St. Croix River Basin - State of the Forest Report

March 8, 2013

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This report was made possible by grant funding from the U.S. Forest Service.

Acknowledgements

Bart Richardson, MN DNR Central Region GIS Coordinator, for development of the initial reclassifications of the NLCD, GAP Land Cover, and Presettlement Land Cover datasets. Michael Pressman, Director of Habitat Protection and Mark White, Forest Ecologist, The Nature Conservancy, for assistance in further development of the reclassification.

Suzanne Magdalene, St. Croix Watershed Research Station of the Science Museum of Minnesota, for assistance in further development of the reclassification, for research on phosphorus export coefficients, and for assistance in the development of this report.

Executive Summary

The St. Croix River Basin (SCRB) spans 7,700 square miles across the States of Minnesota and Wisconsin. The area drains to Lake St. Croix, a naturally impounded riverine lake that makes up the lower 25 miles of the St. Croix River. In 1968, the St. Croix River was designated a National Wild & Scenic River from the St. Croix Flowage dam to the dam near Taylors Falls. In 1972, this designation was expanded to the lower portion of the St. Croix, and in 1976 the designation was fully approved (BLM et. al., 2012). In 2008, Lake St. Croix was added to Minnesota's 303(d) Impaired Waters List due to eutrophication, or excess nutrients, resulting from phosphorus loading to the lake.

This report provides a historical analysis of land cover within the St. Croix River Basin (SCRB), with a focus on forested land cover. Presettlement land cover, such as forest, shrub, and grass, has a lower contribution to phosphorus loading than cover types converted by humans such as agriculture or urban development. Maintaining the forested land that is left in the SCRB will play a part in preventing further degradations in water quality. Understanding how land cover in the SCRB has changed over time will help to make management decisions that will protect forested land, and thus water quality, into the future. To this end, land cover change analyses were conducted at the basin, tributary, and riparian level.

Land cover datasets that cover the entire SCRB exist for four time periods: mid-late 1800s, 1992, 2001, and 2006. Each dataset uses a different collection/analysis methodology and classification system, with the exception of the 2001 and 2006 datasets. In the basin level land cover change analysis, datasets were aggregated to the boundaries of the SCRB. In the tributary level analysis, datasets were aggregated to drainage areas for tributaries that converge with the St. Croix River. To compare the distribution of land cover represented by these datasets, a reclassification of the cover types was completed. The distribution of land cover change within the basin was then described in relation to the location of the tributary watersheds within the SCRB.

The land cover in the SCRB in the mid-late 1800s (presettlement) ranged from upland forest and lowland vegetation in the north to grassland, prairie, and shrubs in the south and southwest. Since then, much of the southern half of the basin has been converted to agriculture, with pockets of non-cultivated lowland and upland vegetation remaining. Overall, forested cover types saw the largest decline both in area and in percent change. Analysis of the distribution of land cover change showed that the farther upstream a tributary watershed was from the mouth of the St. Croix River, the less likely the tributary was to see change to converted cover types such as cultivated crops and developed areas. Watersheds such as the Snake and the Kettle Rivers in Minnesota, and the Clam and the Yellow Rivers in Wisconsin are at the edge of this northeastward and upstream advance of converted lands, and represent good areas to focus protection strategies for forested lands.

In the riparian level land cover change analysis, datasets that were appropriate for the scale of riparian areas were used to show change between the time periods they represented (from 2001 to 2006). Geoprocessing methodologies were used that respected the scale of riparian zones, the cell size (resolution) of the land cover datasets, and the riparian buffer distance that had the greatest impact on water quality. The distribution of change once again showed an upstream pattern across the SCRB. However, the pattern switched from change from non-converted cover types to converted cover types to change within converted cover types. While change to developed cover types decreased farther upstream, change to cultivated crops reversed in this trend and increased farther upstream. Over half of the change to developed cover types was from cultivated crops. The majority of change for upland forest and woody wetland cover types was to other non-converted cover types. The most common cover types to be converted to developed cover types were from pasture/hay, cultivated crops, and deciduous forest.

An accuracy assessment was conducted using aerial imagery for select areas and cover types in riparian zones. Contiguous areas of change classifications were reviewed for whether the overall change classification was accurate. Because riparian zones constrict the size of the polygons that are analyzed for accurate change descriptions, the accuracy assessment may not be applicable to the datasets across the entire SCRB. The accuracy of the change classifications was moderate. Change to developed cover types was more accurate than change to cultivated crops.

Forested land has been lost on a large scale across the SCRB since presettlement times, amounting to over 20% of the basin. As human expansion has pushed upstream, change from low phosphorus export cover types such as forest, shrub, and grassland to high phosphorus export cover types such as cultivated crops and developed land has been the result. Riparian areas in downstream tributary watersheds are recently seeing advanced stages of this human expansion where cultivated crops are being converted to developed land.

While the relationship of tributary watershed position within the watershed to change to converted land cover types is complex, it exists and can be used to determine where to target particular types of water quality improvement strategies. In the downstream portion of the basin, restoration and mitigation strategies will be important because a higher portion of the land cover has already been converted to higher phosphorus exporting land cover types. Mid-basin, protection strategies would be more appropriate to preserve some of the low-phosphorus export land cover types that still exist in abundance. Failure to preserve these low phosphorus export land cover types could mean failure to meet water quality goals in the SCRB.

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INTRODUCTION

Phosphorus loading has been demonstrated to cause eutrophication of water bodies resulting in loss of biological diversity and recreational quality. Significant efforts have been undertaken to explain and calculate phosphorus loading within watersheds in Minnesota and Wisconsin, including the Legislative Report: Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (MPCA 2004), the Lake St. Croix Total Phosphorus Loading Study (Magdalene 2009), and the Lake St. Croix Nutrient Total Maximum Daily Load (MPCA & WI DNR 2012). These studies have determined that forested land is among the lowest of the potential contributors of non-point source loading of phosphorus in terms of export rates by area.

This report is intended to provide a historical analysis of land cover within the St. Croix River Basin (SCRB) and the tributary watersheds within the SCRB with a focus on forested lands that protect water quality. This historical analysis of land cover will allow for assessment of how the land cover has changed in the basin both overall and at the tributary level. Analyzing recent land cover changes (from 2001 to 2006) at the riparian level will narrow the land cover analysis to areas that have the most impact on water quality using datasets that are appropriate for that scale. Illustrating how forested landscapes have changed over time can help to understand some of the reasons why water quality has declined in the SCRB, and to identify areas that could be protected to keep water quality from declining further than it already has.

BACKGROUND

St. Croix Basin Hydrology

For much of its length, the St. Croix River serves as a portion of the boundary between the States of Minnesota and Wisconsin. The St. Croix River Basin (SCRB) spans about 7,700 square miles (20,000 sq. km) across the two states (Figure 1). Overall drainage patterns are toward the center of the basin, and from north to south, toward the Mississippi River at its mouth.

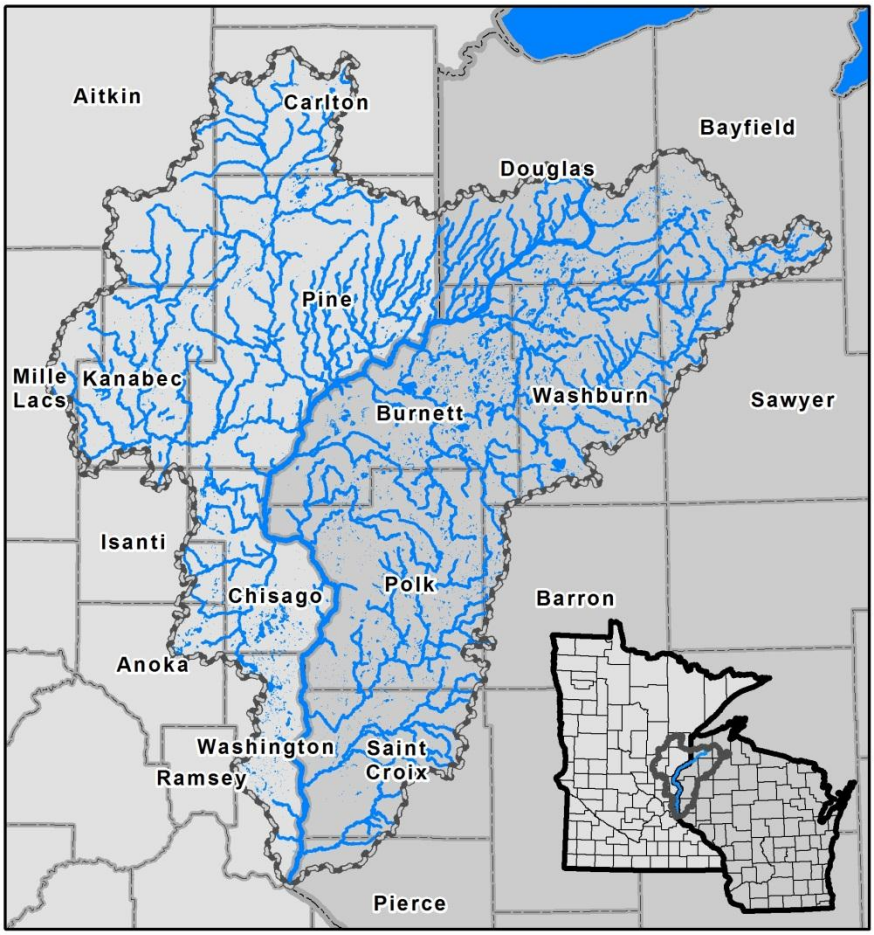

Figure 1. St. Croix River Basin in Minnesota and Wisconsin.

History of Land Cover Mapping in the St. Croix Basin

The mid-late 1800s mark the earliest available snapshot of land cover mapping in the SCRB which was developed in two parts, for each state. In Minnesota, Marschner (1974) developed a map from the notes of public land surveys that were conducted 1847-1907. The Marschner Presettlement Map was then digitized by the DNR Division of Forestry in the early 1990s to create the Presettlement Land Cover dataset. The digitization process omitted thousands of small polygons, primarily in the prairie and transitional forest areas of the state. In Wisconsin, Finley (1976) compiled notes of public land surveys that were conducted 1832-1866 to create the Original Vegetation Cover Map of Wisconsin. This map was then digitized by students at the UW-Madison under the direction of Professor Steve Ventura in 1990 to create the Original Vegetation Cover dataset.

Land cover was not mapped in a spatially continuous dataset across the SCRB for a second time until the 1990s. Advances in Geographic Information Systems software and availability of satellite imagery allowed for generation of land cover datasets by computer classification of remotely recorded brightness values from multiple bands of electromagnetic emissions. This automated process reduced necessary field work needed for data collection to only include accuracy checks of the computer generated land cover delineations. In Minnesota, a statewide land cover dataset titled "GAP Land Cover" was created using this process as part of the Upper Midwest Gap Analysis Program (1992). In Wisconsin, a statewide land cover dataset titled "WISCLAND" was created using this process as part of the Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (1992). Both datasets were created using Landsat Thematic Mapper (TM) satellite imagery.

Subsequent land cover datasets have become available through the Multi-Resolution Land Characteristics Consortium in the form of the National Land Cover Datasets (NLCD) for 2001 (Version 2.0) and 2006, which were created using Landsat Enhanced Thematic Mapper imagery. These two datasets represent the first nation-wide coverages that are directly comparable across different time periods. The NLCD 2001 and 2006 datasets use the same classification system. However, each of the other datasets discussed above uses a different system. By reclassifying all of the datasets using simplified cover types that apply across all time periods, a historical analysis of land cover change can be conducted.

As an example, the Aspen-Birch trending to Hardwood Forest of the mid-late 1800's, the Mixed Deciduous Broadleaf Forest of 1992, and the Deciduous Forests of 2001 and 2006, were all classified as Upland Forest cover types (Appendix D). While this analysis requires a reduction in classification precision down to the level of the "lowest common denominator", it can provide a good picture of how SCRB land cover has changed with time since the earliest available maps.

Linkages between Land Cover and Water Quality in the St. Croix Basin

One measure of water quality is the mass load (in pounds, kilograms, or tons) of total phosphorus that is carried by the water, or how much phosphorus loading is occurring. Some level of phosphorus loading is due to the original natural landscape, which is known as "background nonpoint source" loading. However, when we convert land from its natural state, this often results in increased loading, the difference in which can be referred to as "cultural nonpoint source" loading (Magdalene 2009).

The relationship between land cover and water quality is a complex interaction between climate, soils, vegetation, and topography. A forest on a steep slope with erodible soils near a water body will have a far different impact on water quality than a forest on a gentle a slope with stable soils that is far from a water body. An area of developed land that is further away from the water body may still have significant influence on water quality due to storm water drainage networks.

Significant efforts have been undertaken to explain and calculate phosphorus loading resulting from land cover within watersheds in Minnesota and Wisconsin. Reports that have covered this topic include the Legislative Report: Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (MPCA 2004), the Lake St. Croix Total Phosphorus Loading Study (Magdalene 2009), and the Lake St. Croix Nutrient Total Maximum Daily Load (MPCA & WI DNR 2012). Each of these reports uses Total Phosphorus Export Coefficients (TPEC), or the mass of phosphorus erosion per unit area over a given period of time (e.g. kg/ha-yr) to quantify land cover contributions of phosphorus loads to water bodies.

The MPCA (2004) report was created to provide the information necessary to comply with newly enacted legislation surrounding phosphorus sources. The report estimated "the total amount of phosphorus entering all of the surface water areas that are present within each major basin" for a range of flow conditions. The MPCA (2004) focused on phosphorus sources delivered to the edge of surface waters, but did not estimate routing of phosphorus through surface waters.

Appendices C, I, and J of the MPCA 2004 report describe the methods used to estimate phosphorus loading from land cover to all surface waters. Coefficients used in calculations varied by watershed due to several factors including rainfall amounts and ecoregions. Non-urban areas were analyzed for agriculture (Appendix C) and non-agricultural rural land use (Appendix I) that existed within 100 meters of water bodies, the area where risk of phosphorus transport to surface waters was agreed to be are greatest. Incorporated urban areas were analyzed for all land cover within their boundaries (Appendix J) under the assumption that all areas drained to open waters via storm drainage networks. For agriculture and non-agricultural rural land use, phosphorus export coefficients were multiplied by the area of land cover types existing within 100 meters of water bodies to calculate expected phosphorus loading. For developed urban land

uses, the calculation of loads was more complex and involved basin specific concentration regression equations, runoff coefficients, and annual rainfall amounts.

Table 1 lists the phosphorus export coefficients for non-agricultural rural land, agriculture, and developed urban land uses. Non-agricultural rural land and agriculture export coefficients were taken from the tables in their respective appendices. Developed urban land use export coefficients were calculated based on calculated load for each cover type divided by the total area of the cover type in the incorporated urban area in the SCRB.

Table 1. Phosphorus export coefficients for the St. Croix River Basin (from MPCA 2004, appendices and source tables listed in table).

