work. Up to three people were able to work at one time on the data, although most of the work was done by one person. There were noticeable differences between the three users as far as detail of delineation typing of land classes, but overall the variations would not change the final results.

Land cover results

Over 16,000 acres of land were classified using heads-up digitizing methods.
Open water that existed in the hydro data was not used in any calculations (water areas of ponds, lakes and Skagit river). Open water that was significant in area (greater than 40 feet across) along streams was digitized as open water and although this area is reported in land cover calculations it is not used in overall percent analysis. The water is considered part of the stream and not part of the land cover of the buffer.

Results of land cover analysis using “standard” buffer widths:
Type 1 & 2 – 200 feet
Type 3 – 100 feet
Type 4 – 50 feet

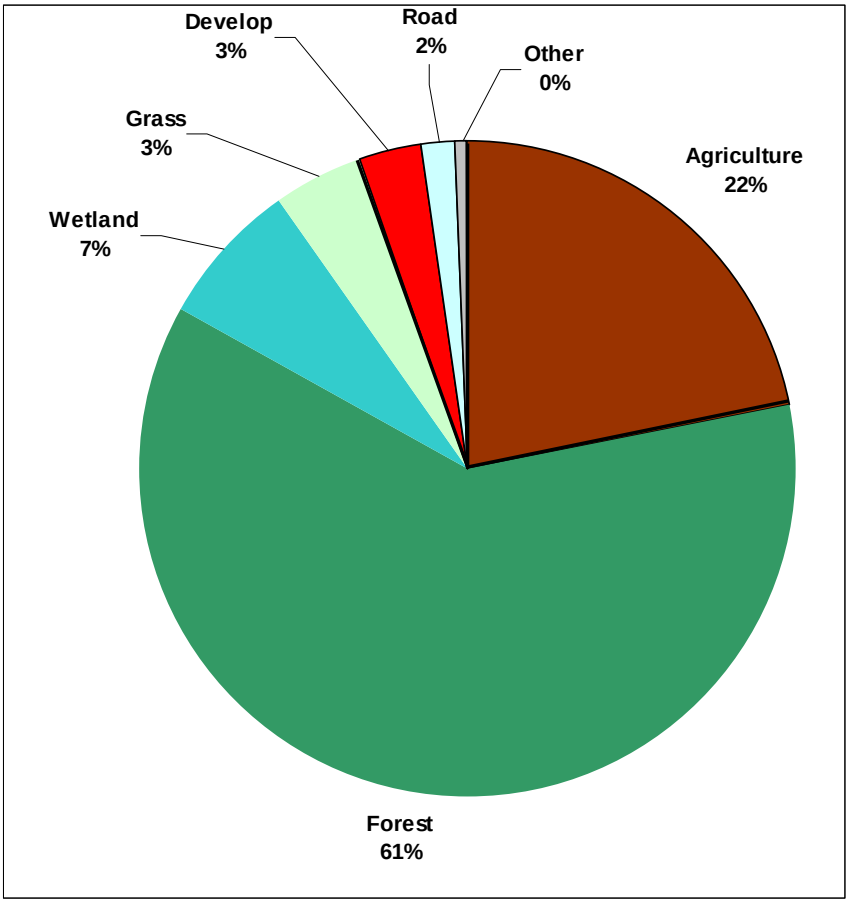
Total area in the buffer was 8,197 acres but that includes some open water areas.
Open water was not used in calculations of percent cover, which leaves 8,031 acres of buffer area. Land cover values by class are shown in table 3.

Table 3. Land use within standard buffer widths.

Land Cover	Category	Acres	% Cover
Mowed/Grazed Field	AG	1312.76	16.35
Crop/Dirt Field	AG	438.55	5.46
Forested Pasture	AG	14.67	0.18
Road	Road	139.65	1.74
Residential	Dev	185.52	2.31
Building	Dev	1.38	0.02
Commercial	Dev	57.34	0.71
Low Shrub/Tree	Forest	718.06	8.94
Mature evergreen forest	Forest	140.23	1.75
Mature Mixed forest	Forest	2136.28	26.60
Mature Deciduous forest	Forest	1907.97	23.76
General Wetland	Wetland	583.36	7.26
Dirt	Grass	41.17	0.51
Grassland/Field	Grass	316.19	3.94
Timber Harvest	Other	34.78	0.43
Open Water		166.15	

When the classes are grouped, the total amount of agriculture cover is 22 percent and the forested land cover is 61 percent (figure 27).

