Mapping Riparian Land Use within Agricultural Zones

A Case Study in Skagit County

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Abstract

In 2008, as part of Skagit County's Salmon Policy Resolution (R20070499), Skagit County tasked its GIS Department with performing a land use analysis within Agricultural-Natural Resource Land (Ag-NRL) and Rural Resource-Natural Resource Land (RRc-NRL) zones. Using heads-up digitizing from high-resolution aerial photos, the GIS Department digitized and analyzed 16,000 acres, 8,031 acres of which were within standard buffer distances. We evaluated our compiled information to answer the most commonly-posed questions from past discussions regarding the imposition of riparian buffers on agricultural land uses:

- How much riparian area in Ag-NRL or RRc-NRL zones is already in a forested, grass, or wetland state that would be expected under a regulatory buffer system?
- Of that land, how much is protected from development by conservation easements, public agencies, or conservation organization ownership?
- How much riparian land would be eligible for protection under a habitat acquisition program such as Skagit County's proposed Salmon Heritage Program?

Our analysis reveals that within standard buffer distances, 73% of the area is forest, wetland, or grass. The remaining land uses includes 22% agriculture and 5% developed land or road cover. The amount of vegetated area decreases as buffer widths increase, but the amount of vegetated area that covers significant distances from streams is contrary to conventional wisdom; at 50 feet, nearly 84% of studied stream reaches are vegetated and more than 80% of that vegetation is forest. Even at 100 feet, 76% of studied stream reaches are vegetated and nearly 85% of that vegetation is forest.

Only 22% of the study area within standard buffer distances is agricultural land. Of that 22%, there are 75 acres of publicly-owned land, 42 acres protected by conservation organizations, and 64 acres with no ecosystem functions or values. Together, these three categories, which would not qualify for habitat acquisition programs, constitute 10% of the total agricultural land studied within the standard buffer area. Of the remaining agricultural area, 90% is potentially restorable. The amount of agricultural land in different regions of the County varied greatly from 13% in the Sauk region to 35% in the Nookachamps.

We compared the results of this study with other satellite land use analysis studies of the area and found that courser studies overestimated agricultural land use by as much as 289%. The information compiled from this study is useful for policy discussions and future planning of riparian protection programs.

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May 6, 2010

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Introduction

Background

The Skagit River is the only large river in Washington State home to all five species of native salmon and two species of trout. A majority of the upper watershed is undeveloped, while the lower Skagit, due to development pressures by increased population and retail services associated with the Interstate 5 corridor, is largely developed. Still, agriculture is the number one industry in the county. According to the Washington State University Skagit County Extension, "Skagit County maintains one of the largest and most diverse agricultural communities west of the Cascade mountain range," with local production of crops, livestock, and dairy products approaching $300 million.

The Washington State Growth Management Act requires that Skagit County 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 maintaining healthy salmon populations, including the Chinook species. Puget Sound Chinook Salmon are listed as "threatened" under the Endangered Species Act, and the Orca that feed on Chinook are listed as "endangered," a more serious classification that triggers the most protective regulations.

Many jurisdictions protect streams and other critical areas using mandatory buffers—strips of land bordering streams where development or farming is not allowed. Like most jurisdictions, Skagit County requires riparian buffers in almost every land use zone; however, it does not require farmers to install riparian buffers on actively-farmed agricultural lands.

Instead, after protracted legal battles with the Swinomish Tribe, Washington Environmental Council, the local Farm Bureau, and the Western Washington Agricultural Association, Skagit County chose to require agriculture to comply with specified "watercourse protection measures" designed to prevent harm to non-buffered critical areas.[1] 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 its protective measures or the entire regulatory scheme if they fail to preserve existing habitat quality. In a 2007 decision, the Washington State Supreme Court upheld Skagit County's authority to take such an approach, but found the County had not yet defined the baseline standards or triggers for corrective action that are necessary for a complete evaluation of the County's monitoring and adaptive management scheme.[2] The County remains non-compliant with the Growth Management Act until it can modify its management approach and adopt a baseline and triggers for corrective action.

Salmon Heritage Program

In early 2007, Skagit County proposed a "Salmon Heritage Program" that envisioned asking voters to approve a property tax increase of ten cents per thousand that would have yielded in excess of $1 million per year to acquire conservation easements or properties in fee along key salmon streams in agricultural areas. After five years, the program would have imposed mandatory buffers on streams Type I-IV where the County had not achieved

[1] Skagit County Code 14.24.120(4), available at www.codepublishing.com/wa/skagitcounty.
[2] Swinomish Indian Tribal Cmty. v. W. Wash. Growth Mgmt. Hearings Bd., et al., 161 Wash.2d 415, at 434 (2007).

protection equal to 80% of the standard buffer widths through voluntary acquisitions. [1] GIS analysis similar to that used in this report would have been required to identify and prioritize stream areas for acquisition.

Although the initial public reaction to the Salmon Heritage Program was positive, and polling data suggests broad support for habitat acquisition as a means of balancing the environment and property rights, failure of school bond measures countywide in 2007 revealed a lack of voter support for increased property taxes during a time of economic uncertainty. The Salmon Heritage Program has been shelved indefinitely.

Ruckelshaus Center SSB 5248 Process

In May 2007, the Legislature passed SSB 5248, creating a statewide "timeout" for the ongoing controversy and litigation over riparian buffers on agricultural land. This timeout prohibits new critical area regulations affecting agriculture and will last until at least July 1, 2011. Various stakeholders are currently participating in a collaborative process at the UW/WSU William D. Ruckelshaus Center, with the intent of creating a uniform and equitable plan to protect riparian habitat in agricultural areas. The Ruckelshaus process is a high priority for Skagit County as the County is at the center of this statewide dispute. If the timeout expires without a solution, Skagit County will need to bring its monitoring and adaptive management program into compliance with the Growth Management Act.

Salmon Policy Resolution

On October 8, 2007, the Skagit County Commissioners approved Resolution R20070499, the Salmon Policy Resolution, directing County departments to pursue salmon recovery efforts proactively. This resolution encourages all County departments to consider utilizing the Puget Sound Salmon Recovery Plan in all department activities. It also directs all County departments to pursue grant funding for salmon habitat enhancement where possible.

County departments must pursue ways to implement the recommendations of the Puget Sound Salmon Recovery Plan whenever possible. These recommendations include enhancing riparian habitat while working on adjacent country roads and drainage control, training road crews in Best Management Practices, avoiding the spraying of harmful pesticides near salmon streams, enhancing riparian habitat within County-owned lands, acquiring riparian habitat adjacent to county parks, and integrating education regarding salmon topics into interpretive centers and road signs. The resolution also requires County departments to provide the Board of Commissioners with an annual report regarding salmon recovery measures accomplished throughout the preceding year.