MPCA Assessment Land Cover		**Phosphorus Export Coefficients (kg/ha/yr)**		
Appendix, Table(s)	**Cover Type**	**Dry**	**Average**	**Wet**
Appendix I: Non-agricultural rural land, derived from Table 8 and Table 9	Deciduous Forest	0.044	0.075	0.110
	Evergreen Forest	0.071	0.123	0.181
	Mixed Forest	0.075	0.130	0.191
	Shrubland	0.075	0.129	0.190
	Grassland/Herbaceous	0.098	0.169	0.248
Appendix C: Agriculture, from Table 3	Agriculture	0.180	0.380	0.690
Appendix J: Developed urban land, derived from Table 6 and Table 10	Urban/Recreational Grasses	0.807	0.939	1.024
	Low Intensity Residential	0.807	0.939	1.024
	High Intensity Residential	1.022	1.192	1.295
	Commercial/Industrial/ Transportation	1.330	1.546	1.687

The MPCA (2004) report focused on watersheds within Minnesota, and did not consider the portion of the St. Croix River Basin that extends into Wisconsin. Both the Lake St. Croix Total Phosphorus Loading Study (Magdalene 2009) and the Lake St. Croix Nutrient Total Maximum Daily Load report (MPCA & WI DNR 2012) focused on phosphorus loading from the SCRB to Lake St. Croix. Upon agreement by representatives from Minnesota and Wisconsin "to achieve a 20% reduction in phosphorus loading to Lake St. Croix by the year 2020" and in preparation for an impending TMDL report, Magdalene (2009) sought to "develop as much information as possible for all that would be necessary for a basin-scale Lake St. Croix Total Maximum Daily Load (TMDL) project".

Magdalene (2009) inventoried all sources of phosphorus loading in the SCRB and focused on phosphorus delivery to Lake St. Croix. To account for nonpoint source loading, the report

employed a similar methodology to that used in the MPCA (2004) report in that areas of different land cover types were multiplied by phosphorus export coefficients to calculate phosphorus loads. The methodologies differed in the values used for phosphorus export coefficients and in how land cover proximity to water bodies was accounted for. Magdalene (2009) also accounted for in stream processes during transport of phosphorus to Lake St. Croix.

Magdalene (2009) arrived at phosphorus export coefficients based on numbers from the MPCA report, additional literature, and the professional judgment of several St. Croix River Basin Team runoff experts with a long history of experience in the SCRB. Table 2 lists the phosphorus export coefficients used in Magdalene (2009). Total areas of each cover type within the SCRB were calculated and multiplied by the corresponding export coefficient to arrive at total field-scale non-point source loads.

Table 2. Phosphorus export coefficients for the St. Croix River Basin (from Magdalene 2009, Table 5).

	Total Phosphorus Export Coefficients (kg/ha/yr)		
Covert Type	**Dry**	**Average**	**Wet**
Water	0.033	0.050	0.075
Forest	0.067	0.100	0.150
Shrub	0.067	0.100	0.150
Grass	0.167	0.250	0.375
Agriculture	0.500	0.750	1.125
Urban	0.500	0.750	1.125

To account for land and in stream processes during transport of phosphorus to Lake St. Croix the presettlement load amount (Triplett et al. 2009) to Lake St. Croix was used to determine the phosphorus delivery ratio (%) from the SCRB to the lake. An iteratively derived reduction of 12.2% was then applied to the total field-scale phosphorus source loads to arrive at the total phosphorus load that was measured in Lake St. Croix. This methodology differed from that used in the MPCA (2004) report in that the MPCA report only calculated loads within 100 meters of water bodies and incorporated urban areas and in that the MPCA (2004) report stopped at the water's edge and did not factor for where the phosphorus loads would eventually be deposited.

The Lake St. Croix Nutrient Total Maximum Daily Load (MPCA & WI DNR 2012), which sought to establish "the needed reduction in the loading of phosphorus from its contributing basin in order to achieve water quality standards", used phosphorus export coefficients "not as a means to estimate watershed loads that were initially unknown, but rather as a means only to estimate the spatial distribution of the Basin's known runoff P load." Phosphorus export coefficients were reduced by 18.5% to coincide with 1990s phosphorus loads entering Lake St.

Croix (Triplett et al. 2009). Areas of land cover types were then multiplied by corresponding phosphorus export coefficients to spatially distribute runoff loads between Minnesota and Wisconsin. Table 3 lists the adjusted phosphorus export coefficients used in MPCA and WI DNR (2012).

Table 3. Phosphorus export coefficients for 1990s average rainfall conditions in the St. Croix River Basin (from MPCA & WI DNR 2012, Table 10).

Cover Type	Phosphorus Export Coefficients (kg/ha/yr)
Water	0.007
Forest	0.098
Shrubland	0.098
Grassland	0.221
Agriculture	0.628
Urban	0.628

While the literature review demonstrates a variety of methods for estimating phosphorus runoff, all reports consistently show that forested lands are among the lowest in phosphorus export. This validates the importance of preserving forested land and other low phosphorus export land cover types for the protection of water quality. If these lands continue to be converted to higher phosphorus export cover types, achieving the goal of reduction of phosphorus loading to Lake St. Croix may prove difficult to achieve.

METHODS

Basin Level Land Cover Change Analysis

This land cover change analysis includes datasets representing mid-late 1800s land cover (Presettlement Land Cover (Minnesota), Original Vegetation Cover (Wisconsin)), early 1990s land cover (Gap Analysis Program Land Cover of Minnesota (GAP), Land Cover of Wisconsin (WISCLAND)), and 2001 and 2006 land cover (National Land Cover Dataset (NLCD)). Datasets that were originally created in raster format (GAP, WISCLAND, and NCLD) were converted from raster to vector format then projected to NAD 1983 UTM 15N. The Presettlement Land Cover and Original Vegetation Cover datasets were merged with areas of open water extracted from the GAP and WISCLAND datasets to account for lack of inclusion of these open water areas during the initial digitization processes.

Spatial resolutions vary across the datasets, which can pose problems in smaller areas such as riparian buffers, especially in the case of the mid-late 1800s data. Positional offsets in the Presettlement Land Cover dataset can be up to 1,000 feet (300 meters) in places, and the original maps were created at 1:1,000,000 and 1:500,000 scale for Marschner's Presettlement Map and the Original Vegetation Cover Map respectively. Spatial resolution greatly improves with the remaining datasets; each has an original cell size of 30 by 30 meters. Some caution must be taken in use of area estimates generated from each of the datasets, particularly in the case of the mid-late 1800s datasets.

In addition to differences in collection/analysis methodologies and spatial resolutions, land cover classification systems within the datasets also vary across the datasets (with the exception of the NLCD 2001 and 2006 datasets). To compare the datasets, they were reclassified into more simplified cover types (Appendix D). In the original dataset classification systems, lowland areas were grouped differently in each dataset. The National Land Cover Dataset grouped lowland forest and lowland shrub; mid-late 1800s datasets for both Minnesota and Wisconsin grouped lowland shrub and wetlands. These lowland areas cannot be split consistently throughout the datasets, and therefore were grouped as "Lowland Vegetation".

The watershed boundaries used to aggregate the land cover data were extracted from the National Hydrologic Dataset (NHD) Watershed Boundary Dataset (WBD) at the Hydrologic Unit Code (HUC) 12 level for the HUC 4 of 0703, which represents the area drained by the mouth of the St. Croix River (the St. Croix River Basin). Areas of each cover type were calculated for the basin and summarized by the simplified cover types (Appendix A).

Tributary Level Land Cover Change Analysis

HUC 12 units within the basin were allocated to tributaries for units upstream from tributary mouths for select streams and rivers to create "tributary watersheds" (Figure 2). Units that were immediately adjacent to the St. Croix River were grouped as "Adjacent Small Streams", and units that contained "Non-Contributing" in the HU_12_Name field were grouped as "Non-Contributing Areas". Areas of land cover types were then calculated for each of the tributary watersheds, summarized by the simplified cover types, and compared across the SCRB (Appendix B).

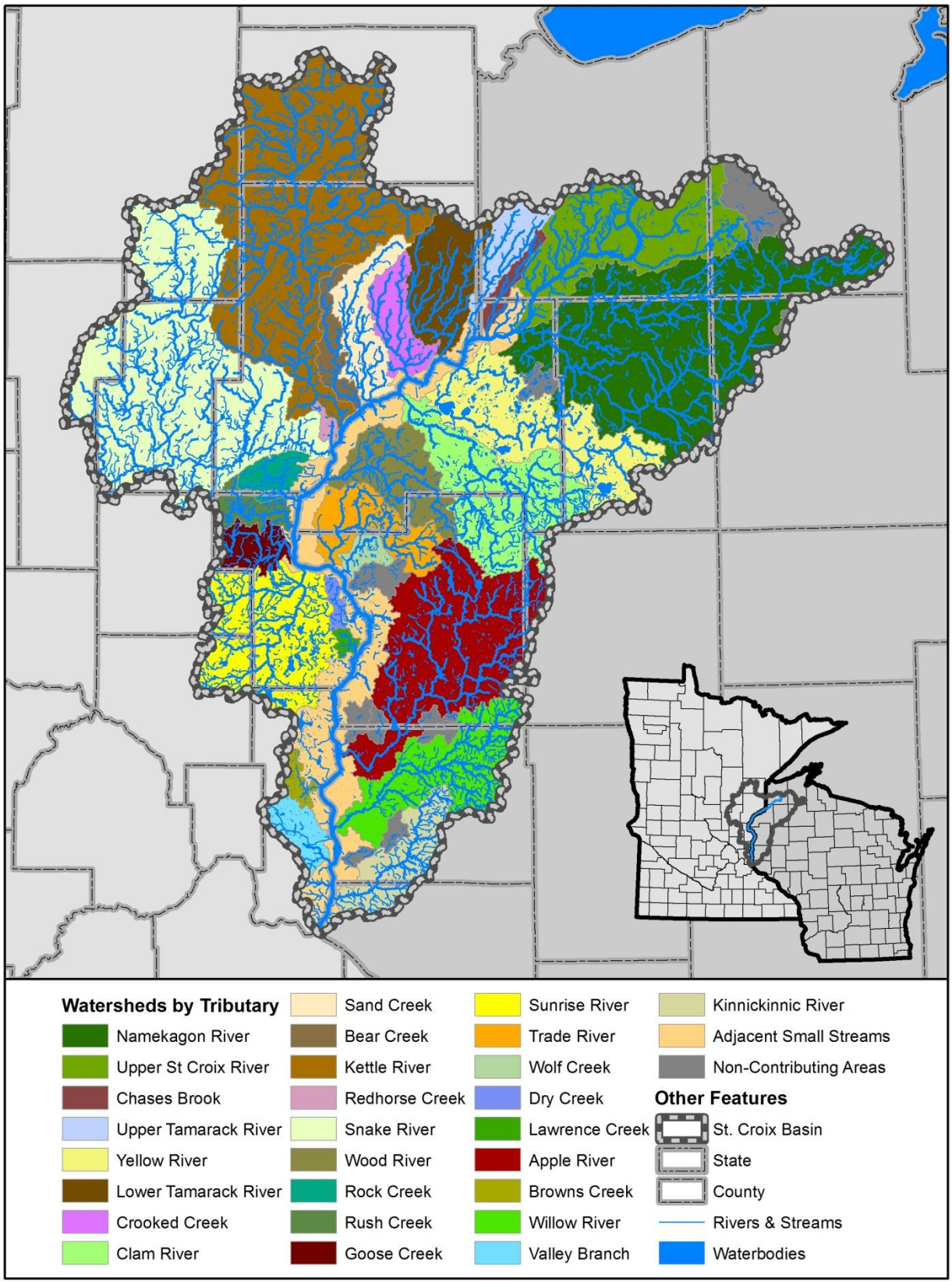

Figure 2. SCRB and tributary watersheds (tributary watersheds listed upstream to downstream).

Riparian Level Land Cover Change Analysis

Land cover change within riparian areas was analyzed using a more detailed geoprocessing methodology. The watershed level analysis employed methodology that converted any raster data to polygon and clipped the polygons to the watershed boundary. That methodology resulted in raster cells at the edge of the watershed being split by the watershed boundary, which may have resulted in a misrepresentation of the portion of the cell that was analyzed. For instance, if a cell was classified as upland forest, and the actual makeup of that cell was 60% upland forest and 40% grassland, and the 40% of grassland was inside the watershed and the 60% of upland forest was outside the watershed, that area inside the watershed would have been incorrectly recorded as upland forest due to the majority classification that was applied to the cell in the original dataset. However, at the basin and tributary levels, those potential misrepresentations, which only occur along the watershed boundary, were acceptable.

To conduct the riparian analysis, respect for the resolution of the land cover data was more imperative. A geoprocessing procedure was employed that maintained the 30 meter resolution of the NLCD data by avoiding resampling the data, and that factored for areas classified as open water within the dataset. This process involved creating a raster representation of the riparian zone that matched the cells of the NLCD data and included cells classified as open water within the 2001 and 2006 NLCD data. This involved a two-step process of (1) creating a polygon representation of water features that flow to the mouth of the St. Croix River using polygon and polyline data sources (NHD) and raster data sources (NLCD), and (2) buffering the water feature polygon representation at an appropriate buffer distance that respected both the cell size of the raster land cover data and that included riparian areas that have a significant influence on water quality.

To create the polygon representation of water features, four datasets were used including all types from NHD Flowlines (polyline) and Water Bodies (polygon) and NLCD 2001 and 2006 open water areas (raster). To create a polygon representation of the streams represented by line features in the Flowlines dataset, a buffer of 0.25 meters of the line features was created. The intent was to create polygon features, not to represent actual stream width. To expand the streams where Water Body polygons were present, polygons within the Water Bodies dataset that intersected Flowlines features were selected. To include areas of open water in the NLCD datasets, the raster datasets were converted to polygon datasets, and areas classified as “Open Water” that intersected Flowlines line features or that intersected Water Body polygons that intersected Flowlines were selected.

The polygon 0.25 meter buffer of the Flowlines, intersecting Water Bodies, and intersecting NLCD open water areas were then merged into one dataset and dissolved. This created one contiguous polygon for all water bodies that were shown to connect to the mouth of the St. Croix River, as well as several non-contiguous polygons for areas that did not show connectivity to the

mouth of the St. Croix River in the NHD datasets. All non-contiguous polygons were then deleted to remove potentially non-contributing water feature polygons. This process resulted in a water feature polygon representation that, when buffered for riparian areas, would result in minimal areas of open water occurring in the riparian buffer zone and would represent only water features that were shown to flow to the mouth of the St. Croix River.

To buffer the water feature polygons, two considerations were made including (1) to use a buffer distance that represented the riparian areas with the greatest influence on water quality, and (2) to respect the cell size of the NLCD dataset and avoid resampling that would result in degraded spatial accuracy. Areas within 31 meters (100 feet) of water bodies have been shown to have the greatest impact on water quality (Roberts et al., 2010). However, cells within the NLCD dataset are 30 x 30 meters, which presented two issues. First, a buffer distance of 30 meters would only include 1 cell next to the water feature. Second, only cells that have greater than half of their area within the buffer area would be analyzed, meaning that in some areas, there would not be any cells analyzed directly out from the water feature (Figure 3).