Figure 27. Summary land cover within standard buffer widths of streams.

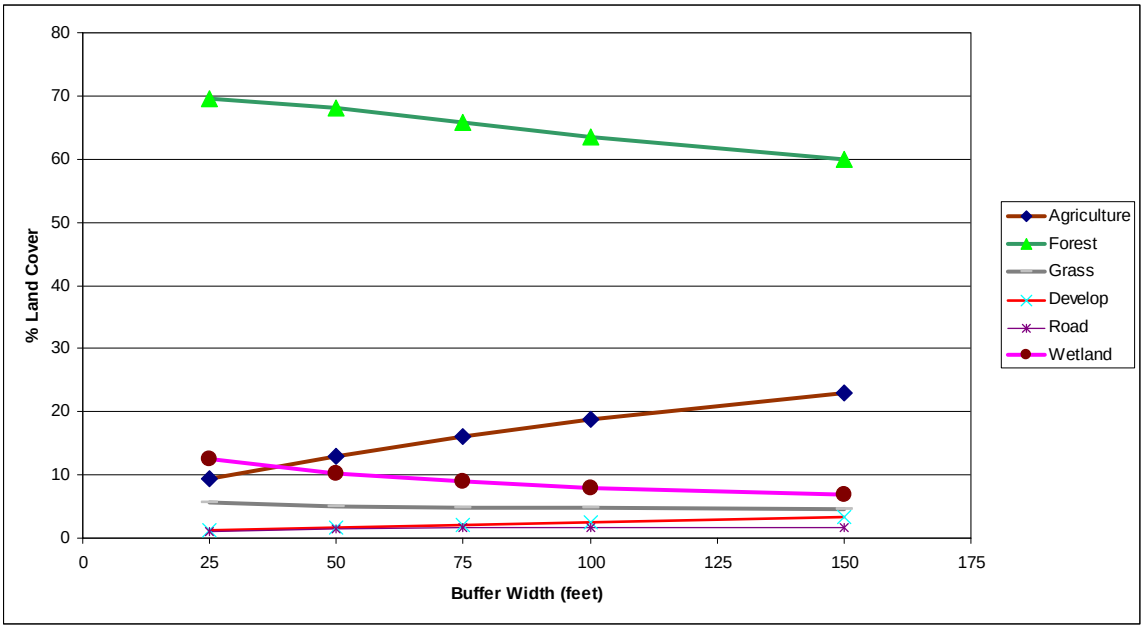


Category	Acres
Agriculture	1766
Forest	4903
Wetland	583
Grass	357
Develop	244
Road	140
Other	36

Buffer widths

Table 4. Percent of buffer in each land cover class for varying buffer widths.

	% of buffer area for varying buffer widths				
Land cover class	**25'**	**50'**	**75'**	**100'**	**150'**
Agriculture	9.49	12.90	16.11	18.84	22.94
Forest	69.59	68.20	65.80	63.58	60.03
Grass	5.67	5.05	4.88	4.78	4.55
Develop	1.24	1.68	2.17	2.60	3.28
Road	1.06	1.51	1.74	1.74	1.68
Wetland	12.56	10.31	8.92	8.03	6.93
Other	0.39	0.35	0.37	0.43	0.60



Land use variation by stream type.

Buffers of 75 feet from all stream types were created to assess the percent cover adjacent to all streams.