Riparian Mapping Project

The Salmon Policy Resolution also directed the County's Geographic Information Systems 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). The resolution provides that,

> *Skagit County Geographic Information Systems shall, by June 1, 2008, (a) assess riparian areas in the AG-NRL and RR-NRL zones to determine existing buffer type and width, (b) determine amount and map location of linear stream distance that has existing riparian buffer (c) determine amount of linear stream distance where location of existing roads, buildings, and other structures preclude riparian buffers, and (d) develop maps and other visual aids to assist County personnel in the Ruckelshaus process.*

The results of this project will assist with the Ruckelshaus Center's effort to protect riparian and agricultural areas, however, Skagit County also intends to use this project to evaluate the status of riparian habitat in the Skagit River Basin, protect and enhance local riparian areas, and assist with efforts related to future habitat acquisition.

Methods

This study took around 1,000 hours of meticulous analysis to complete. While one person completed most of the work, up to three people worked on the data at any given time. The use of three individuals provided small variations in land use classification within the study area; however, all three members collaborated and discussed any controversial designations thereby making the variations statistically insignificant.

Study Area

Skagit County is located in northwest Washington State and transcends a variety of landscapes from marine areas in the Puget Sound to alpine areas along the Cascade Mountains crest. The County is roughly 1.2 million acres in size and the majority of its 116,000 people live in the western lowlands. The Skagit River runs through the middle of the County and forms the third-largest river system on the west coast of the United States. 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. During floods, however, discharge rates can exceed 160,000 cubic ft/sec (USGS, 2006).

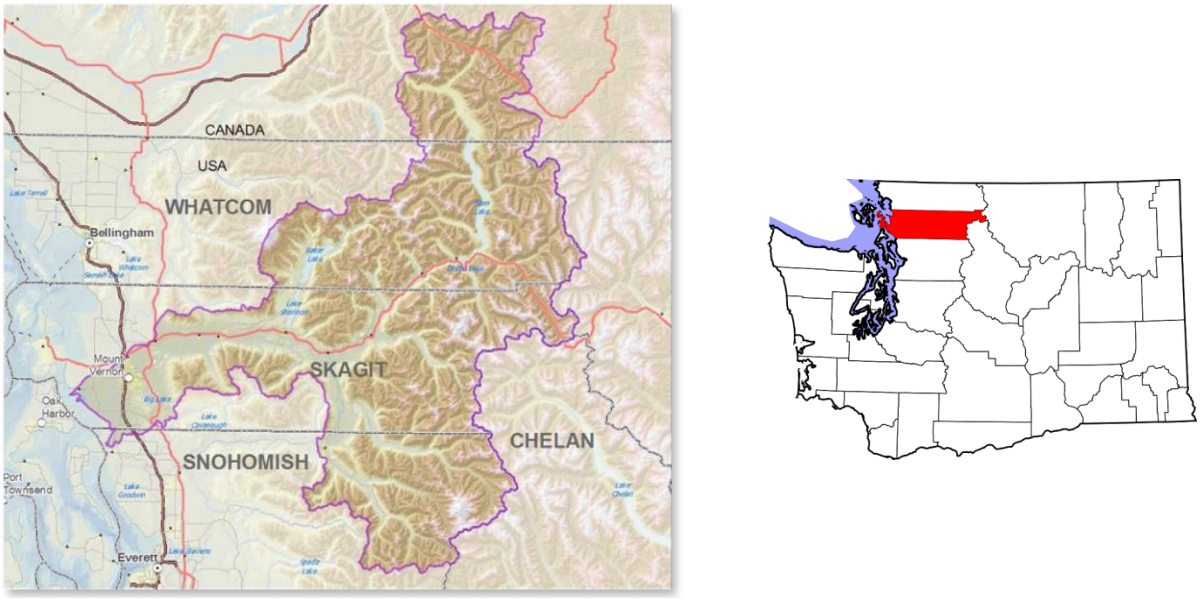


Figure 1. Skagit River Watershed

Zones and Watercourses

This study assessed only lands zoned Agriculture (Ag-NRL) or Rural Resource (RRc-NRL) as currently designated in the County's Comprehensive Plan, on which riparian buffers are not required for ongoing agriculture. Agricultural zoning covers 87,688 acres and Rural Resource zoning covers 26,872 acres (Figure 2).

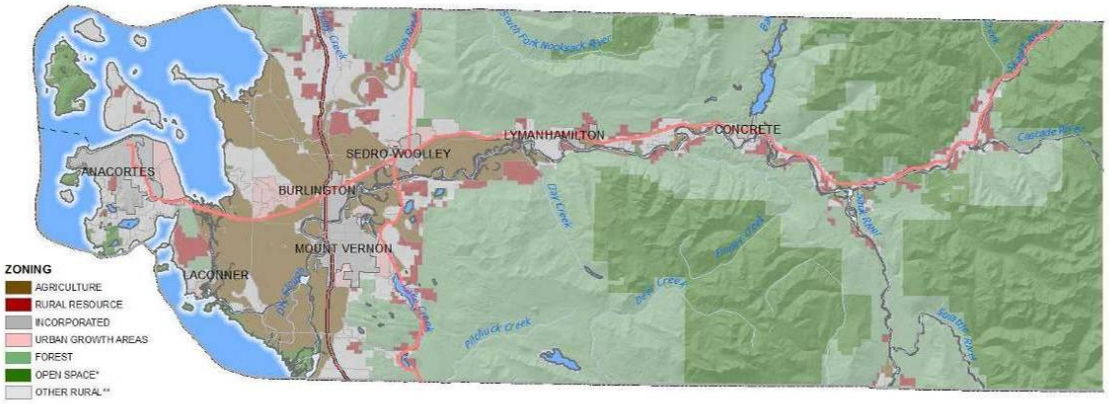


Figure 2. Comprehensive Plan Zones for Skagit County

Figure 3 presents the final study area, which excludes those areas outside of Skagit County's jurisdiction (cities and towns), and any diking and drainage district covered by the Drainage and Fish Initiative and the Tidegate and Fish Initiative agreements, which is most of the historic Skagit River Delta (see Table 1 for all lands included in the study). Within the study area, we examined watercourses of Types 1 through 4. See "Hydrology Data" on page 10 for an explanation of watercourse types.