To account for these issues, a buffer distance of 60 meters was used, which resulted in buffer areas that were between 30 meters (the side of one cell) to 85 meters (two times the diagonal of a cell) from water body polygons. To show the difference in resulting analysis areas from different buffer distances, Figure 3 illustrates the results of the 30 meter (Figure 3.A) and 60 meter (Figure 3.B) buffers. Water body polygons are shown in blue, the polygon buffer is shown in red crosshatch, and the resulting cells to be analyzed are shown in gray.

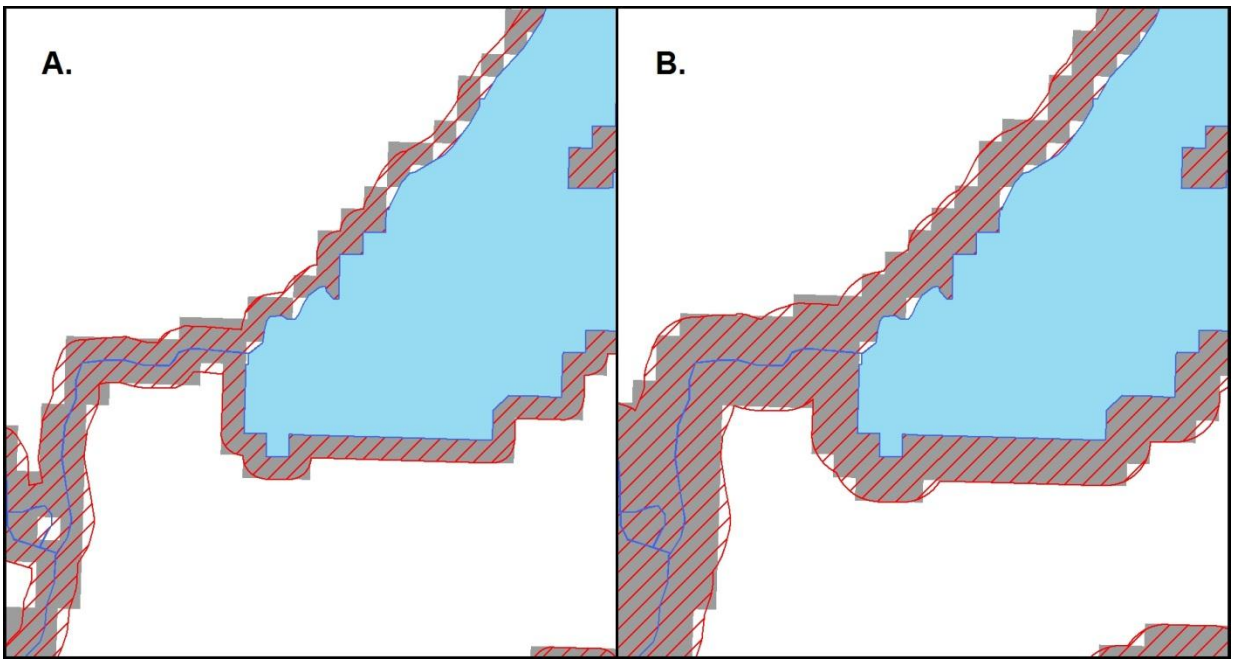

Figure 3. Water feature polygon representation in blue, buffered in red crosshatch at 30 meters (3.A.) and 60 meters (3.B.), and resulting riparian cells to be analyzed in gray.

Riparian Level Land Cover Change Accuracy Assessment

One cell in the NLCD dataset represents a 30 x 30 meter area, or 900 square meters, which is equal to 0.09 hectares, which rounds to 0.1 hectares. By using a geoprocessing methodology that did not resample the NLCD data, this spatial accuracy was maintained throughout the riparian level analysis. While the spatial accuracy of the riparian analysis was immediately quantifiable, the accuracy of the classifications made in the land cover datasets was not readily available. The MRLC website states that a "formal accuracy assessment of the NLCD2006 land cover change product is planned for 2011" (MRLC 2012). No other mention of the accuracy assessment was found on the website at the time it was reviewed. Within the contributing riparian areas in the basin, there are 2,354 polygons covering 605 hectares (1,495 acres) representing contiguous cover type changes as identified by the NLCD datasets.

To conduct an assessment of the accuracy of change in riparian areas from 2001 to 2006, each of these polygons could be evaluated using available aerial imagery. Imagery for 1992 (black/white), 2004 (color), and 2006 (color) is publicly available for most of the SCRB. While imagery from 2001 is not publicly available, the 1992 imagery adequately represents conditions before the change occurred, the 2004 imagery represents mid-change, and the 2006 represents the end of the change period. Conducting an accuracy assessment of all riparian polygons representing change was beyond the scope of this report. However, an evaluation of some select areas was completed.

Two accuracy assessments were conducted using available aerial imagery for whether the overall change description for contiguous areas was accurate or inaccurate. The first focused on watersheds that represented outliers in terms of change in percent cover of cultivated crops, developed cover types, or upland forest cover types. The second focused on change that involved converted cover types including cultivated crops and developed cover types. A random sample of 20% of contiguous cover change polygons were selected and assessed.

RESULTS AND DISCUSSION

Basin Level Land Cover Change

The land cover in the SCRB in the mid-late 1800s (presettlement) ranged from upland forest and lowland vegetation in the north to grassland, prairie, and shrubs in the south and southwest (Figure 3.A). Since then, much of the southern half of the basin has been converted to agriculture, with pockets of non-cultivated lowland and upland vegetation remaining. The northern half has retained much of its presettlement land cover characteristics of upland forests and lowland vegetation, with only pockets of agriculture and developed cover types changing the landscape (Figure 3.B).

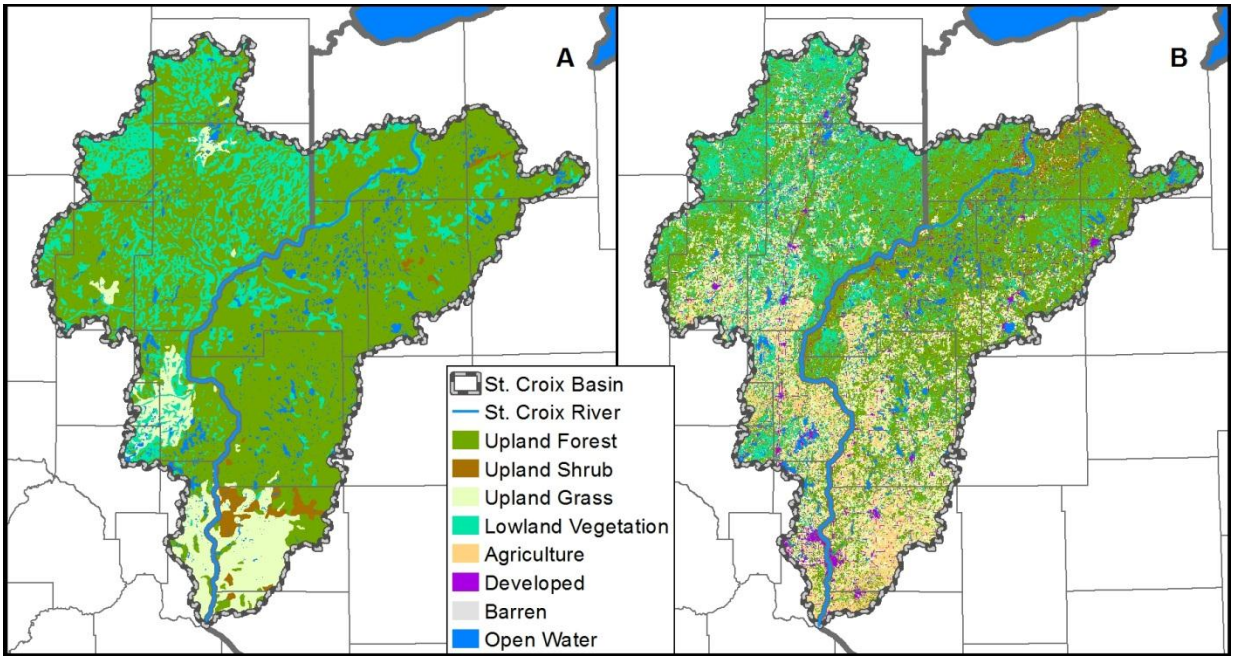

Figure 4. St. Croix River Basin land cover in, (A) mid-late 1800s, and (B) 2006.

Variability for collection methodologies caused significant issues in conducting a change comparison between 1992 datasets and the NLCD 2001 and 2006 datasets. For instance, a significant amount of the increase from 1992 to 2001 of the developed cover type can be attributed to better capture of transportation infrastructure by the methodology used for the NLCD data. In light of this, this discussion is limited to comparison between the first (mid-late 1800s) and last (2006) datasets available and to the directly comparable datasets (2001 and 2006).

From presettlement to 2006, land cover of agriculture, developed, upland grass, and upland shrub cover types increased while land cover of lowland vegetation and upland forest cover types decreased (Table 4). Developed cover types were minimal during presettlement times, and native settlements were not comparable to the impervious landscapes of modern cities. While

agricultural practices were employed in presettlement times by native populations, those practices were not comparable to what is now classified as "agriculture". Given these differences, developed and agriculture cover types can be said to not have existed in presettlement times.

Upland shrub, which was originally classified as "brush" or "brush prairie" in presettlement datasets, showed a high percent change (82%), but still remained a small portion of the basin (2.8%). Upland grass, which was originally classified as "prairie" or jack pine and/or oak openings in presettlement datasets showed a high increase, but much of that increase can be explained by looking at the more detailed NLCD classification (Table A3) for the 2006 land cover, which shows that much of that grassland (88%) is actually pasture/hay.

The starkest change from presettlement to 2006 land cover is the loss of upland forest. The loss of nearly 34% of upland forest, totaling 447,000 hectares (1.1 million acres), or more than 20% of the basin, puts the results of human activity into perspective.

Table 4. SCRB reclassified land cover areas (in hectares and acres) and change from mid-late 1800s to 2006.

	mid-late 1800s			2006 (compared to mid-late 1800s)			
Land Cover Reclassification	**Area (Hectares)**	**Percent of Total Area**		**Area (Hectares)**	**Percent of Total Area**	**Hectares Change**	**Percent Change**
Agriculture	0	0.0		192,757	9.6	192,757	-
Barren	0	0.0		271	0.0	271	-
Developed	0	0.0		103,486	5.2	103,486	-
Lowland Vegetation	374,346	18.8		356,906	17.9	-17,440	-4.7
Open Water	87,373	4.4		79,564	4.0	-7,809	-8.9
Upland Forest	1,322,725	66.3		875,280	43.8	-447,445	-33.8
Upland Grass	180,343	9.0		334,106	16.7	153,763	85.3
Upland Shrub	30,531	1.5		55,572	2.8	25,040	82.0
Totals	**1,995,319**	**100.0**		**1,997,942**	**100.0**	**-**	**-**

	mid-late 1800s			2006 (compared to mid-late 1800s)			
Land Cover Reclassification	**Area (Acres)**	**Percent of Total Area**		**Area (Acres)**	**Percent of Total Area**	**Acres Change**	**Percent Change**
Agriculture	0	0.0		476,312	9.6	476,312	-
Barren	0	0.0		669	0.0	669	-
Developed	0	0.0		255,719	5.2	255,719	-
Lowland Vegetation	925,030	18.8		881,935	17.9	-43,095	-4.7
Open Water	215,903	4.4		196,608	4.0	-19,295	-8.9
Upland Forest	3,268,525	66.3		2,162,865	43.8	-1,105,660	-33.8
Upland Grass	445,638	9.0		825,594	16.7	379,957	85.3
Upland Shrub	75,444	1.5		137,320	2.8	61,876	82.0
Totals	**4,930,541**	**100.0**		**4,937,022**	**100.0**	**-**	**-**

Table 5 shows changes and rates of change in percent cover for the basin. The date for the presettlement datasets is not exact; the date of 1866 was chosen simply to provide a 140 year time span with which to derive a rate of change. The expected change in percent cover over 5 years was calculated by dividing the change in percent cover from presettlement to 2006 by 140 years to obtain a rate of change, then multiplying that rate of change by 5 years.

Percent cover is more useful at the tributary level where it provides an area normalized statistic that can be used for comparison across each tributary. Analysis of change at the tributary level is included below in the riparian analysis. At the basin level, the changes and rates of change in percent cover can give context for the changes occurring at the tributary level by providing an expected rate of change. Comparing the rates of change in percent cover for different time periods at the basin level can also show whether the overall trends for each cover type have changed in the most current time period available.

Compared to the 140 year period from presettlement to 2006, the change occurring in the 5 year period showed that the increase in percent cover of agriculture changed to a slight decrease and the decrease in percent cover of lowland vegetation changed to an increase. Developed, upland grass, and upland shrub cover types continued to increase while upland forest continued to decrease. Rates of increase for developed and upland grass cover types were less than expected. Rates of decrease in upland forest were also less than expected.

Table 5. SCRB change in percent cover from presettlement (assuming 1866) to 2006, expected change in percent cover over 5 years, and change in percent cover from 2001 to 2006.

Land Cover Reclassification	Percent Cover, mid-late 1800s, assuming 1866	Percent Cover 2001	Percent Cover 2006	Change in Percent Cover, Presettlement to 2006	Expected Change in Percent Cover over 5 years	Change in Percent Cover, 2001 to 2006
Agriculture	0.000	9.649	9.648	9.648	0.345	-0.001
Barren	0.000	0.008	0.014	0.014	0.000	0.006
Developed	0.000	5.077	5.180	5.180	0.185	0.102
Lowland Veg	18.761	17.577	17.864	-0.898	-0.032	0.286
Open Water	4.379	4.025	3.982	-0.397	-0.014	-0.043
Upland Forest	66.291	44.345	43.809	-22.482	-0.803	-0.536
Upland Grass	9.038	16.597	16.723	7.684	0.274	0.125
Upland Shrub	1.530	2.721	2.781	1.251	0.045	0.060

Tributary Level Land Cover Change

The distribution of change in land cover types by tributary watersheds exhibited a spatial pattern for the two cover types with the highest export of phosphorus: agriculture and developed lands (converted cover types). The spatial distribution showed that the farther upstream a tributary is in the SCRB, the less likely it is to have high levels of conversion to converted cover types (Figure 5 and 6). In terms of developed lands, their distribution is most likely influenced by the location of major transportation routes, which successively in history were: rivers, railroads, and highways. The opening of new transportation routes are often followed by urban growth along those routes. For agriculture, location of soils, climates suitable for farming, and transportation routes to markets are the most likely driving factors.