Table 5. Percent area in each of the buffer types

%	Type 1 & 2	Type 3	Type 4
Agriculture	10.1	18.4	22.4
Forest	71.4	61.9	58.3
Grass	4.2	5.3	6.8
Develop	1.6	2.8	1.6
Road	1.6	2.0	2.3
Wetland	11.2	9.2	7.0
Other	0.1	0.3	1.5

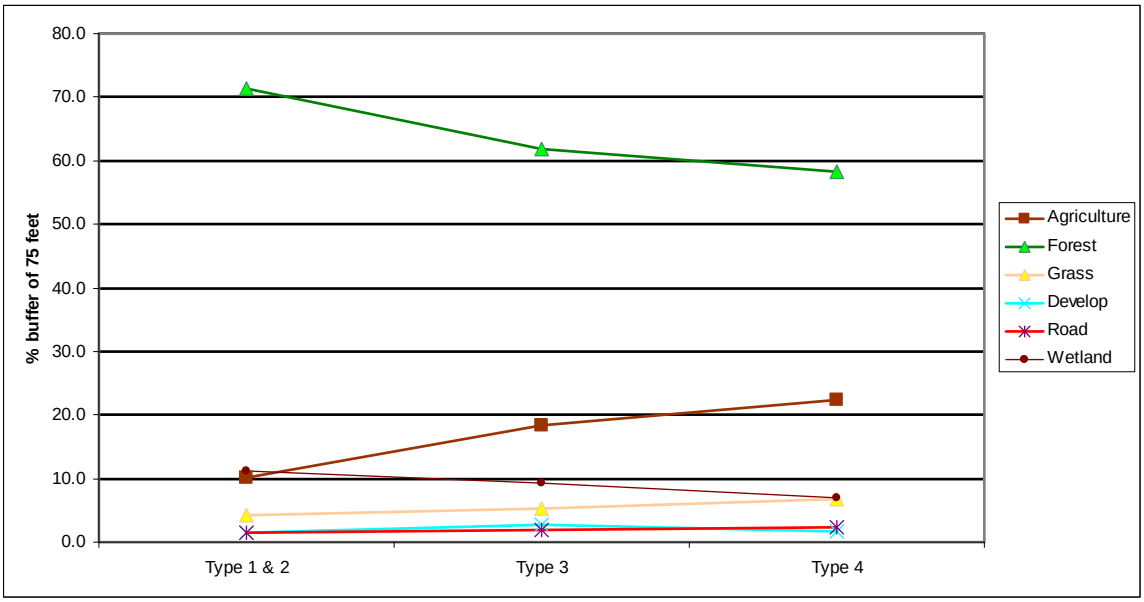


Figure 28. Percent land use adjacent to streams (using 75 feet for all stream types).

Land cover variation by study region

Table 6. Acres in Standard buffer for each region

Colony Creek	Upper Skagit	Sauk	Samish	Nookachamps	Middle Skagit
519	613	311	1258	1560	3752

Table 7. Percent land cover in standard buffer by region

Summaries						
% Buffer	Colony Creek	Upper Skagit	Sauk	Samish	Nookachamps	Middle Skagit
Agriculture	32.0	14.2	12.8	20.2	35.1	17.9
Forest	41.9	77.4	74.0	57.0	43.9	68.5
Grass	10.1	2.0	2.5	1.2	8.0	3.8
Develop	3.0	2.8	4.1	3.5	1.4	3.5
Road	3.6	2.3	3.7	1.5	1.0	1.6
Wetland	8.1	0.6	2.2	16.4	10.5	4.3
Other	1.3	0.8	0.6	0.1	0.2	0.5