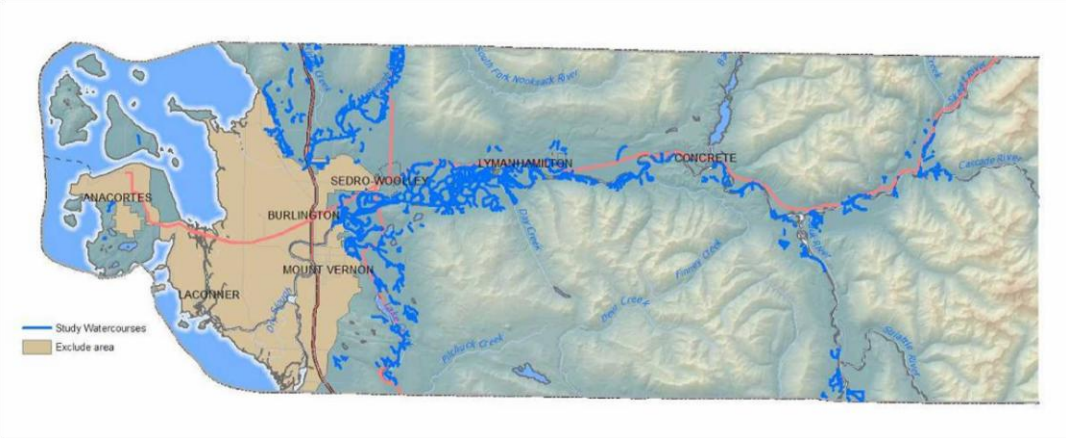


Figure 3. Study area watercourses excluding incorporated areas and drainage districts

Table 1. Areas included in study

Inclusion Data	Data Source
Ag-NRL or RRc-NRL Zoned Lands in Unincorporated Skagit County	Comprehensive Plan
Within 300 feet of watercourses Type 1 through 4	Buffer of County 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

Regions

To assess the variability of land use results in this study, we created six regions based on natural breaks in topography and zoning (Figure 4). This divided the study area into six discrete, watershed-oriented areas. We then

analyzed the land uses within each of the regions to determine whether patterns were consistent across the entire study area or whether they were regional patterns.

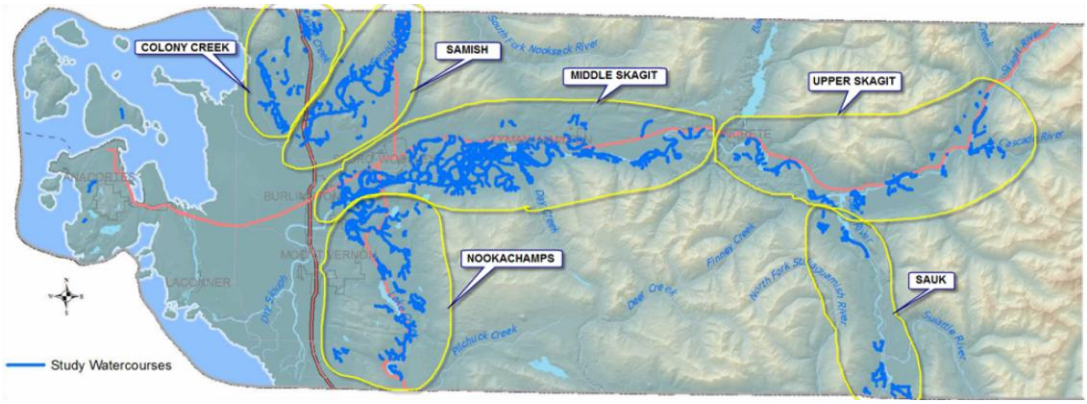


Figure 4. The six regions created to assess variations within the study area

Buffers

In GIS analysis, buffer zones refer to the area of a specified width drawn around a map element, such as a stream (Aronoff, 1989). In this analysis, we drew buffer zones along streamlines to determine the land uses of the areas bordering the streams. The width of these buffers vary by stream type as shown in Figure 5 and can have multiple widths as shown in Figure 6. We assigned buffer widths based on then-current County regulations.

Table 2. Buffer distances based on steam types

Stream Type	BufferDistance
Type 1 & 2	200 feet
Type 3	100 feet
Type 4	50 feet
Type 5	Excluded from study

Figure 5. Example of buffers created at varying widths based on stream type

Figure 6. Example of multiple buffer distances around a single watercourse

Hydrology Data

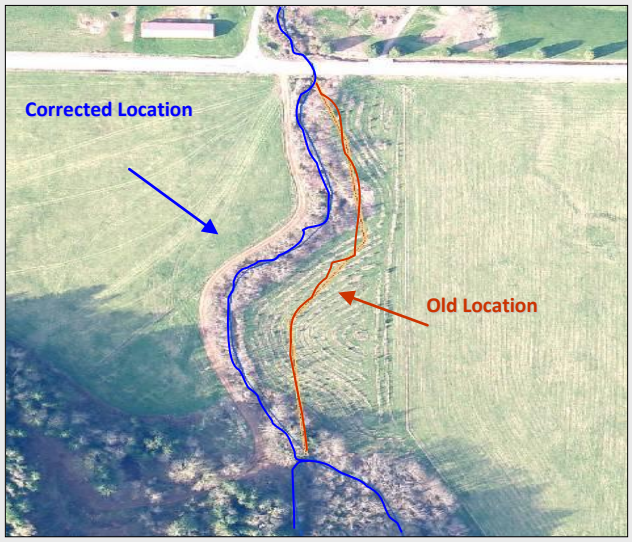
The Washington State Department of Natural Resources (DNR) provided the original hydrology data for this study, which outlined watercourse locations in the study area. The DNR's watercourse locations, however, did not match Skagit County's 2007 aerial photography of the study area. We therefore corrected the existing hydrological data to realign misrepresented stream locations. Figure 7 provides an example of this process.

We used the same 2007 aerial photography to depict both stream location and land use classifications (e.g. roads, structures, class of vegetation). This was important in creating a strong and consistent analysis of the study area. This information is available upon request and at www.skagitcounty.net/gis (click on "Digital Data").

Figure 7. Stream Realignment

The red line, or old location, represents the location of a watercourse as provided by the Washington State Department of Natural Resources (DNR). The blue line, or corrected location, depicts the actual location of the watercourse as provided by the 2007 aerial photography.

The project team modified all misaligned DNR watercourses to match the correct information provided by the 2007 aerial photography.



Watercourse types are defined by Washington Administrative Code 222-16-31:

- Type 1: All waters, within their ordinary high-water mark, as inventoried as "shorelines of the state" under chapter RCW 90.58.
- Type 2: Segments of natural waters not classified as Type 1 Water and have a high fish, wildlife, or human use.
- Type 3: Segments of natural waters 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.

We used data from the Skagit River System Cooperative (SRSC), a non-profit research agency of the local Sauk-Suiattle and Swinomish Indian Tribes, to update DNR's watercourse types. The typing we used for this study, therefore, was the best available and most up-to-date data.

Aerial Photography

In March 2007, Pictometry International provided Skagit County with aerial photos of the study area. Flying over Skagit County with a set of digital cameras positioned around the airplane, Pictometry took photographs in both a straight-down orientation as well as at a 40-degree angle. The photos are georegistered using a combination of an airborne Global Positioning System (GPS), an Inertial Measurement Unit (IMU), and a digital elevation model of the earth's surface. The resulting orthophotos are one-foot color; the oblique photos have variable resolution but are invaluable for determining land use and land class information.