Though determining the reasons for the correlation of distance upstream to increased change to converted lands is complicated, the relationship does exist. This relationship can help to decide what tributary watersheds to target for conservation of land cover types that have low phosphorus export such as forest, shrub, and grass, and to identify where there is high potential for phosphorus exports due to high concentrations of high phosphorus export cover types. Watersheds such as the Snake and the Kettle Rivers in Minnesota, and the Clam and the Yellow Rivers in Wisconsin are at the edge of this northeastward and upstream advance of converted lands. With more lands being converted to developed cover as cities expand and to agriculture as the climate changes and commodity prices rise, protection of low phosphorus export land cover types such as forests becomes an increasingly important piece to keeping water quality from degrading further than it already has.

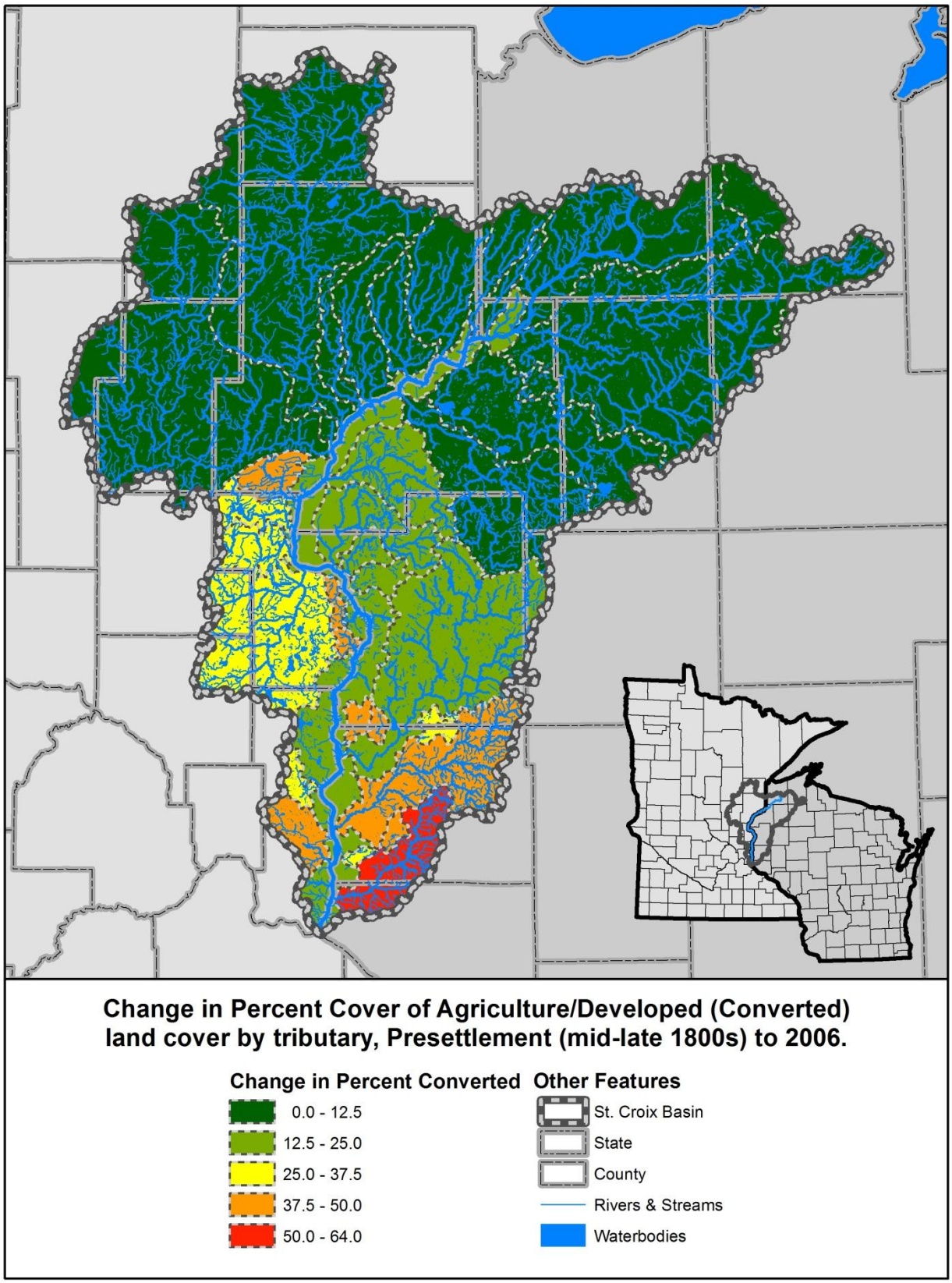

Figure 5. Change in percent cover of converted land cover, mid-late 1800s to 2006.

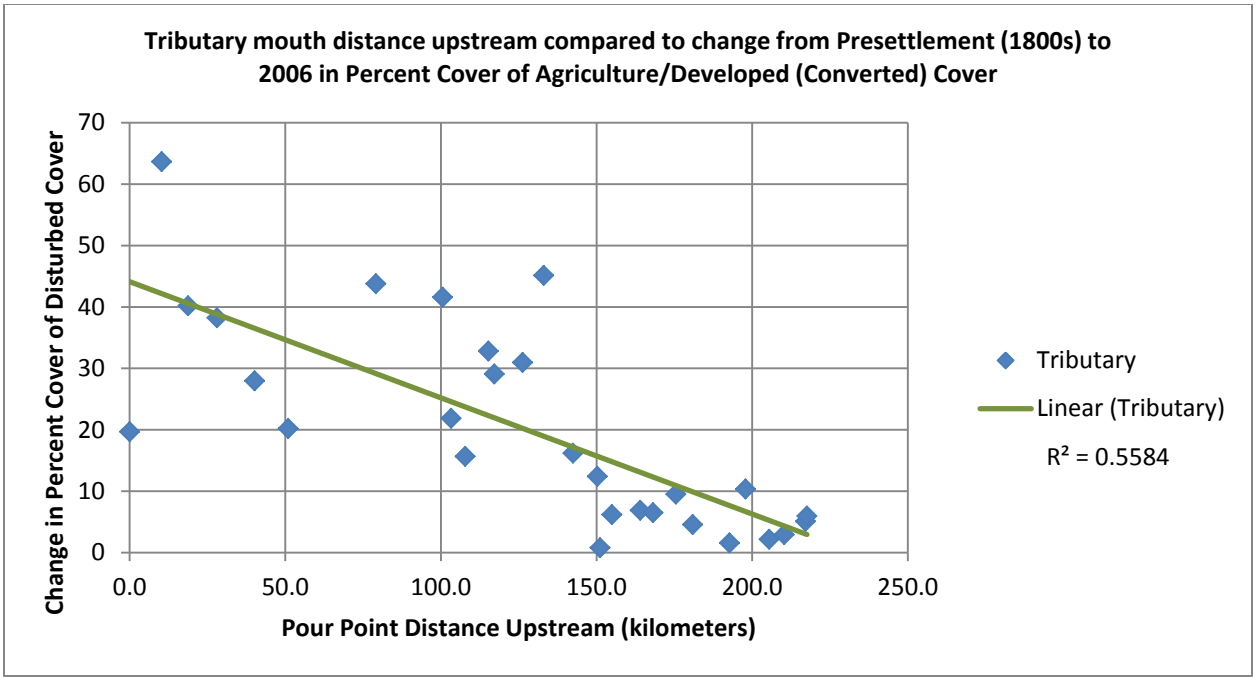

Figure 6. Tributary mouth distance upstream from the Mississippi River compared to change in percent converted cover.

Riparian Level Land Cover Change

The land cover in SCRB contributing riparian areas, which are areas that are within 30 to 85 meters of flow pathways that include all flow types (perennial, intermittent) and are connected to the mouth of the St. Croix River, showed similarities and differences compared to changes occurring basin-wide (Table 6 and Table 7). In contributing riparian areas and basin-wide, developed, lowland vegetation, upland grass, and upland shrub cover types showed increases in area and upland forest showed a decrease in area. Agriculture increased in contributing riparian areas while slightly decreasing basin-wide.

Table 6. SCRB contributing riparian area reclassified land cover areas (in acres and hectares) and change from 2001 to 2006.

Land Cover Reclassification	Area 2001 (Hectares)	Area 2006 (Hectares)	Area Change (Hectares)	Area 2001 (Acres)	Area 2006 (Acres)	Area Change (Acres)
Agriculture	10,536.8	10,560.7	23.9	26,036.9	26,096.0	59.2
Barren	3.1	3.1	0.0	7.6	7.6	0.0
Developed	6,344.7	6,418.9	74.2	15,678.2	15,861.4	183.3
Lowland Veg	46,546.3	46,558.1	11.8	115,018.4	115,047.5	29.1
Open Water	183.3	176.3	-7.0	453.0	435.7	-17.3
Upland Forest	53,770.6	53,599.5	-171.1	132,870.0	132,447.2	-422.8
Upland Grass	17,271.6	17,331.0	59.4	42,679.1	42,825.9	146.8
Upland Shrub	2,394.7	2,403.5	8.8	5,917.5	5,939.3	21.8
Total Riparian Area	**137,051.1**	**137,051.1**	**-**	**338,660.6**	**338,660.6**	**-**

Areas of open water represented less than two-tenths of a percent of the total riparian area analyzed, showing that the analysis methodology succeeded in filtering out open water areas (Table 7). Lowland vegetation and upland shrub showed very little change. The largest change was a decrease in upland forest, followed by an increase in developed and upland grass. Change in contributing riparian areas over the five year period was less pronounced than basin-wide change, except in the case of agriculture.

Table 7. SCRB contributing riparian area change in percent cover from 2001 to 2006, basin-wide change in percent cover from 2001 to 2006, and expected change in percent cover over 5 years.

Land Cover Reclassification	Percent Cover 2001	Percent Cover 2006	Riparian Change in Percent Cover, 2001 to 2006	Basin-wide Change in Percent Cover, 2001 to 2006	Expected Change in Percent Cover over 5 years
Agriculture	7.688	7.706	0.017	-0.001	0.345
Barren	0.002	0.002	0.000	0.006	0.000
Developed	4.629	4.684	0.054	0.102	0.185
Lowland Veg	33.963	33.971	0.009	0.286	-0.032
Open Water	0.134	0.129	-0.005	-0.043	-0.014
Upland Forest	39.234	39.109	-0.125	-0.536	-0.803
Upland Grass	12.602	12.646	0.043	0.125	0.274
Upland Shrub	1.747	1.754	0.006	0.060	0.045

The comparison of 2001 to 2006 NLCD data allows for a direct comparison where reclassification of cover types is no longer necessary. The following discussion on change in contributing riparian areas includes the more detailed NLCD classifications. Table 8 shows change in contributing riparian areas from 2001 to 2006 across the SCRB. Cultivated crops saw an increase of 23.9 hectares (59.2 acres). Upland forest cover types (deciduous, evergreen, and mixed forest) saw a decline of 171.1 hectares (422.8 acres). Within this decline, a net loss of 24.1 hectares (59.6 acres), or 14.1%, was to cultivated crops (Table 9) and 15.9 hectares (39.4 acres), or 9.3%, was to developed cover types (Table 10). Of the total decline of 171.1 hectares, 40.0 hectares, or 23.4% of the decline, was to converted cover types and 76.6% was within non-converted cover types.

The woody wetlands cover type saw the largest decline of 202.0 hectares (499.3 acres). Within this decline, a net loss of 12.6 hectares (31.1 acres), or 6.3%, was to cultivated crops (Table 11) and 2.9 hectares (7.1 acres), or 1.4%, was to developed cover types (Table 12). Of the total decline of 202.0 hectares, 15.5 hectares, or 7.7% of the decline, was to converted cover types. So while the decline of woody wetlands was the largest, a majority of this decline (92.3%) was to other non-converted cover types.

Developed cover types saw an increase of 74.2 hectares (183.3 acres). Within this increase, nearly half (49.0%) was to "developed, open space" (Table 13). Of the total increase in developed cover types, pasture/hay (32.9%), cultivate crops (31.4%), and deciduous forest (18.9%) were the most commonly converted cover types.

Table 8. SCRB contributing riparian area NLCD cover type areas (in hectares and acres) and change from 2001 to 2006.

NLCD Cover Type	2001 Area (Hectares)	2006 Area (Hectares)	Area Change (Hectares)		2001 Area (Acres)	2006 Area (Acres)	Area Change (Acres)
Open Water	183.3	176.3	-7.0		453.0	435.7	-17.3
Developed, Open Space	4,838.6	4,874.0	35.5		11,956.4	12,044.0	87.6
Developed, Low Intensity	1,165.6	1,188.3	22.7		2,880.2	2,936.3	56.0
Developed, Medium Intensity	270.1	284.1	14.0		667.4	702.1	34.7
Developed, High Intensity	70.5	72.5	2.0		174.1	179.0	4.9
Barren Land (Rock/Sand/Clay)	3.1	3.1	0.0		7.6	7.6	0.0
Deciduous Forest	46,280.5	46,139.5	-141.0		114,361.7	114,013.2	-348.5
Evergreen Forest	2,719.3	2,709.5	-9.8		6,719.4	6,695.2	-24.2
Mixed Forest	4,770.8	4,750.6	-20.3		11,788.9	11,738.9	-50.0
Shrub/Scrub	2,394.7	2,403.5	8.8		5,917.5	5,939.3	21.8
Grassland/Herbaceous	2,595.8	2,658.5	62.7		6,414.3	6,569.3	155.0
Pasture/Hay	14,675.9	14,672.5	-3.3		36,264.8	36,256.6	-8.2
Cultivated Crops	10,536.8	10,560.7	23.9		26,036.9	26,096.0	59.2
Woody Wetlands	27,269.2	27,067.1	-202.0		67,383.6	66,884.4	-499.3
Emergent Herbaceous Wetlands	19,277.1	19,490.9	213.8		47,634.8	48,163.2	528.4
Total Riparian Area	**137,051.1**	**137,051.1**			**338,660.6**	**338,660.6**	

Table 9. SCRB contributing riparian areas net change of Upland Forest to Cultivated Crops from 2001 to 2006.

2001	2006	Area (Hectares)	Area (Acres)
Deciduous Forest	Cultivated Crops	19.1	47.1
Evergreen Forest	Cultivated Crops	1.5	3.8
Mixed Forest	Cultivated Crops	7.0	17.3
Change of Upland Forest to Cultivated Crops		**27.6**	**68.3**
Cultivated Crops	Deciduous Forest	0.3	0.7
Cultivated Crops	Mixed Forest	3.2	8.0
Change of Cultivate Crops to Upland forest		**3.5**	**8.7**
Net change of Upland Forest to Cultivated Crops		**24.1**	**59.6**

Table 10. SCRB contributing riparian areas change of Upland Forest to Developed from 2001 to 2006.