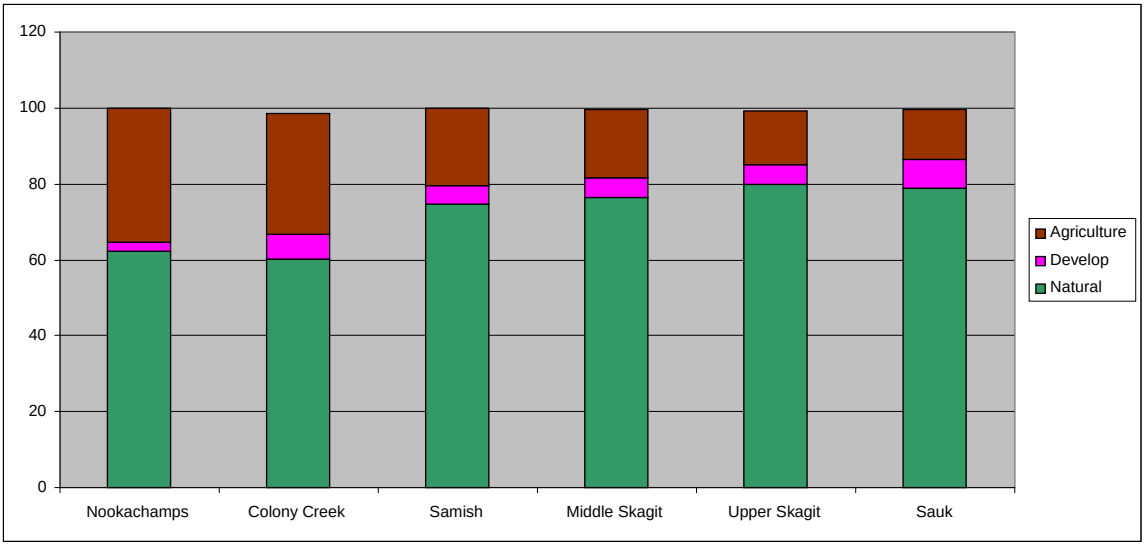


Figure 29. Land use in 3 general categories shown as percent for each of the sub regions.

Open Space Agriculture

There are 1,383 acres in the Open Space Agriculture program that is within the standard buffer. Within the Open space properties, about 40% of the standard buffer is Agriculture land use, as compared to 8.4% in the non OS Ag areas.

Table 8. Land cover in standard buffer in relation to Open Space Tax program

	OS Ag	NOT OS Ag
Agriculture	1383	381
Forested/Shrub	1565	3342
General Wetland	233	350
Grass/Dirt	206	150
Res/Com/Bldg	69	174
Road	22	116.
TOTAL	3480	4514

*Sums do not match totals due to rounding.

Amount of protected land in study area and land cover of protected properties

There are 640 acres of protected lands in the standard buffer (see table 9). The majority of those protected lands are forest cover (70%) while only 42 acres (6%) are agricultural land cover.

Table 9. Protected properties within standard buffer.

Land Cover	Acres	% Cover
Agriculture	42.0	6.6
Forest	449.8	70.2
Grass	38.2	6.0
Develop	1.6	0.3
Road	1.4	0.2
General Wetland	107.5	16.8
Other	0.0	0.0
Total	640.59	

Amount of public land in study area and land cover of public properties

Within the standard buffer, 868 acres were publicly owned lands with the majority of that area being in Forest cover (Table 10). Only 75 acres of the public land were in agricultural use and with further investigation the major land owner of these lands is Washington Fish and Wildlife.

Table 10. Public Land in Standard Buffer

Land Cover	Acres	% Cover
Agriculture	75.0	8.6
Forest	737.1	84.9
Grass	20.8	2.4
Develop	2.7	0.3
Road	2.8	0.3
Wetland	27.5	3.2
Other	2.1	0.2
Total	868.11	

Functions and values analysis

Out of the total 1,766 agriculture acres within the buffer area, 64.2 acres of the agriculture land cover is non-functional This suggests that only 3.6% of the agricultural

land cover would not benefit much from riparian protections for the adjacent watercourses.

Comparison of land cover techniques

National Land Cover Database

The National Land Cover Database (NLCD) is a free dataset that is created using Landsat Satellite data. This product is a course analysis of land cover using a thirty-meter grid and computer-generated classification. The advantage of using this data is that the data is provided without charge and it covers the entire state. A comparison was made between the results of this study and the NLDC within the standard buffer study area.

Not all land cover classes matched exactly but the majority of land cover types were grouped into six categories shown in table 11.

Table 11. Accuracy assessment of NLCD in standard buffer regions*.

		Skagit Land Cover							
		Agriculture	Forest	Develop	Grass/Dirt	Wetland	Water		TOTAL
NLCD	Agriculture	1063.2	733.2	53.5	153.8	131.8	26.2		2161.7
	Forest	579.9	3645.0	124.0	146.0	334.8	114.3		4944.1
	Develop	39.8	51.5	27.6	10.3	10.5	3.0		142.6
	Grass/Dirt	26.6	53.7	5.5	6.2	2.3	2.2		96.6
	Wetland	38.4	99.1	3.5	18.3	58.9	9.9		228.0
	Water	11.7	122.3	1.9	5.7	30.5	1.5		173.7
								Acres	
	TOTAL	1759.6	4704.8	215.9	340.2	569.0	157.1		7746.6

Correct =	4802.5
Accuracy%=	62%

Agriculture Accuracy=	60%
non-specific Ag Accuracy=	123%

*This style of table is commonly used for error analysis and represents the "accurate" land cover along the top and the "classified" data down the left (Congalton and Green 1999). To see how much agriculture both methods classified the same you match the top field and the side field (1063 acres). To see the error you would look at the cross comparisons. For example the NLCD misclassified 579 acres as forest that are actually Agriculture.