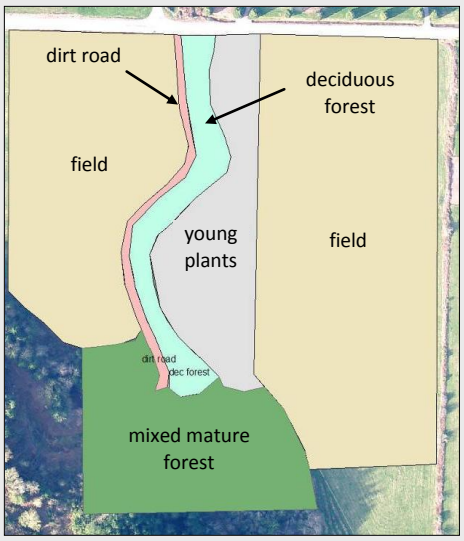
Heads-Up Digitizing Versus Automatic Classification

There are two main methods used for performing a land cover or land use classification analysis: heads-up digitizing and automatic classification. We used heads-up digitizing for the purpose of our study. Heads-up digitizing is the oldest method and requires one person to evaluate photos and draw lines around the boundaries of different land use classifications. The accuracy of this approach depends on the quality of the photos and the skill of the digitizer.

Figure 8. Identifying Riparian Areas

Using 2007 aerial photography, the project team categorized the types of ground cover within 200-feet of each stream in the study area. Map designations distinguish between young plants, mixed mature forests, deciduous forests, and other vegetation and ground cover classifications such as roads and structures.

Image to right: an example of a map showing different designations of riparian areas.



Automatic classification is a newer technique that uses a computer to analyze images and determine classifications, or at least the boundaries of the study areas. This method is often faster and more systematic and is therefore easier to repeat. Computer-derived classification is more common with lower-resolution satellite images; however, newly-developed software programs and techniques assist in classifying higher-resolution data.

Skagit County GIS attempted to use automated techniques on the 2007 imagery but the results were not accurate enough for the project as the boundaries were very small in area or covered multiple classes. The detail of classification needed for this project required the use of the more time-consuming heads-up digitizing approach. This approach also provided for the use of the oblique photos as there were no software programs readily available that used multiple oblique photos along with traditional orthophotos to classify land use. See **Error! eference source not found.** for an example of designated riparian areas.

Land Use Classifications

All study areas within this project fall into one of the following categories. See Appendix A (page 21) for descriptions of each classification.

Table 3. All Land Use classifications divided into Agricultural and Non-Agricultural categories

Agricultural Land Uses	Non-Agricultural Land Uses		
• Crop/Dirt Field	• General Wetland	• Residential	• Deciduous Trees
• Forested Pasture	• Grassland/Field	• Commercial	• Mixed Trees
• Mowed/Grazed Field	• Low Shrub/Tree	• Building	• Evergreen Trees
	• Open Water	• Dirt	• Road
	• Dike	• Timber Harvest	

Results

Land Use by Type

We classified over 16,000 acres of land using heads-up digitizing methods. Of the 16,000 acres, 8,197 acres resided within standard buffer distances including 166 acres of open water areas. Table 4 describes land use values of areas within standard buffer areas by class. After grouping similar classes, we conclude that agriculture covers 22% of the total buffer area and forestland covers 61% (Figure 9).

Table 4. Land use within standard buffer widths

Land Use	Acres	% Cover
Agriculture	**1,765.98**	**21.99**
Mowed/Grazed Field	1,312.76	16.35
Crop/Dirt Field	438.55	5.46
Forested Pasture	14.67	0.18
Developed	**244.24**	**3.04**
Residential	185.52	2.31
Building	1.38	0.02
Commercial	57.34	0.71
Forest	**4,902.54**	**61.05**
Low Shrub/Tree	718.06	8.94
Mature Evergreen forest	140.23	1.75
Mature Mixed forest	2,136.28	26.6
Mature Deciduous forest	1,907.97	23.76
Grass	**357.36**	**4.45**
Dirt	41.17	0.51
Grassland/Field	316.19	3.94
Timber Harvest	34.78	0.43
General Wetland	583.36	7.26
Road	139.65	1.74
Open Water	166	0.02

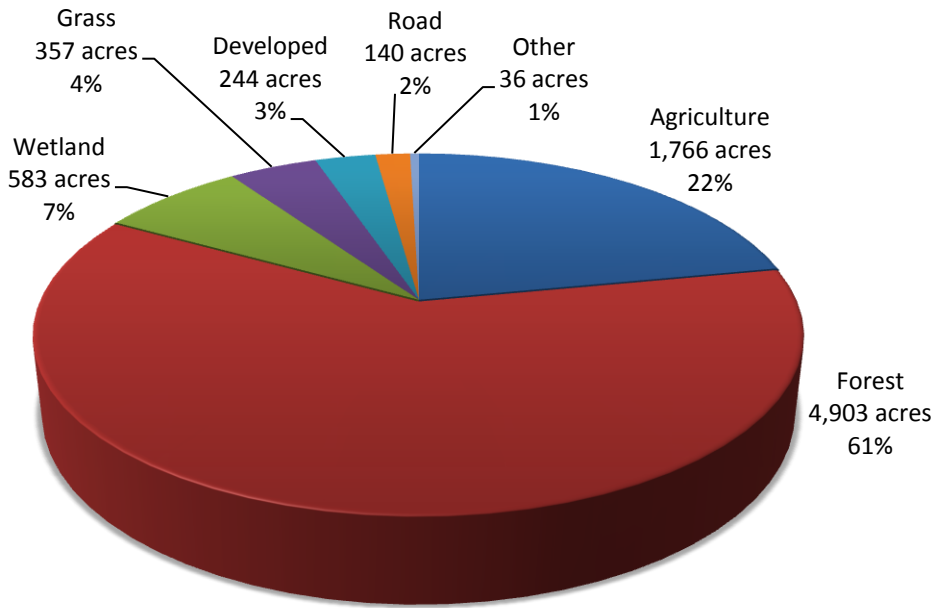


Figure 9. Summary of land use designations within standard buffer widths of streams

Variation by Buffer Width

Land use varied with different buffer widths. Within 25 feet of a stream, less than 10 percent of the buffer area was in agricultural use; agriculture was almost 23 percent of the area, however, within 150 feet of a stream. Conversely, within 25 feet of a stream, forest cover accounted for almost 70 percent; however, forest only made up 60 percent of the buffer area within 150 feet of a stream.