2001	2006	Area (Hectares)	Area (Acres)
Deciduous Forest	Developed, Low Intensity	3.2	7.8
Deciduous Forest	Developed, Medium Intensity	1.7	4.2
Deciduous Forest	Developed, Open Space	9.2	22.7
Evergreen Forest	Developed, Low Intensity	0.2	0.4
Evergreen Forest	Developed, Open Space	1.4	3.6
Mixed Forest	Developed, Low Intensity	0.3	0.7
Change of Upland Forest to Developed		**15.9**	**39.4**

Table 11. SCRB contributing riparian areas net change of Woody Wetlands to Cultivated Crops from 2001 to 2006.

2001	2006	Area (Hectares)	Area (Acres)
Woody Wetlands	Cultivated Crops	21.2	52.5
Change of Woody Wetlands to Cultivated Crops		**21.2**	**52.5**
Cultivated Crops	Woody Wetlands	8.6	21.3
Change of Cultivated Crops to Woody Wetlands		**8.6**	**21.3**
Net change of Woody Wetlands to cultivated crops		**12.6**	**31.1**

Table 12. SCRB contributing riparian areas change of Woody Wetlands to Developed from 2001 to 2006.

2001	2006	Area (Hectares)	Area (Acres)
Woody Wetlands	Developed, Low Intensity	2.0	4.9
Woody Wetlands	Developed, Open Space	0.9	2.2
Change of Woody Wetlands to Developed		**2.9**	**7.1**

Table 13. SCRB contributing riparian areas change from non-Developed to Developed cover types from 2001 to 2006.

2001	2006	Area (Ha)	Area (Ac)	Percent of subtotal increase	Percent of total increase
Cultivated Crops	Developed, Open Space	6.5	16.0	17.8	8.7
Deciduous Forest	Developed, Open Space	9.2	22.7	25.2	12.4
Emergent Herbaceous Wetlands	Developed, Open Space	1.3	3.1	3.5	1.7
Evergreen Forest	Developed, Open Space	1.4	3.6	4.0	1.9
Grassland/Herbaceous	Developed, Open Space	1.4	3.3	3.7	1.8
Pasture/Hay	Developed, Open Space	14.8	36.5	40.6	19.9
Shrub/Scrub	Developed, Open Space	1.0	2.4	2.7	1.3
Woody Wetlands	Developed, Open Space	0.9	2.2	2.5	1.2
Subtotal (increase in Developed, Open Space)		**36.4**	**89.8**	**100.0**	**49.0**
Cultivated Crops	Developed, Low Intensity	7.6	18.7	33.3	10.2
Deciduous Forest	Developed, Low Intensity	3.2	7.8	13.9	4.2
Emergent Herbaceous Wetlands	Developed, Low Intensity	1.7	4.2	7.5	2.3
Evergreen Forest	Developed, Low Intensity	0.2	0.4	0.8	0.2
Grassland/Herbaceous	Developed, Low Intensity	0.8	2.0	3.6	1.1
Mixed Forest	Developed, Low Intensity	0.3	0.7	1.2	0.4
Pasture/Hay	Developed, Low Intensity	6.8	16.9	30.2	9.2
Shrub/Scrub	Developed, Low Intensity	0.2	0.4	0.8	0.2
Woody Wetlands	Developed, Low Intensity	2.0	4.9	8.7	2.7
Subtotal (increase in Developed, Low Intensity)		**22.7**	**56.0**	**100.0**	**30.6**
Cultivated Crops	Developed, Medium Intensity	8.0	19.8	61.0	10.8
Deciduous Forest	Developed, Medium Intensity	1.7	4.2	13.0	2.3
Emergent Herbaceous Wetlands	Developed, Medium Intensity	0.4	0.9	2.7	0.5
Grassland/Herbaceous	Developed, Medium Intensity	0.6	1.6	4.8	0.8
Pasture/Hay	Developed, Medium Intensity	2.4	6.0	18.5	3.3
Subtotal (increase in Developed, Medium Intensity)		**13.1**	**32.5**	**100.0**	**17.7**
Cultivated Crops	Developed, High Intensity	1.3	3.1	63.6	1.7
Grassland/Herbaceous	Developed, High Intensity	0.4	0.9	18.2	0.5
Pasture/Hay	Developed, High Intensity	0.4	0.9	18.2	0.5
Subtotal (increase in Developed, High Intensity)		**2.0**	**4.9**	**100.0**	**2.7**
Total increase in Developed cover types		**74.2**	**183.3**		**100.0**

To compare change across tributaries, areas of cover types were normalized by dividing by the total contributing riparian area in the tributary resulting in percent coverage of each cover type (Appendix C). The percent coverage from 2001 was subtracted from 2006 to find the percent cover change. Change in percent cover of converted cover types (cultivated crops and developed cover types) that have a higher phosphorus export than non-converted cover types are displayed in Figure 7. No tributary watersheds saw a decline in percent cover of total converted cover type areas; some smaller tributary watersheds saw no change in percent cover of total converted cover type areas.

Once again, a spatial pattern progressing upstream was evident. Although, as opposed to the pattern seen across the SCRB from mid-late 1800s to 2006 where less change to both agriculture and developed cover types occurred at distances further upstream, the pattern from 2001 to 2006 in riparian areas showed that the trend continued for developed cover types, but the trend for agriculture (cultivated crops) was reversed. This relationship is illustrated in Figures 7, 8, and 9. Browns Creek, which was an outlier for both increase in developed cover types and decrease in cultivated crops, was not included in the comparison charts (Figures 8 and 9). Figure 8 shows the correlation of less change to developed cover types with distances farther upstream and Figure 9 shows the reversal of this trend to more change in cultivated crops with distances farther upstream.

Agricultural cover and developed cover exhibited an inverse relationship where, as developed cover types increased, cultivated crops decreased (Figure 10). Over half (51.2%) of the change of cultivated crops to another cover type was to developed cover types (Table C8). As in the basin-wide analysis of mid-late 1800s to 2006 land cover, the datasets replicate a typical pattern of human expansion. However, in the more recent riparian land cover change analysis, the trend has progressed from increase of converted cover types to change within converted cover types where land that was first converted to agriculture is now being converted to developed land.

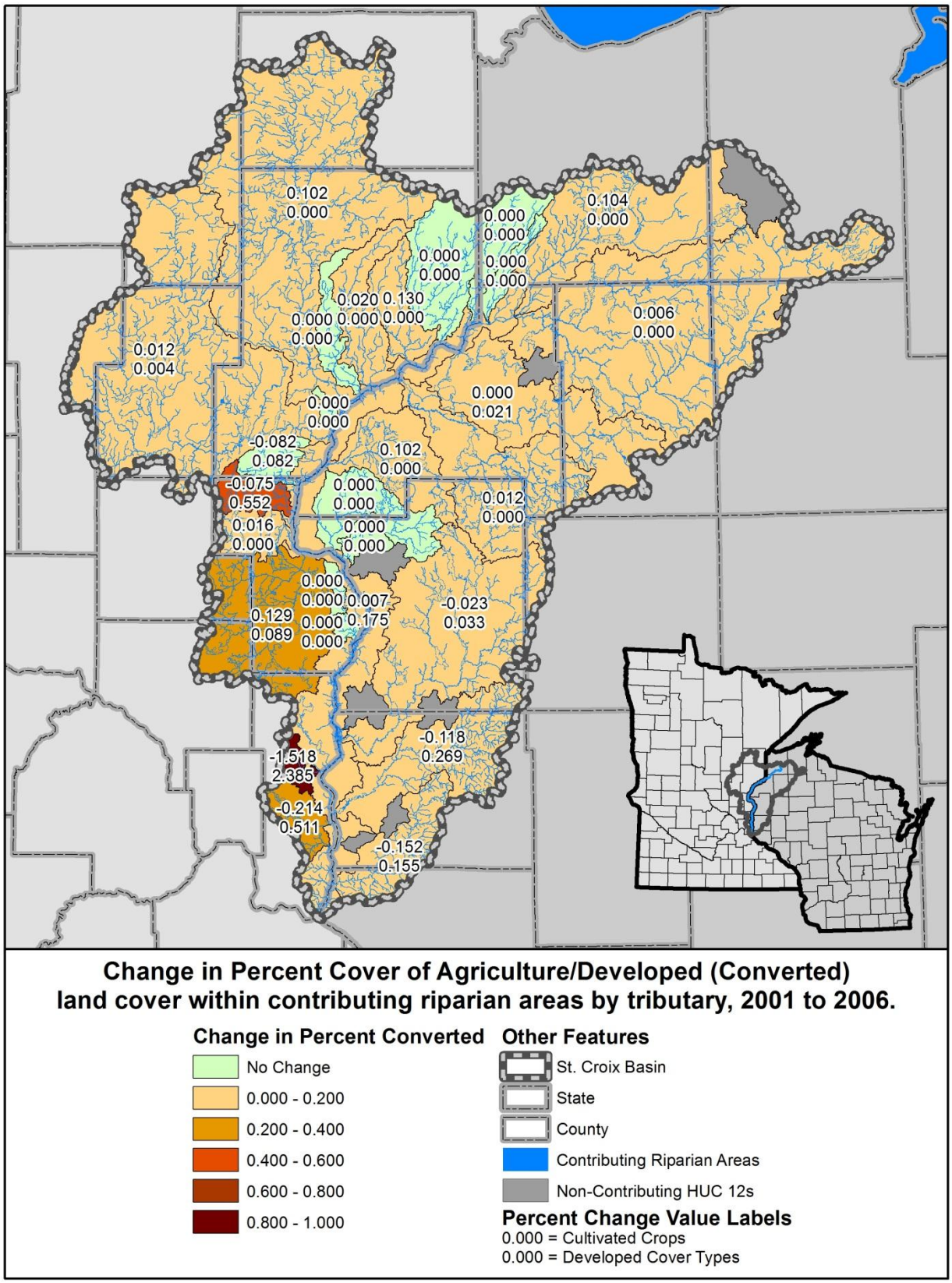

Figure 7. Change in percent cover of converted land cover in contributing riparian areas, 2001 to 2006.

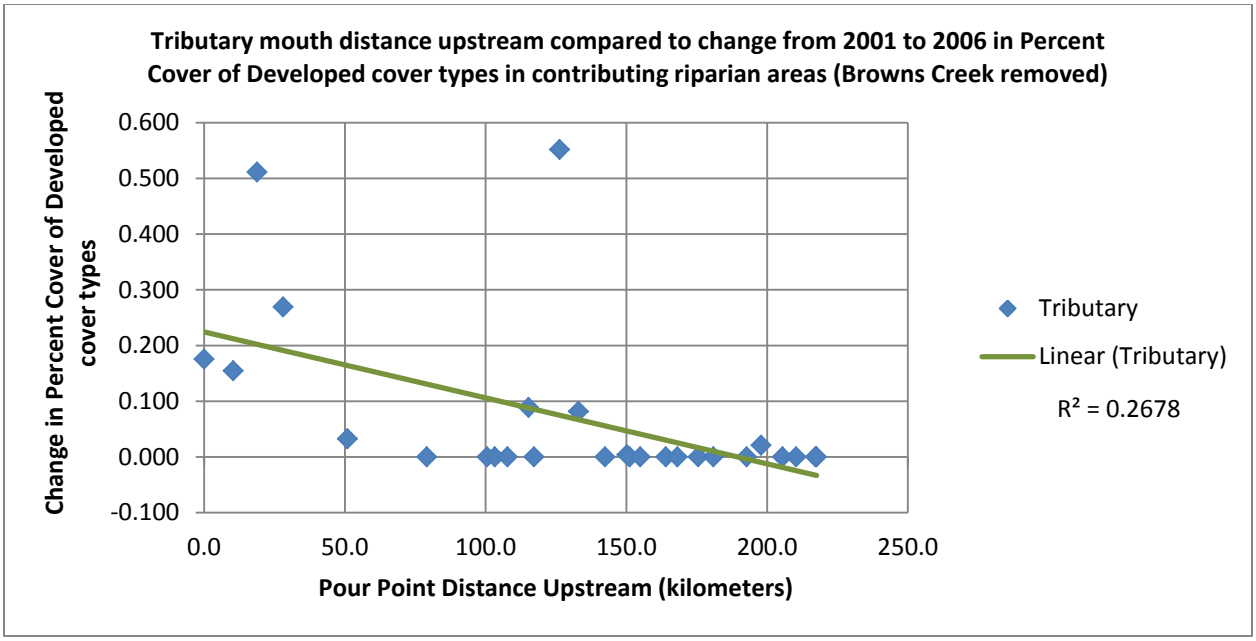

Figure 8. Tributary mouth distance upstream compared to change from 2001 to 2006 in Percent Cover of Developed cover types in contributing riparian areas (Browns Creek removed).

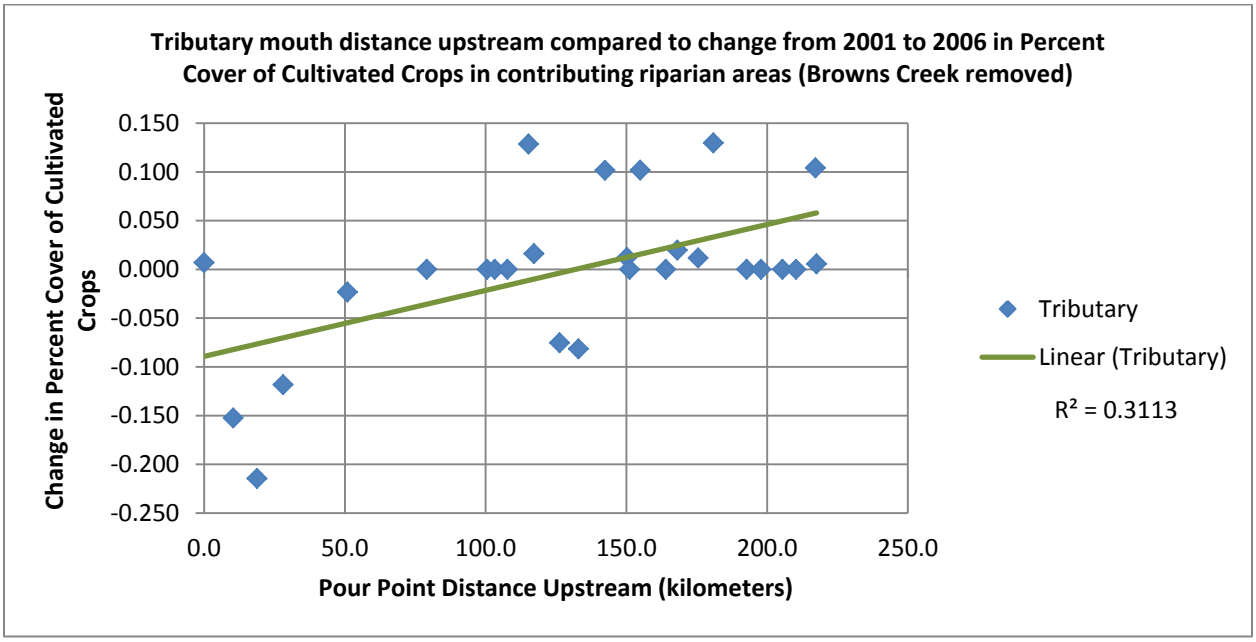

Figure 9. Tributary mouth distance upstream compared to change from 2001 to 2006 in Percent Cover of Cultivated Crops in contributing riparian areas (Browns Creek removed).