Overall accuracy of the NLCD was 62% within the standard buffer. The NLCD predicted only 60% of the agricultural areas correctly, but the total agriculture area prediction was 400 acres higher than the observed, which means NLCD predicted 123% more agriculture area.

Rural Technology Institute

The Rural Technology Institute (RTI) at the University of Washington has created some statewide land cover datasets. These data were created using Landsat satellite imagery and the results of the Skagit data were compared with their results. Similar to the NLCD, not all categories could be matched exactly but the major categories could be grouped together for this comparison.

Table 12. Accuracy assessment of RTI land cover data in standard buffer regions.

		Skagit Land Cover				
		AG	Forest	Develop	water	**TOTAL**
RTI	AG	1383.2	2904.2	578.8	181.5	5047.6
	Forest	95.0	1342.8	73.4	54.4	1565.6
	Develop	204.6	147.4	91.5	52.1	495.6
	Water	63.8	520.8	5.4	35.9	625.9
	TOTAL	1746.6	4915.1	749.1	324.0	7734.8

Correct=	2853.368
Overall Accuracy=	37%

Agriculture Accuracy =	79%
Non-Specific Ag Accuracy=	289%

Overall accuracy of the RTI land cover was 37% within the standard buffer. The RTI data predicted 79% of the agricultural areas correctly but at the expense of over predicting agricultural areas by 289%. Whereas this study identified 1,746 acres of agriculture, the RTI analysis predicted over 5,000 acres.

Conclusions

Ongoing discussions about riparian buffers in Skagit County have often been hampered by a lack of information about the land use within the buffer area. Estimating the cost of a proposed program or evaluating impacts to farming activities has only been left to guessing in the past. The results of this analysis provide a very accurate value for land cover and land use along side the watercourse that flow through Agriculture and Rural Resource zones. There are many ways the data can be reported and compared to existing data. This project evaluated the numbers based on the most common questions that have arisen during past buffer discussions but the data could be assessed in many more ways and can even serve as a baseline to compare change over time.

Standard buffer distances (200, 100, 50 feet) were used for most of the analysis in this project but the data was collected in such a way that any distance up to 300 feet could be used. Within the standard buffer area of 8,031 acres, some 1,766 acres were in agricultural use, about 22 percent of the buffer. Only 5% of the buffer is in developed or road cover which suggests the rest of the 73% of the area is in a category of forest, wetland, or “natural” grass. The amount of agricultural activity did vary by region—from 12 percent in the Sauk region to 35 percent in the Nookachamps.

Within the buffer area that is categorized as agriculture, 42 acres are protected, 75 acres are public lands, and 64 acres are considered non-functional. Altogether, these 181 acres of agricultural land use would not be considered as prime targets for restoration programs, which leaves 90% of the agricultural areas as potentially restorable.

Comparisons of the land use created in this project were compared to other methods that have been done using satellite data. These methods use automated processing of the land cover and only have a resolution of 30 meters meaning they are detecting large scale patterns. In addition these other methods are classifying land cover which is slightly different than land use. What was found during the analysis of this project is there are many clues and cover types that are not being detected by the 30-meter data that were able to be seen in the high resolution photography. The course resolution data over estimated agricultural land cover in both comparisons. The estimates were 123% and 280% higher than what was seen in the result from this study.

While it may be cost-prohibitive to perform a detailed analysis such as this one in other regions, care should be taken when using coarse imagery for land cover calculations. The role of unmanaged areas such as fallow fields are probably beneficial to riparian health yet are likely classified as agriculture in coarse scale imagery. This is only one study so the coarse estimates may vary from one county to another, but some attempts to reconcile errors should be made before drawing conclusions based on the results.

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