Table 5. Percent of buffer in each land use classification for varying buffer widths

	Buffer area for varying buffer widths				
Land Use Classification	**25 feet**	**50 feet**	**75 feet**	**100 feet**	**150 feet**
Agriculture	9.49%	12.90%	16.11%	18.84%	22.94%
Natural	**87.82%**	**83.56%**	**79.6%**	**76.39%**	**71.51%**
Forest	69.59%	68.20%	65.80%	63.58%	60.03%
Grass	5.67%	5.05%	4.88%	4.78%	4.55%
Wetland	12.56%	10.31%	8.92%	8.03%	6.93%
Development	**2.69%**	**3.54%**	**4.28%**	**4.77%**	**5.56%**
Developed	1.24%	1.68%	2.17%	2.60%	3.28%
Road	1.06%	1.51%	1.74%	1.74%	1.68%
Other	0.39%	0.35%	0.37%	0.43%	0.60%

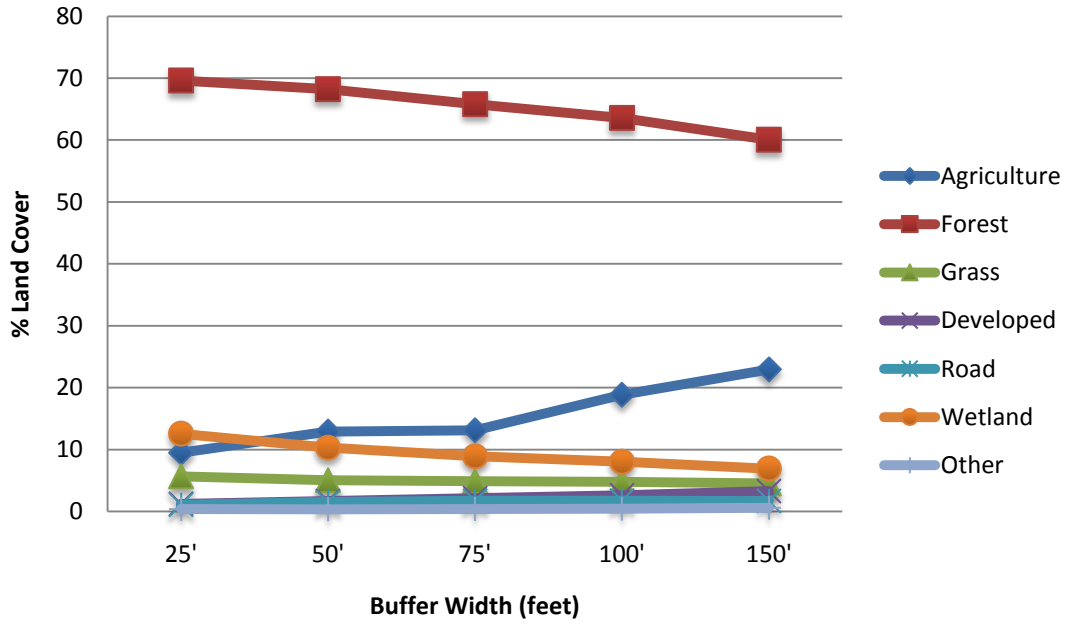


Figure 10. Percent of buffer in each land use classification for varying buffer widths

Variation by Stream Type

We created 75-foot buffers around all stream types to assess the percent cover adjacent to all streams (Table 6 and Figure 11). We found a greater percentage of forest cover adjacent to larger streams (Types 1 and 2) and less next to the smaller streams (Types 3 and 4). In areas with less forest cover, we found more agriculture, which increased from 10 percent around larger streams to over 20 percent around smaller streams.

Table 6. Percent of land use area in each buffer type

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

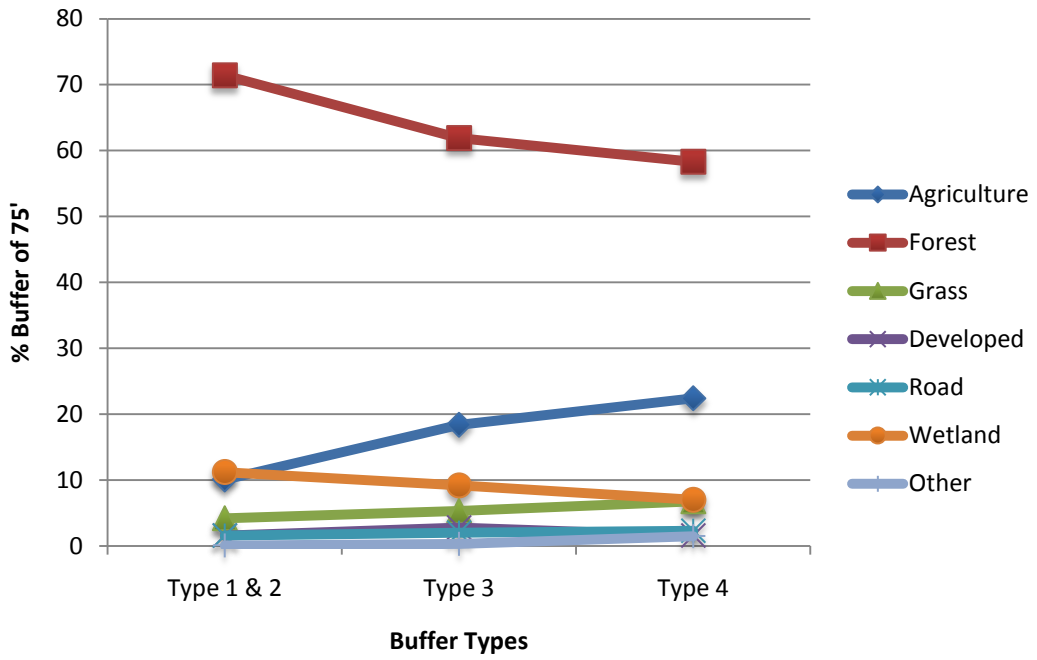


Figure 11. Percent land use adjacent to streams (using 75 feet for all stream types)

Variation by Study Region

There are considerable land use differences within Skagit County. Since study regions varied in size, we reported all values as percentage of land use. The Sauk region had the fewest *acres* of agricultural land adjacent to streams while the Nookachamps and Colony Creek areas had the largest *percentage*.

Table 7. Acres in standard buffer for each region

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

Table 8. Percent land use in standard buffer by region

Classification		Colony	Upper Skagit	Sauk	Samish	Nookachamps	Middle Skagit
Agriculture		32.0%	14.2%	12.8%	20.2%	35.1%	17.9%
Developed/Road		6.6%	5.1%	7.8%	5%	2.4%	5.1%
Natural	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%
	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%