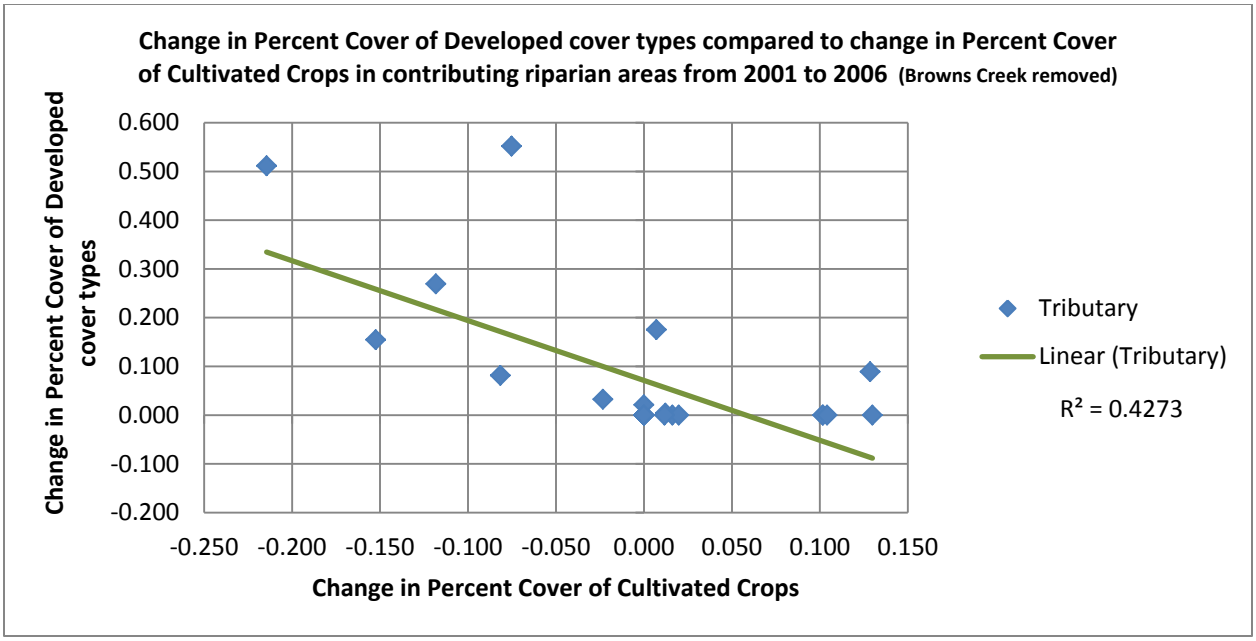

Figure 10. Change in Percent Cover of Developed cover types compared to change in Percent Cover of Cultivated Crops in contributing riparian areas from 2001 to 2006 (Browns Creek removed).

Riparian Level Land Cover Change Accuracy Assessment

The collection/analysis methodologies used to create the NCLD datasets (and others for that matter) have some inherent error included. A formal accuracy assessment conducted by the Multi-Resolution Land Characteristics Consortium (MRLC) of the change between the 2001 and 2006 NLCD datasets was underway at the time of the drafting of this report (MRLC 2012). Understanding the error inherent in the datasets is important when discussing their data.

To understand the accuracy of change represented by the NLCD datasets, an analysis was conducted of tributaries showing high amounts of change and of randomly selected areas throughout the basin where change involved converted cover types. It should be noted that extrapolating this accuracy assessment to the entire dataset would be inappropriate given the restrictions that riparian buffers impose on the size of contiguous polygons representing change. Change to and from cultivated crops and developed cover types was assessed, and overall accuracy was 52.5%. The accuracy of change to cultivated crops was at a low 13.3%. The accuracy of change to developed cover types was high at 73.2%.

To begin the accuracy assessment, outliers in terms of change in percent cover of cultivated crops, developed cover types, or upland forest cover types were selected for evaluation. All tributary watersheds showed an increase in percent cover of developed cover types of less than 1% except Browns Creek (increase of 2.385%) (Table C7). Browns Creek also showed the highest decrease in percent cover of agriculture (decline of 1.518%), yet still resulted in the highest increase of converted cover types (0.867%). All tributary watersheds showed increase or a decrease in percent cover of upland forest cover types of less than 1% except Redhorse Creek (decline of 1.892%). These two outlier tributary watersheds were evaluated for whether the overall change description was accurate or inaccurate.

All areas of change within Redhorse Creek (5.5 hectares) were either from woody wetlands (2.7 hectares), deciduous forest (2.6 hectares), or open water (0.1 hectare) to emergent herbaceous wetlands. Determining accuracy using aerial imagery was not possible for these changes. Within Browns Creek, 96% (7.0 hectares) of the total area of riparian change (7.3 hectares) was to developed cover types, and over half of this change (4.4 hectares) was from cultivated crops. These areas were verifiable from aerial imagery as suburban developments and represented accurate changes.

As found in the evaluation of Browns Creek and Redhorse Creek, change within non-converted cover types is generally difficult to assess using aerial imagery. Additionally, according to estimated phosphorus exports, change within non-converted cover types has less influence on water quality than does change involving converted cover types (MPCA 2004). To include a random sampling of accuracy of riparian change, areas of change were evaluated that involved converted cover types. Of the 2,354 polygons representing contiguous areas of change in riparian

areas, 607 involved converted cover types. A sample of 20% (121) of the polygons covering 33.7 hectares representing change to or from a converted cover type was evaluated for accuracy.

Of the riparian areas showing change involving converted cover types, 53% of the area was determined to be accurate, 46% of the area was determined to be inaccurate, and 1% of the area was indeterminable (Table C9). The most commonly misclassified change was woody wetlands to cultivate crops. Of the accurate change classifications, the majority (73.6% of the area) were to developed cover types. Of the change to developed cover types, 73.2% of the area was accurate. Of the inaccurate change classifications, the majority (66.9% of the area) were to cultivated crops. Of the change to cultivated crops, 86.7% of the area was inaccurate.

CONCLUSIONS

Forested land has been lost on a large scale across the St. Croix Basin since presettlement times. As human expansion has pushed upstream, change from low phosphorus export cover types such as forest, shrub, and grassland to high phosphorus export cover types such as cultivated crops and developed land has been the result. Riparian areas in downstream tributary watersheds are recently seeing advanced stages of this human expansion where cultivated crops are being converted to developed land.

The change description that was found to be most accurate in riparian areas for converted cover types from 2001 to 2006 was from all non-developed cover types to developed cover types. Of the non-developed cover types, pasture/hay, cultivated crops, and deciduous forest were the most common cover types to be converted to developed cover types in riparian areas. So while some of the change in riparian areas was within high phosphorus export cover types, some change from the lowest phosphorus export cover types (deciduous forest) to high phosphorus export cover types (Developed) was still occurring in these critical areas.

Where this change was occurring in terms of stream hierarchy was not examined. Additional analysis of the riparian land cover change data could provide additional insight into what impact this change had on overall water quality. Given the moderate level of accuracy exhibited by the 2001 and 2006 land cover datasets in riparian areas, additional verification of the change classification would be necessary.

While the relationship of tributary watershed position within the basin to change in converted land cover types is complex, it exists and can be used to determine where to target particular types of water quality improvement strategies. In the lower portion of the basin, mitigation and restoration strategies will be important because a higher portion of the land cover has already been converted to higher phosphorus exporting land cover types. Midway upstream, protection strategies would be more appropriate to preserve some of the low-phosphorus export land cover types that still exist in abundance. Failure to preserve some of these low phosphorus export land cover types such as forested lands could mean failure to meet water quality goals in the SCRB.

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(Citations for GIS data are included in Appendix E – GIS Methodology Data Dictionary)

APPENDIX A – Summary tables of basin-wide analyses

Table A1. St. Croix Basin land cover areas (in hectares) and changes over time between mid-late 1800s, 1992, 2001, 2006. Land cover type losses are noted in red font.

	mid-late 1800s				1992 (compared to mid-late 1800s)		
Land Cover	**Hectares**	**Hectares Change**	**Percent Change**		**Hectares**	**Hectares Change**	**Percent Change**
Agriculture	0	-	-		335,728	335,728	-
Barren	0	-	-		8,616	8,616	-
Developed	0	-	-		14,272	14,272	-
Lowland Vegetation	374,346	-	-		371,825	-2,522	-0.7
Open Water	87,373	-	-		75,526	-11,847	-13.6
Upland Forest	1,322,725	-	-		859,438	-463,287	-35.0
Upland Grass	180,343	-	-		292,390	112,047	62.1
Upland Shrub	30,531	-	-		39,667	9,136	29.9
Totals	**1,995,319**	-	-		**1,997,463**	-	-

	2001 (compared to 1992)				2006 (compared to 2001)		
Land Cover	**Hectares**	**Hectares Change**	**Percent Change**		**Hectares**	**Hectares Change**	**Percent Change**
Agriculture	192,777	-142,951	-42.6		192,757	-21	0.0
Barren	153	-8,464	-98.2		271	118	77.3
Developed	101,443	87,170	610.8		103,486	2,043	2.0
Lowland Vegetation	351,185	-20,640	-5.6		356,906	5,721	1.6
Open Water	80,426	4,899	6.5		79,564	-861	-1.1
Upland Forest	885,983	26,545	3.1		875,280	-10,702	-1.2
Upland Grass	331,606	39,216	13.4		334,106	2,500	0.8
Upland Shrub	54,370	14,703	37.1		55,572	1,202	2.2
Totals	**1,997,942**	-	-		**1,997,942**	-	-

Table A2. St. Croix Basin land cover areas (in acres) and changes over time between mid-late 1800s, 1992, 2001, 2006. Land cover type losses are noted in red font.

	mid-late 1800s				1992 (compared to mid-late 1800s)		
Land Cover	**Acres**	**Acres Change**	**Percent Change**		**Acres**	**Acres Change**	**Percent Change**
Agriculture	0	-	-		829,602	829,602	-
Barren	0	-	-		21,291	21,291	-
Developed	0	-	-		35,268	35,268	-
Lowland Vegetation	925,030	-	-		918,799	-6,231	-0.7
Open Water	215,903	-	-		186,630	-29,274	-13.6
Upland Forest	3,268,525	-	-		2,123,717	-1,144,808	-35.0
Upland Grass	445,638	-	-		722,512	276,875	62.1
Upland Shrub	75,444	-	-		98,020	22,575	29.9
Totals	**4,930,541**	-	-		**4,935,839**	-	-

	2001 (compared to 1992)				2006 (compared to 2001)		
Land Cover	**Acres**	**Acres Change**	**Percent Change**		**Acres**	**Acres Change**	**Percent Change**
Agriculture	476,363	-353,239	-42.6		476,312	-51	0.0
Barren	377	-20,914	-98.2		669	291	77.3
Developed	250,670	215,402	610.8		255,719	5,049	2.0
Lowland Vegetation	867,797	-51,002	-5.6		881,935	14,138	1.6
Open Water	198,736	12,107	6.5		196,608	-2,128	-1.1
Upland Forest	2,189,311	65,594	3.1		2,162,865	-26,446	-1.2
Upland Grass	819,417	96,904	13.4		825,594	6,178	0.8
Upland Shrub	134,351	36,331	37.1		137,320	2,970	2.2
Totals	**4,937,022**	-	-		**4,937,022**	-	-

Table A3. St. Croix Basin land cover (in hectares and acres), reclassified and NLCD cover type classifications (2006).

Reclassification	NLCD Classification	Area in Hectares	Area in Acres
Agriculture	Cultivated Crops	192,757	476,312
Barren	Barren Land (Rock/Sand/Clay)	271	669
Developed	Developed, High Intensity	1,874	4,631
	Developed, Low Intensity	21,665	53,536
	Developed, Medium Intensity	5,788	14,303
	Developed, Open Space	74,158	183,249
Lowland Vegetation	Emergent Herbaceous Wetlands	127,013	313,855
	Woody Wetlands	229,894	568,080
Open Water	Open Water	79,564	196,608
Upland Forest	Deciduous Forest	733,132	1,811,609
	Evergreen Forest	65,898	162,837
	Mixed Forest	76,250	188,419
Upland Grass	Grassland/Herbaceous	38,517	95,178
	Pasture/Hay	295,589	730,416
Upland Shrub	Shrub/Scrub	55,572	137,320
Totals		**1,997,942**	**4,937,022**

APPENDIX B – Summary tables of tributary analyses

Table B1. Tributary areas (in hectares, acres, and percent total) of the St. Croix River Basin.

Tributary	Area, Hectares (ha)	Area, Acres (ac)	% of Basin
Namekagon River	256,730	634,394	12.8
Upper St Croix River	110,059	271,962	5.5
Chases Brook	9,424	23,288	0.5
Upper Tamarack River	25,664	63,417	1.3
Yellow River	94,836	234,344	4.7
Lower Tamarack River	50,483	124,747	2.5
Crooked Creek	25,964	64,158	1.3
Clam River	96,688	238,921	4.8
Sand Creek	36,365	89,860	1.8
Bear Creek	17,360	42,898	0.9
Kettle River	272,324	672,927	13.6
Redhorse Creek	3,385	8,363	0.2
Snake River	260,433	643,545	13.0
Wood River	46,361	114,560	2.3
Rock Creek	14,626	36,141	0.7
Rush Creek	14,777	36,514	0.7
Goose Creek	18,134	44,809	0.9
Sunrise River	99,164	245,041	5.0
Trade River	39,134	96,703	2.0
Wolf Creek	8,687	21,465	0.4
Dry Creek	4,478	11,066	0.2
Lawrence Creek	3,437	8,494	0.2
Apple River	144,640	357,414	7.2
Browns Creek	7,390	18,260	0.4
Willow River	74,145	183,216	3.7
Valley Branch	17,955	44,367	0.9
Kinnickinnic River	40,476	100,019	2.0
Adjacent Small Streams	147,243	363,845	7.4
Non-Contributing Areas	57,581	142,286	2.9
Totals	**1,997,942**	**4,937,022**	**100.0**

Table B2. Percent of tributary area in land cover type (mid-late 1800s).

mid-late 1800s	Percent of tributary area in land cover type								
Tributary	Agri-culture	Barren	Devel-oped	Lowland Veget-ation	Open Water	Un-classified	Upland Forest	Upland Grass	Upland Shrub
Namekagon River	0.0	0.0	0.0	9.5	6.1	0.0	83.5	0.0	0.9
Upper St Croix River	0.0	0.0	0.0	13.2	4.4	0.0	80.9	0.0	1.6
Chases Brook	0.0	0.0	0.0	14.5	0.7	0.0	84.8	0.0	0.0
Upper Tamarack River	0.0	0.0	0.0	37.5	1.0	1.2	60.3	0.0	0.0
Yellow River	0.0	0.0	0.0	4.1	10.2	0.0	85.7	0.0	0.0
Lower Tamarack River	0.0	0.0	0.0	56.7	0.7	0.3	42.4	0.0	0.0
Crooked Creek	0.0	0.0	0.0	29.3	1.6	0.0	69.0	0.0	0.0
Clam River	0.0	0.0	0.0	6.9	4.1	0.0	89.0	0.0	0.0
Sand Creek	0.0	0.0	0.0	40.5	0.8	0.0	57.6	1.1	0.0
Bear Creek	0.0	0.0	0.0	31.5	0.2	0.0	68.3	0.0	0.0
Kettle River	0.0	0.0	0.0	35.8	2.8	0.0	58.6	2.8	0.0
Redhorse Creek	0.0	0.0	0.0	60.1	0.7	0.0	39.2	0.0	0.0
Snake River	0.0	0.0	0.0	32.6	1.7	0.0	64.0	1.7	0.0
Wood River	0.0	0.0	0.0	17.0	5.1	0.0	77.9	0.0	0.0
Rock Creek	0.0	0.0	0.0	31.1	0.3	0.0	68.6	0.0	0.0
Rush Creek	0.0	0.0	0.0	17.4	12.0	0.0	65.8	4.8	0.0
Goose Creek	0.0	0.0	0.0	26.7	4.2	0.0	36.6	32.6	0.0
Sunrise River	0.0	0.0	0.0	22.7	9.3	0.0	34.9	33.1	0.0
Trade River	0.0	0.0	0.0	12.5	3.0	0.0	84.5	0.0	0.0
Wolf Creek	0.0	0.0	0.0	8.9	3.5	0.0	87.6	0.0	0.0
Dry Creek	0.0	0.0	0.0	8.2	0.2	0.0	87.2	4.4	0.0
Lawrence Creek	0.0	0.0	0.0	15.0	0.1	0.0	84.8	0.0	0.0
Apple River	0.0	0.0	0.0	3.6	7.0	0.0	80.7	4.5	4.1
Browns Creek	0.0	0.0	0.0	2.8	3.7	0.0	3.1	90.5	0.0
Willow River	0.0	0.0	0.0	0.7	1.7	0.0	50.3	35.1	12.2
Valley Branch	0.0	0.0	0.0	0.4	3.0	0.0	16.7	79.9	0.0
Kinnickinnic River	0.0	0.0	0.0	0.0	0.3	0.0	13.7	81.3	4.8
Adjacent Small Streams	0.0	0.0	0.0	11.8	6.2	1.4	52.9	23.7	3.8
Non-Contributing Areas	0.0	0.0	0.0	1.3	4.5	0.0	75.6	11.8	6.9

Table B3. Percent of tributary area in land cover type (1992).

1992	Percent of tributary area in land cover type								
Tributary	Agri-culture	Barren	Devel-oped	Lowland Veget-ation	Open Water	Un-classified	Upland Forest	Upland Grass	Upland Shrub
Namekagon River	1.3	0.3	0.2	17.0	5.4	0.0	65.2	7.2	3.5
Upper St Croix River	0.0	0.2	0.0	16.4	3.8	0.0	63.6	5.2	10.6
Chases Brook	0.0	0.6	0.0	28.9	0.6	0.0	63.5	6.5	0.0
Upper Tamarack River	0.3	0.2	0.0	38.9	0.9	0.1	55.7	3.9	0.0
Yellow River	4.8	0.4	0.4	13.6	9.0	0.0	53.8	15.2	2.6
Lower Tamarack River	1.4	0.1	0.0	33.7	0.7	0.0	60.7	2.9	0.5
Crooked Creek	7.9	0.3	0.0	27.8	1.1	0.0	54.8	7.6	0.4
Clam River	6.3	0.2	0.1	15.0	3.4	0.0	52.1	21.1	1.6
Sand Creek	10.4	0.2	0.0	28.0	0.4	0.0	50.9	9.3	0.8
Bear Creek	15.3	0.3	0.1	24.2	0.2	0.0	46.2	13.3	0.4
Kettle River	11.3	0.6	0.2	29.8	2.3	0.0	43.3	12.1	0.4
Redhorse Creek	0.4	0.1	0.0	48.2	0.7	0.0	45.3	3.8	1.6
Snake River	21.8	0.7	0.2	25.4	1.6	0.0	37.4	12.8	0.1
Wood River	7.8	0.5	0.4	25.0	3.7	0.0	35.7	23.7	3.3
Rock Creek	64.5	1.5	0.2	8.5	0.3	0.0	8.3	16.6	0.1
Rush Creek	43.1	1.2	0.7	14.8	9.1	0.0	13.3	17.8	0.0
Goose Creek	37.2	0.8	1.1	19.7	3.7	0.0	17.0	20.1	0.3
Sunrise River	39.4	0.6	2.8	17.9	7.7	0.0	17.9	13.3	0.4
Trade River	9.5	0.2	0.6	20.3	2.6	0.0	39.9	22.7	4.4
Wolf Creek	18.7	0.2	0.0	12.8	2.9	0.0	24.5	39.9	0.9
Dry Creek	54.0	0.7	0.1	6.5	0.2	0.0	20.4	18.1	0.1
Lawrence Creek	60.9	1.3	1.0	10.5	0.1	0.0	13.4	12.8	0.0
Apple River	23.6	0.4	0.4	10.0	6.2	0.0	33.0	26.4	0.1
Browns Creek	41.0	0.0	6.6	6.5	3.7	0.0	8.4	30.1	3.7
Willow River	46.5	0.3	1.1	4.1	1.5	0.0	15.2	31.2	0.0
Valley Branch	51.9	0.0	16.0	3.6	3.0	0.0	8.1	13.8	3.6
Kinnickinnic River	58.9	0.6	1.5	1.0	0.2	0.0	15.0	22.7	0.0
Adjacent Small Streams	22.1	0.4	2.1	10.1	5.7	0.3	38.2	16.7	4.4
Non-Contributing Areas	21.5	0.2	0.2	3.9	3.8	0.0	50.9	17.0	2.6

Table B4. Percent of tributary area in land cover type (2001).

2001	Percent of tributary area in land cover type								
Tributary	Agri-culture	Barren	Devel-oped	Lowland Veget-ation	Open Water	Un-classified	Upland Forest	Upland Grass	Upland Shrub
Namekagon River	1.0	0.0	4.9	13.1	5.8	0.0	69.0	4.1	2.1
Upper St Croix River	0.1	0.0	4.8	11.7	3.9	0.0	64.5	1.9	13.1
Chases Brook	0.4	0.0	2.4	11.8	0.2	0.0	78.3	2.9	4.0
Upper Tamarack River	0.4	0.0	1.7	26.7	0.6	0.0	64.1	1.4	5.1
Yellow River	3.9	0.0	6.4	7.2	10.2	0.0	59.4	11.9	1.0
Lower Tamarack River	0.2	0.0	1.4	40.6	1.2	0.0	53.0	1.1	2.5
Crooked Creek	2.7	0.0	1.8	27.6	1.9	0.0	55.9	8.3	1.7
Clam River	4.6	0.0	4.9	6.4	4.3	0.0	60.8	18.7	0.3
Sand Creek	3.7	0.0	2.7	32.5	0.9	0.0	47.5	10.4	2.3
Bear Creek	3.8	0.0	3.0	30.0	0.4	0.0	41.3	19.2	2.3
Kettle River	2.2	0.0	4.0	38.4	2.7	0.0	35.0	13.6	4.2
Redhorse Creek	0.4	0.0	0.4	48.5	1.6	0.0	47.2	0.3	1.6
Snake River	8.4	0.0	3.9	26.7	1.8	0.0	35.8	21.6	1.7
Wood River	11.3	0.0	4.9	15.5	4.0	0.0	41.9	21.0	1.5
Rock Creek	38.6	0.0	6.5	9.3	0.3	0.0	4.8	37.4	3.0
Rush Creek	24.0	0.0	6.7	18.8	9.3	0.0	9.8	27.9	3.4
Goose Creek	22.8	0.0	6.3	18.0	3.5	0.0	19.9	28.4	1.1
Sunrise River	25.2	0.0	7.5	15.7	7.0	0.0	22.6	21.7	0.3
Trade River	11.1	0.0	4.6	17.1	3.1	0.0	42.7	20.0	1.4
Wolf Creek	17.5	0.0	4.4	6.4	3.3	0.0	28.8	39.4	0.2
Dry Creek	37.3	0.0	4.4	4.0	0.1	0.0	21.9	32.1	0.1
Lawrence Creek	38.0	0.0	5.6	6.3	0.3	0.0	14.4	35.2	0.3
Apple River	14.7	0.0	5.3	6.0	5.7	0.0	38.3	29.9	0.2
Browns Creek	11.8	0.0	14.6	4.8	6.0	0.0	19.2	41.3	2.3
Willow River	31.1	0.0	6.9	2.3	1.2	0.0	21.0	37.4	0.2
Valley Branch	18.8	0.0	20.9	2.2	3.9	0.0	21.2	30.7	2.3
Kinnickinnic River	56.0	0.0	7.7	1.2	0.1	0.0	16.2	18.5	0.3
Adjacent Small Streams	12.8	0.0	6.6	8.5	6.0	0.0	42.7	19.2	4.2
Non-Contributing Areas	14.6	0.0	4.9	2.7	3.7	0.0	50.7	18.7	4.7

Table B5. Percent of tributary area in land cover type (2006).

2006	Percent of tributary area in land cover type								
Tributary	Agri-culture	Barren	Devel-oped	Lowland Veget-ation	Open Water	Un-classified	Upland Forest	Upland Grass	Upland Shrub
Namekagon River	1.1	0.0	4.9	13.1	5.8	0.0	67.9	4.8	2.3
Upper St Croix River	0.3	0.0	4.8	12.3	3.9	0.0	62.6	3.3	12.9
Chases Brook	0.5	0.0	2.4	12.8	0.4	0.0	77.1	2.9	3.8
Upper Tamarack River	0.4	0.0	1.7	27.5	0.6	0.0	63.2	1.5	5.0
Yellow River	3.9	0.0	6.5	7.4	10.2	0.0	58.9	11.9	1.2
Lower Tamarack River	0.2	0.0	1.4	41.1	1.2	0.0	52.4	1.2	2.5
Crooked Creek	2.8	0.0	1.8	29.2	1.7	0.0	54.2	8.5	1.9
Clam River	4.6	0.0	4.9	6.9	4.3	0.0	60.2	18.7	0.5
Sand Creek	3.8	0.0	2.7	33.5	0.8	0.0	46.5	10.4	2.4
Bear Creek	3.9	0.0	3.0	30.2	0.4	0.0	41.0	19.2	2.3
Kettle River	2.2	0.0	4.0	38.9	2.6	0.0	34.5	13.6	4.2
Redhorse Creek	0.4	0.0	0.4	49.6	1.3	0.0	46.4	0.3	1.5
Snake River	8.5	0.0	4.0	27.0	1.7	0.0	35.5	21.6	1.7
Wood River	11.3	0.0	4.9	15.8	3.9	0.0	41.5	20.9	1.6
Rock Creek	38.6	0.0	6.5	9.3	0.3	0.0	4.9	37.3	3.0
Rush Creek	24.0	0.0	7.0	18.8	9.4	0.0	9.8	27.8	3.3
Goose Creek	22.8	0.0	6.3	18.0	3.5	0.0	19.9	28.3	1.2
Sunrise River	25.1	0.0	7.7	15.7	7.0	0.0	22.5	21.5	0.4
Trade River	11.0	0.0	4.6	17.2	2.7	0.0	42.8	20.0	1.6
Wolf Creek	17.5	0.0	4.4	6.4	3.3	0.0	28.8	39.4	0.2
Dry Creek	37.2	0.0	4.4	4.0	0.1	0.0	21.9	32.0	0.3
Lawrence Creek	37.8	0.0	6.0	6.3	0.4	0.0	14.4	35.0	0.3
Apple River	14.7	0.0	5.4	6.1	5.7	0.0	38.2	29.7	0.2
Browns Creek	11.1	0.0	16.9	4.7	5.7	0.0	19.2	40.0	2.4
Willow River	31.0	0.0	7.2	2.3	1.2	0.0	20.9	37.1	0.2
Valley Branch	18.2	0.0	21.9	2.2	3.9	0.0	21.3	30.1	2.3
Kinnickinnic River	55.5	0.0	8.1	1.2	0.1	0.0	16.3	18.3	0.3
Adjacent Small Streams	12.8	0.0	6.9	8.8	5.9	0.0	42.3	19.0	4.3
Non-Contributing Areas	14.6	0.0	5.0	2.7	3.7	0.0	50.0	19.4	4.7

APPENDIX C – Summary tables of riparian analyses

Table C1. Land cover change (in hectares and acres) within contributing riparian areas (within 30 to 85 meters) in contributing HUC 12 units in the St. Croix River Basin, NLCD classifications (2001 to 2006).

	NLCD 2001				
NLCD Cover Type	**Area (Hectares)**	**Area (Acres)**	**Percent of Total Riparian Area**	**Area Change (Hectares)**	**Area Change (Acres)**
Open Water	183.3	453.0	0.1	-	-
Developed, Open Space	4838.6	11956.4	3.5	-	-
Developed, Low Intensity	1165.6	2880.2	0.9	-	-
Developed, Medium Intensity	270.1	667.4	0.2	-	-
Developed, High Intensity	70.5	174.1	0.1	-	-
Barren Land (Rock/Sand/Clay)	3.1	7.6	0.0	-	-
Deciduous Forest	46280.5	114361.7	33.8	-	-
Evergreen Forest	2719.3	6719.4	2.0	-	-
Mixed Forest	4770.8	11788.9	3.5	-	-
Shrub/Scrub	2394.7	5917.5	1.7	-	-
Grassland/Herbaceous	2595.8	6414.3	1.9	-	-
Pasture/Hay	14675.9	36264.8	10.7	-	-
Cultivated Crops	10536.8	26036.9	7.7	-	-
Woody Wetlands	27269.2	67383.6	19.9	-	-
Emergent Herbaceous Wetlands	19277.1	47634.8	14.1	-	-
Total Riparian Area	**137051.1**	**338660.6**			
	NLCD 2006				
NLCD Cover Type	**Area (Hectares)**	**Area (Acres)**	**Percent of Total Riparian Area**	**Area Change (Hectares)**	**Area Change (Acres)**
Open Water	176.3	435.7	0.1	-7.0	-17.3
Developed, Open Space	4874.0	12044.0	3.6	35.5	87.6
Developed, Low Intensity	1188.3	2936.3	0.9	22.7	56.0
Developed, Medium Intensity	284.1	702.1	0.2	14.0	34.7
Developed, High Intensity	72.5	179.0	0.1	2.0	4.9
Barren Land (Rock/Sand/Clay)	3.1	7.6	0.0	0.0	0.0
Deciduous Forest	46139.5	114013.2	33.7	-141.0	-348.5
Evergreen Forest	2709.5	6695.2	2.0	-9.8	-24.2
Mixed Forest	4750.6	11738.9	3.5	-20.3	-50.0
Shrub/Scrub	2403.5	5939.3	1.8	8.8	21.8
Grassland/Herbaceous	2658.5	6569.3	1.9	62.7	155.0
Pasture/Hay	14672.5	36256.6	10.7	-3.3	-8.2
Cultivated Crops	10560.7	26096.0	7.7	23.9	59.2
Woody Wetlands	27067.1	66884.4	19.7	-202.0	-499.3
Emergent Herbaceous Wetlands	19490.9	48163.2	14.2	213.8	528.4
Total Riparian Area	**137051.1**	**338660.6**			

Table C2. Land cover (in hectares) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2001).