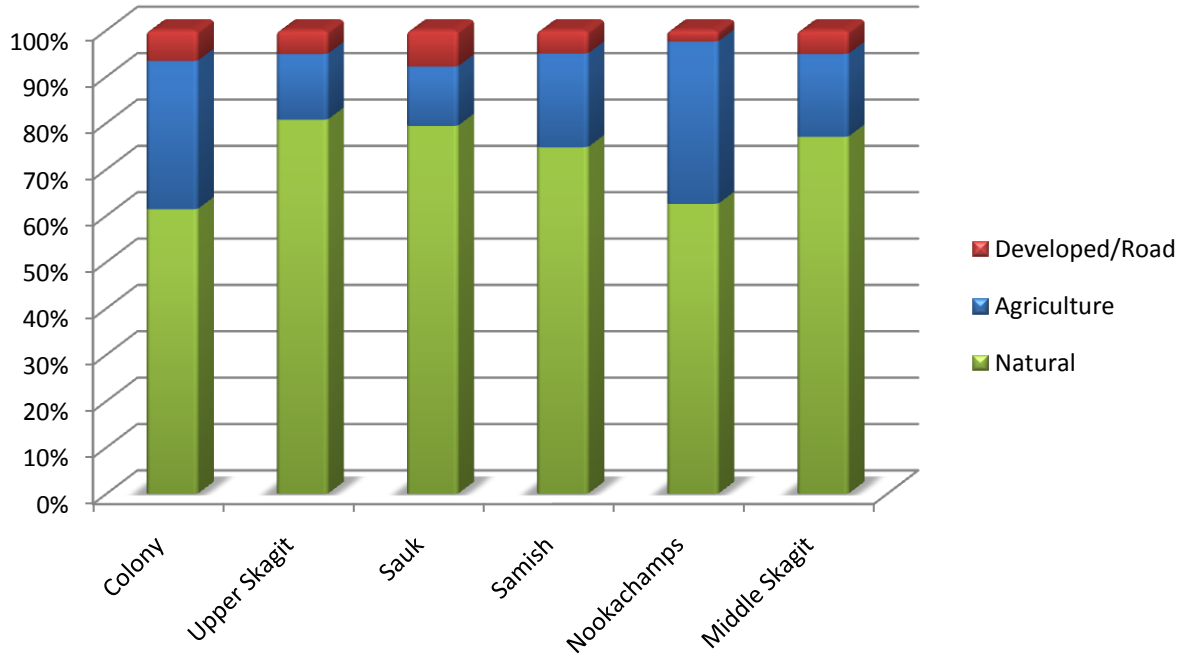


Figure 12. Land use in three general categories shown as percentages within each sub region

No Ecosystem Functions and Values

Skagit County Code considers areas physically separated from the watercourse (such as areas on the far side of a dike, SCC 14.24.530(1)(b), or a road, SCC 14.24.530(4)) to have no ecological function or value ("NFV") because the physical separation restricts the benefits that a protected buffer would provide to a watercourse. Therefore, we excluded these NFV areas from our analysis.

Of the 1,766 agricultural acres within the standard buffer area, 64.2 acres have no function or value, i.e. a buffer in those locations would provide no ecosystem services. This suggests that 3.6% of the agricultural land use would not benefit from watercourse riparian protection efforts.

Open Space-Agricultural Tax Designation

Within the standard buffer area, there are 3,480 acres currently receiving reduced tax rates as farm and agricultural land under Washington State's Open Space Taxation Act program (RCW 84.34). Approximately 40% of this area, or 1,383 acres, qualify as agricultural land use as compared to 8.4% in other areas (Table 9).

Table 9. Land use in the standard buffer area in relation to the Open Space (OS) tax program

Land Use Classification	OS-Agriculture	Other Areas
Agriculture	1,383	381
Forested/Shrub	1,565	3,342
General Wetland	233	350
Grass/Dirt	206	150
Res/Com/Bldg	69	174
Road	22	116
Total	**3,480**	**4,514**

Sums do not match totals due to rounding

Privately-Protected Public Lands

There are many private organizations in Skagit County dedicated to protecting properties from development. In addition, there are many properties owned by public organizations; these properties are priorities for riparian improvements as they have little impact on individual landowners (Figure 13). A quantitative analysis of these public lands is an important aspect of the riparian protection discussion as many argue that a great number of public lands reside inside buffer zones.

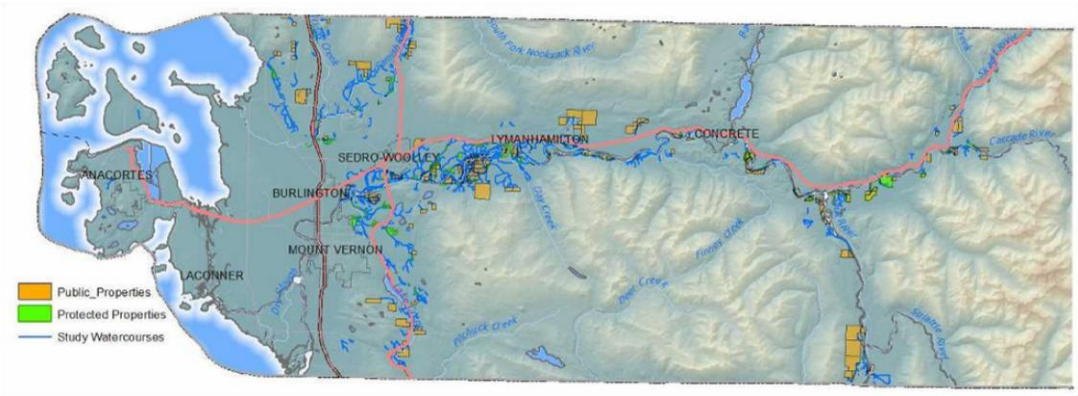


Figure 13. Protected and publicly owned properties in the study area

Privately-Protected Lands

Within the standard buffer, there are 640 acres that are protected from development by conservation organizations either through ownership in fee or conservation easement, or participation in the USDA Conservation and Reserve Enhancement Program (Table 10). Of these, 70% are forest cover; only 6% are agricultural land use. Nearly 596 acres of forested, grass, or wetland acres are protected.

Table 10. Protected properties within standard buffer

Land Use	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**	**100%**

Public Lands

There are 868 publicly-owned acres within standard buffers. A majority of this area is forest cover while only 75 acres are in agricultural use (Table 11). Throughout the course of our study, we discovered that the Washington Department of Fish and Wildlife owns a majority of the studied public lands.

Table 11. Public land in standard buffer

Land Use	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**	**100%**

Comparison of Land Use Techniques

We did not perform an *intensive* accuracy assessment of our work for this project; however, we performed some accuracy assessments by visiting specific sites in person and comparing our on-the-ground observations with our compiled photography results. We also achieved greater accuracy using the oblique photos than normal overhead photos. In addition, we compared our land use data with two previously-classified datasets that were performed using satellite data.

National Land Cover Database

The National Land Cover Database (NLCD) is a dataset created from Landsat satellite data. The NLCD uses a thirty-meter grid and computer-generated classification to produce a course analysis of land cover. The NLCD database classifies the entire state and is available without charge. We compared the results of this study with the NLCD data (within the standard buffer study area).

The NLCD grouped land cover types into six categories. These categories did not exactly match our study's categories but were close enough for comparison. Table 12 displays our accurate land use assessment across the top and the NLCD's classified dataset down the left (Congalton & Green, 1999).The dark boxes indicate the amount of land both study methods classified within the same category. For example, both the NLCD Assessment and our study classified 1,063.2 acres as agriculture and 3,645 acres as forest. To determine the amount of land that was misclassified, cross comparisons must be examined. For example, the NLCD classified 579.9 acres as forest that is actually agriculture and 39.8 acres as developed that is also agriculture.

Table 12. Accuracy assessment of NLCD in standard buffer regions

		Skagit County GIS Assessment						
		Agriculture	Forest	Developed	Grass/Dirt	Wetland	Water	Total
NLCD Assessment	Agriculture	**1,063.2**	733.2	53.5	153.8	131.8	26.2	2,161.7
	Forest	579.9	**3,645**	124	146	334.8	114.3	4,944
	Developed	39.8	51.5	**27.6**	10.3	10.5	3	142.7
	Grass/Dirt	26.6	53.7	5.5	**6.2**	2.3	2.2	96.5
	Wetland	38.4	99.1	3.5	18.3	**58.9**	9.9	228.1
	Water	11.7	122.3	1.9	5.7	30.5	**1.5**	173.6
	Total	1,759.6	4,704.8	216	340.3	568.8	157.1	**7,746.6**
							Total	**15,493.2**

The NLCD's database correctly classified 4,802.5 acres making the database 62% accurate within the standard buffer. The NLCD only correctly classified 60% of agricultural areas; the final calculation was 400 acres higher than our observed results. The NLCD therefore classified 123% more agricultural area than actually exists.

Rural Technology Institute

The Rural Technology Institute (RTI) at the University of Washington created statewide land cover datasets using Landsat satellite imagery. We also compared our results with these datasets. Similar to the NLCD, the categories did not match exactly; however, we grouped the major categories together for comparison (Table 13).

Table 13. Accuracy assessment of RTI land cover data in standard buffer regions

		Skagit County GIS Assessment				
		Agriculture	Forest	Developed	Water	Total
RTI	Agriculture	**1,383.2**	2,904.2	578.8	181.5	5,047.7
	Forest	95.0	**1,342.8**	73.4	54.4	1,565.6
	Developed	204.6	147.4	**91.5**	52.1	495.6
	Water	63.8	520.8	5.4	**35.9**	625.9
	Total	1,746.6	4,915.1	749.1	324.0	**7,734.8**
					Total	**15,469.6**

RTI's data correctly classified 2,835.4 acres making the dataset 37% accurate within the standard buffer. RTI correctly classified 79% of agricultural areas, however, RTI over-predicted total agricultural area by 289%. While our study identified 1,746 acres of agriculture using these five categories, the RTI analysis predicted over 5,000 acres.

Conclusions

This study provides an accurate land use analysis of areas surrounding watercourses that flow through Agricultural and Rural Resource zones.

For the purpose of our report, we evaluated our compiled information based on the most commonly-posed questions collected throughout past buffer discussions. It is possible, however, to use this data for many other purposes not addressed in this study such as establishing a baseline for comparing change over time.

We classified land uses out to 300 feet from the streams, but we used standard buffer distances (50, 100, and 200 feet depending on stream type) for most of the analysis in this project. Of the 8,031 acres of standard buffer area analyzed, we classified the following land uses: 22% agriculture, 5% developed land or road covered, and 73% forest, wetland, or natural grass. Agricultural activity varied by region ranging from 13% in the Sauk region to 35% in the Nookachamps.

One purpose of this study was to determine how many acres of riparian agricultural land would be eligible for habitat protection. For agricultural use areas within standard buffer areas (1,766 acres), we concluded that there are 42 acres of protected land, 75 acres of public land, and 64 acres of land with no functions or values. Together, these three categories, which would not qualify for habitat acquisition programs, constitute 10% of the agricultural land studied within the standard buffer area. Of the remaining agricultural area, 90% is potentially restorable.

We also compared our land use data with other compiled satellite data sets. These other studies used an automated processing of land cover and have a course resolution of only 30 meters, which detects only large-scale patterns. In addition, these other methods classified land cover, which is slightly different from land use. During this analysis, we found that the high-resolution photography detected many clues and cover types that the 30-meter data set did not detect. In comparison with our study, both course resolution studies over-estimated agricultural land use—NLCD by 123% and RTI by 289%.

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

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Appendix A. Land Use Classification Descriptions

Crop/Dirt Field

This classification includes all agricultural areas with disturbed soil that appear to be for the purpose of crop planting.

Figure 14. Example of Crop/Dirt Field land use

Forested Pasture

A forested pasture consists of forested areas with evidence of cattle or horse grazing. Animal grazing also classifies as agricultural use. This category is difficult to classify with single snapshot aerial photos, however, we selected this category in cases where grazing appeared certain under tree coverage.

Figure 15. Example of Forested Pasture land use

Mowed/Grazed Field

Mowed/Grazed fields consist of areas mowed for agricultural activities. Large parcels of land that require a tractor for mowing, as well as areas of livestock grazing, qualify as a Mowed/Grazed. Differentiating between this category and the non-agriculture Grassland/Field category is difficult; however, a lack of senescent grasses, occurrence of ground patterns from tractors or animals, and in some cases, enrollment in the open space agriculture program classify the land as a Mowed/Grazed field.

Figure 16. Example of Mowed/Grazed Field land use

General Wetland

This broad category includes areas of standing water with vegetation growth, or several small open water areas that are not individually large enough to classify as open water.

Figure 17. Example of General Wetland land use

Grassland/Field

Grasslands/Fields are non-agricultural, open grass areas that do not show any annual disturbance from mowing. Grassy areas along roads that are not mowed and are not used for agricultural purposes also qualify. The main difference between this class and the Agricultural Mowed/Grazed Field class is the presence of senescent grasses, occasional small shrubs, or blackberries.

Figure 18. Example of Grassland/Field land use

Low Shrub/Tree

This classification contains shrubs and small trees and can infrequently include mature trees. When shrubs or small trees do not cover the entire area, we classify the land as a mixture of different classes. We often classify infrequently mowed areas and areas with natural blackberry growth in this class. This class also includes small trees planted for conservation buffers such as the USDA's Conservation Reserve Enhancement Program.

Figure 19. Example of Low Shrub/Tree classifications

Deciduous Trees

This classification contains areas made up of only deciduous trees over 10-15 feet tall. The trees must cover more than 50% of the area.

Figure 20. Example of Deciduous Trees land use

Mixed Trees

The Mixed Trees classification contains forested areas made up of trees over 10-15 feet tall that cover over 50% of the selected area. The area may contain a mixture of deciduous and evergreen trees. The ratio of deciduous to evergreen trees may vary greatly, however, there must be a combination of both. The boundary of this class can be subjective and often blends with the low shrub/tree classification.

Figure 21. Example of Mixed Trees land use

Evergreen Trees

This classification must contain a predominance of evergreen trees exceeding 10-15 feet that must cover over 50% of the selected area.

Figure 22. Example of Evergreen Trees land use

Residential

This classification encompasses all land use types associated with residential homes. Cover types may include driveways, houses, accessory dwellings, lawns, personal gardens, and small orchards. If a field appears too large for the use of a residential mower, we classify the field as Grassland/Field.

Figure 23. Example of Residential classifications

Commercial

This classification contains areas made up of a large number of buildings, access roads, abandoned vehicles, or large amounts of paved areas. The properties may not necessarily be commercial in terms of business. This class is similar to the residential class and in some cases may contain a residence; however, this class contains a more sporadic and intense use of the land than the residential class.

Figure 24. Example of a Commercial classification

Building

This classification contains buildings that are mostly freestanding and separate from residential or commercial activity. It only includes buildings, not paths or driveways, and often includes barns or storage sheds separated from other activities.

Figure 25. Example of a Building land use

Dirt

This classification contains large areas of exposed dirt used for non-agricultural purposes. To distinguish the difference between a non-agricultural dirt area and an agricultural dirt area, we examine the overall size of the area, determine if the area is enrolled in an open space taxation program, and look for a lack of characteristics normally found in agricultural areas such as rows and paths from plowing and barns.

Figure 26. Example of a Dirt classification

Road

Road classifications include (a) paved public and private roads, (b) dirt roads that are significant enough in size and construction to make relocation of the road a substantial expense, (c) railroad tracks, (d) roadside shoulders and pullouts, and (e) large, maintained trails.

Figure 27. Example of a Road classification

Timber Harvest

This class contains areas of cleared timber with little or no re-growth. The land is often bare with disturbed soil or dead wood debris. Once re-growth begins, we classify the area as Low Shrub/Tree.

Figure 28. Example of Timber Harvest land use

Open Water

This classification contains bodies of water wider than 40 feet (Figure 29). The hydrological dataset used for this study does not contain shape data for bodies of water less than 40 feet wide. As such, these bodies of water are represented only by a thin centerline; we drew the buffer area from this centerline (Figure 30). Our photography is from late March and early April 2008, when there is significant freestanding water on the ground. This is important as some open water areas are visible in spring but diminish or disappear altogether by fall. We did not classify areas with grass visible in the water because the presence of grass would indicate the water body is not continuously present since grass could not grow with continuous water cover.

Figure 29. Example of an Open Water land use

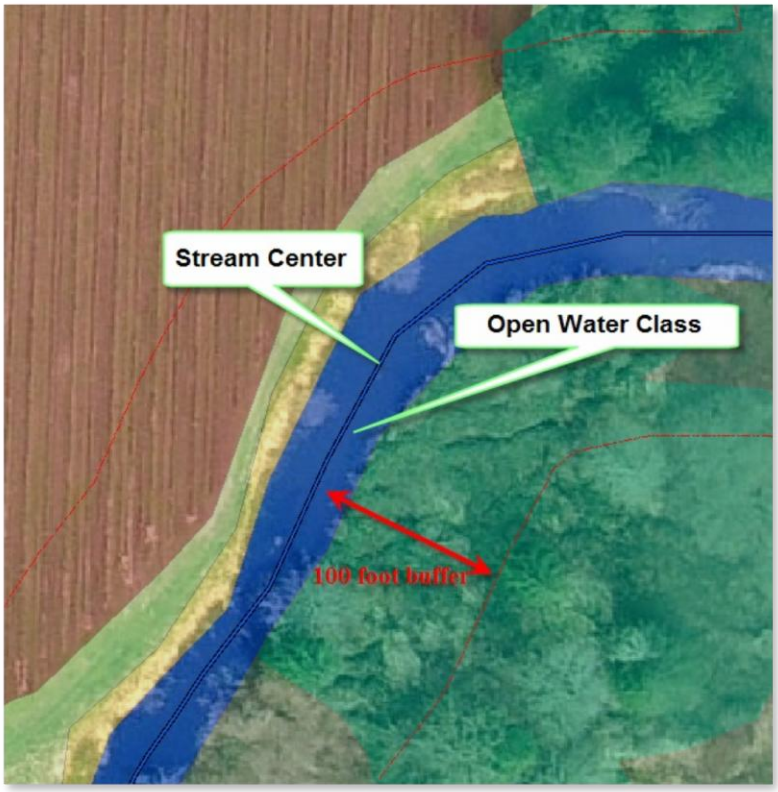

Figure 30. Example of a body of open water less than 40 feet wide; the buffer is drawn from the centerline of the stream

For bodies of water that are 40 feet and wider, the hydrological dataset contains shape data depicting the watercourse. For these larger bodies of water, we drew the buffer from the perimeter of the shape (Figure 31).

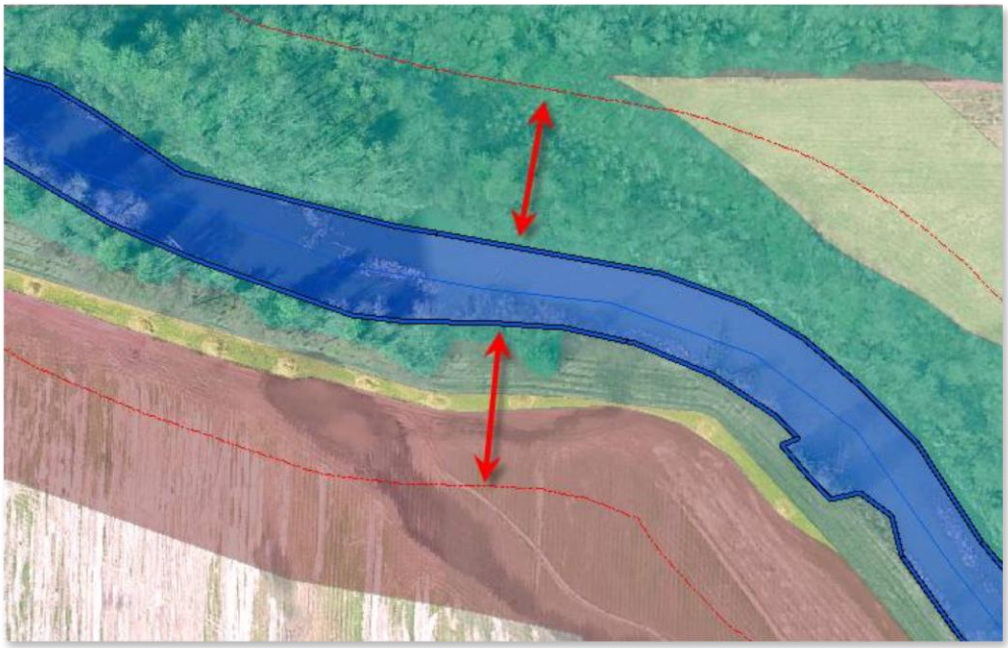

Figure 31. Example of open water greater than 40 feet for which a stream shape is provided; the buffer is drawn from the perimeter of this shape

Dike

Dike areas consist of elevated land used for the purpose of controlling water flow or preventing floods. Almost all dikes in this project's study area are outside official dike district areas; most are also mowed as part of an annual maintenance routine.

Figure 32. Example of a Dike classification


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