	NLCD 2001 Area (Hectares)							
Tributary	**Open Water**	**Developed, Open Space**	**Developed, Low Intensity**	**Developed, Medium Intensity**	**Developed, High Intensity**	**Barren**	**Deciduous Forest**	**Evergreen Forest**
Namekagon River	35.9	673.2	134.2	20.3	3.4	0.0	6676.8	757.9
Upper St Croix River	3.7	157.4	95.5	9.2	0.2	0.0	3475.4	348.2
Chases Brook	0.5	18.5	3.2	0.0	0.0	0.0	645.1	13.7
Upper Tamarack River	3.5	23.2	5.0	0.0	0.0	0.0	840.2	4.7
Yellow River	7.8	198.1	25.3	4.3	0.1	0.0	2106.3	87.8
Lower Tamarack River	9.3	41.9	4.4	0.0	0.0	0.0	1207.7	23.1
Crooked Creek	4.1	36.3	2.8	0.8	0.0	0.0	620.5	6.8
Clam River	12.3	331.0	9.7	1.2	0.0	0.0	4686.9	100.8
Sand Creek	6.6	57.1	5.7	0.0	0.0	0.0	616.7	7.7
Bear Creek	0.6	22.1	1.1	0.0	0.0	0.0	220.1	1.9
Kettle River	38.3	680.0	127.2	15.3	5.6	0.0	3761.5	346.7
Redhorse Creek	1.0	0.5	0.0	0.0	0.0	0.0	45.3	0.0
Snake River	13.2	577.3	133.3	9.3	2.5	0.0	5191.9	101.4
Wood River	3.0	179.0	11.7	3.6	0.5	0.0	954.5	157.8
Rock Creek	0.5	56.7	13.8	3.5	0.7	0.0	196.3	10.6
Rush Creek	0.4	94.1	19.7	5.4	0.4	0.0	115.7	24.7
Goose Creek	1.2	78.1	10.0	2.5	0.0	0.0	356.2	11.6
Sunrise River	4.9	279.1	144.0	46.0	9.7	0.0	1801.2	84.9
Trade River	2.5	138.7	13.9	1.4	0.2	1.0	1138.2	30.9
Wolf Creek	0.2	14.9	0.1	0.1	0.0	0.0	202.5	3.6
Dry Creek	0.0	9.5	0.7	0.0	0.0	0.0	88.5	2.7
Lawrence Creek	0.4	13.4	1.8	1.4	0.0	0.0	72.5	13.6
Apple River	7.3	316.9	49.8	10.2	2.3	0.1	3486.2	167.1
Browns Creek	0.1	12.2	14.7	3.6	0.0	0.0	53.7	3.0
Willow River	2.5	279.2	51.6	9.1	1.3	0.0	2265.8	91.4
Valley Branch	1.2	99.8	92.3	49.9	24.9	0.0	385.4	25.5
Kinnickinnic River	0.9	192.8	77.1	14.0	2.1	0.2	853.2	49.4
Adjacent Small Streams	21.7	257.6	117.3	59.2	16.7	1.8	4216.3	241.8
SCRB Contributing	**183.3**	**4838.6**	**1165.6**	**270.1**	**70.5**	**3.1**	**46280.5**	**2719.3**

Table C2. Land cover (in hectares) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2001) (cont).

	NLCD 2001 Area (Hectares)						
Tributary	**Mixed Forest**	**Shrub/ Scrub**	**Grassland/ Herba-ceaous**	**Pasture/ Hay**	**Cultivated Crops**	**Woody Wetlands**	**Emergent Herba-ceous Wetlands**
Namekagon River	2343.5	222.5	59.6	217.9	66.5	4739.7	246.2
Upper St Croix River	832.8	422.9	33.9	45.5	9.5	1637.2	17.9
Chases Brook	7.5	57.2	6.0	14.8	4.1	95.5	2.9
Upper Tamarack River	16.5	118.9	12.3	14.8	3.4	709.9	41.0
Yellow River	525.9	21.2	20.3	267.3	65.9	659.9	297.4
Lower Tamarack River	10.1	65.4	9.6	36.5	4.9	1435.2	656.6
Crooked Creek	1.8	12.8	3.0	53.9	16.9	708.7	404.0
Clam River	422.3	8.8	63.5	1060.1	320.3	926.2	542.8
Sand Creek	6.7	31.6	3.0	144.1	56.4	1164.1	629.0
Bear Creek	3.3	18.0	3.3	131.1	37.7	441.6	330.0
Kettle River	157.7	536.7	69.6	1808.3	379.3	8109.9	4931.3
Redhorse Creek	0.0	1.1	0.0	0.0	0.0	68.0	22.1
Snake River	69.9	230.7	523.8	2648.0	1083.8	3380.3	4534.5
Wood River	105.8	27.8	190.9	469.4	452.3	152.0	746.3
Rock Creek	11.5	126.5	16.7	374.0	402.5	71.8	149.0
Rush Creek	23.8	72.7	8.3	294.3	322.7	197.7	255.7
Goose Creek	5.0	8.3	109.1	333.0	348.3	90.5	318.6
Sunrise River	11.6	27.5	526.2	1122.7	1390.2	218.9	1822.1
Trade River	27.7	11.0	99.3	507.0	340.9	116.3	623.9
Wolf Creek	1.1	2.3	50.0	146.8	46.6	25.7	79.1
Dry Creek	2.5	0.0	18.0	82.2	121.1	3.3	21.9
Lawrence Creek	3.5	0.3	12.9	102.8	95.1	3.1	24.6
Apple River	99.7	13.4	246.5	1069.1	540.9	614.0	1095.7
Browns Creek	0.0	12.6	26.0	101.9	17.1	1.5	44.2
Willow River	5.8	14.2	163.2	2236.1	1579.3	119.8	337.1
Valley Branch	1.5	53.6	45.0	191.4	77.0	12.7	31.1
Kinnickinnic River	3.1	17.8	28.6	565.7	2242.6	277.8	42.4
Adjacent Small Streams	70.5	259.1	247.2	637.3	511.6	1288.0	1029.9
SCRB Contributing	**4770.8**	**2394.7**	**2595.8**	**14675.9**	**10536.8**	**27269.2**	**19277.1**

Table C3. Land cover (in hectares) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2006).

	NLCD 2006 Area (Hectares)							
Tributary	**Open Water**	**Developed, Open Space**	**Developed, Low Intensity**	**Developed, Medium Intensity**	**Developed, High Intensity**	**Barren**	**Deciduous Forest**	**Evergreen Forest**
Namekagon River	36.3	672.8	134.2	20.7	3.4	0.0	6649.7	753.8
Upper St Croix River	4.1	157.4	95.5	9.2	0.2	0.0	3464.1	347.5
Chases Brook	0.5	18.5	3.2	0.0	0.0	0.0	644.4	13.7
Upper Tamarack River	3.6	23.2	5.0	0.0	0.0	0.0	838.4	4.7
Yellow River	7.8	197.9	25.7	5.0	0.1	0.0	2104.4	87.8
Lower Tamarack River	8.3	41.9	4.4	0.0	0.0	0.0	1206.2	23.1
Crooked Creek	3.5	36.3	2.8	0.8	0.0	0.0	614.7	7.2
Clam River	12.1	331.0	9.7	1.2	0.0	0.0	4674.1	100.3
Sand Creek	6.3	57.1	5.7	0.0	0.0	0.0	609.6	7.7
Bear Creek	0.6	22.1	1.1	0.0	0.0	0.0	219.1	1.9
Kettle River	34.8	680.0	127.2	15.3	5.6	0.0	3743.1	344.7
Redhorse Creek	0.8	0.5	0.0	0.0	0.0	0.0	42.7	0.0
Snake River	12.2	577.3	133.7	9.6	2.5	0.0	5176.5	100.2
Wood River	2.2	179.0	11.7	3.6	0.5	0.0	953.7	157.9
Rock Creek	0.5	56.7	14.0	4.5	0.7	0.0	196.3	10.6
Rush Creek	0.5	98.1	22.9	6.2	0.4	0.0	114.9	24.7
Goose Creek	1.2	78.1	10.0	2.5	0.0	0.0	355.1	11.6
Sunrise River	5.2	281.3	147.4	47.0	9.7	0.0	1794.8	84.6
Trade River	2.0	138.7	13.9	1.4	0.2	1.0	1138.4	30.9
Wolf Creek	0.4	14.9	0.1	0.1	0.0	0.0	202.5	3.6
Dry Creek	0.0	9.5	0.7	0.0	0.0	0.0	88.5	2.7
Lawrence Creek	0.4	13.4	1.8	1.4	0.0	0.0	72.5	13.6
Apple River	6.7	317.8	50.1	11.4	2.3	0.1	3477.4	167.1
Browns Creek	0.1	14.4	15.6	6.5	0.9	0.0	53.5	3.0
Willow River	3.1	287.1	60.8	11.3	1.3	0.0	2260.0	90.8
Valley Branch	1.2	102.1	93.9	50.6	26.0	0.0	385.1	25.5
Kinnickinnic River	0.9	194.8	79.5	16.4	2.1	0.2	853.4	49.2
Adjacent Small Streams	21.4	272.2	118.1	59.6	16.7	1.8	4206.5	241.2
SCRB Contributing	**176.3**	**4874.0**	**1188.3**	**284.1**	**72.5**	**3.1**	**46139.5**	**2709.5**

Table C3. Land cover (in hectares) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2006) (cont).

	NLCD 2006 Area (Hectares)						
Tributary	**Mixed Forest**	**Shrub/ Scrub**	**Grassland/ Herba-ceaous**	**Pasture/ Hay**	**Cultivated Crops**	**Woody Wetlands**	**Emergent Herba-ceous Wetlands**
Namekagon River	2332.7	226.6	143.5	216.9	67.4	4691.3	248.3
Upper St Croix River	825.8	418.9	33.9	45.5	16.8	1631.0	39.4
Chases Brook	7.5	57.0	5.9	14.9	4.1	95.5	4.0
Upper Tamarack River	16.5	116.8	12.3	15.0	3.4	707.0	47.4
Yellow River	525.7	21.2	25.3	266.6	65.9	655.6	298.5
Lower Tamarack River	10.1	65.3	9.6	36.5	4.9	1426.2	668.3
Crooked Creek	1.8	12.8	2.9	56.3	19.4	688.0	426.0
Clam River	421.5	9.0	64.2	1064.2	321.3	922.1	555.5
Sand Creek	5.9	32.9	3.0	144.1	57.0	1148.3	651.0
Bear Creek	3.0	18.0	3.3	131.1	37.7	440.6	332.4
Kettle River	156.0	532.4	68.7	1810.6	400.6	8047.7	5000.5
Redhorse Creek	0.0	1.1	0.0	0.0	0.0	65.3	27.6
Snake River	69.5	231.5	522.7	2654.8	1086.0	3354.1	4569.2
Wood River	105.8	29.3	189.5	470.1	455.8	152.0	743.7
Rock Creek	11.5	126.6	16.6	374.0	401.3	71.8	149.0
Rush Creek	23.8	72.4	6.9	290.7	321.6	197.1	255.5
Goose Creek	5.0	13.7	104.5	333.0	348.6	90.5	318.6
Sunrise River	11.3	30.2	518.1	1120.5	1399.9	210.1	1828.9
Trade River	27.6	11.1	99.3	507.0	340.9	116.3	624.2
Wolf Creek	1.1	2.3	49.8	146.8	46.6	25.7	79.1
Dry Creek	2.5	0.0	18.0	82.2	121.1	3.3	21.9
Lawrence Creek	3.5	0.3	12.9	102.8	95.1	3.1	24.6
Apple River	99.7	13.4	246.5	1072.4	539.1	623.3	1091.7
Browns Creek	0.0	12.5	24.7	101.1	12.7	1.5	44.2
Willow River	8.6	14.2	160.1	2231.6	1570.9	121.1	335.6
Valley Branch	1.5	53.6	44.4	189.2	74.6	12.7	30.9
Kinnickinnic River	3.4	17.6	28.6	565.5	2236.0	277.8	42.4
Adjacent Small Streams	69.5	263.1	243.5	629.5	512.2	1288.0	1032.8
SCRB Contributing	**4750.6**	**2403.5**	**2658.5**	**14672.5**	**10560.7**	**27067.1**	**19490.9**

Table C4. Land cover change (in hectares) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2001 to 2006).

	NLCD Change Area (Hectares)							
Tributary	**Open Water**	**Developed, Open Space**	**Developed, Low Intensity**	**Developed, Medium Intensity**	**Developed, High Intensity**	**Barren**	**Deciduous Forest**	**Evergreen Forest**
Namekagon River	0.4	-0.5	0.0	0.5	0.0	0.0	-27.1	-4.1
Upper St Croix River	0.4	0.0	0.0	0.0	0.0	0.0	-11.3	-0.7
Chases Brook	0.0	0.0	0.0	0.0	0.0	0.0	-0.7	0.0
Upper Tamarack River	0.1	0.0	0.0	0.0	0.0	0.0	-1.8	0.0
Yellow River	0.0	-0.2	0.5	0.6	0.0	0.0	-1.9	0.0
Lower Tamarack River	-1.0	0.0	0.0	0.0	0.0	0.0	-1.5	0.0
Crooked Creek	-0.6	0.0	0.0	0.0	0.0	0.0	-5.8	0.5
Clam River	-0.3	0.0	0.0	0.0	0.0	0.0	-12.9	-0.5
Sand Creek	-0.3	0.0	0.0	0.0	0.0	0.0	-7.1	0.0
Bear Creek	0.0	0.0	0.0	0.0	0.0	0.0	-1.0	0.0
Kettle River	-3.4	0.0	0.0	0.0	0.0	0.0	-18.4	-2.0
Redhorse Creek	-0.2	0.0	0.0	0.0	0.0	0.0	-2.6	0.0
Snake River	-1.0	0.0	0.4	0.4	0.0	0.0	-15.4	-1.3
Wood River	-0.8	0.0	0.0	0.0	0.0	0.0	-0.8	0.1
Rock Creek	0.0	0.0	0.2	1.0	0.0	0.0	0.0	0.0
Rush Creek	0.1	4.0	3.2	0.8	0.0	0.0	-0.8	0.0
Goose Creek	0.0	0.0	0.0	0.0	0.0	0.0	-1.1	0.0
Sunrise River	0.4	2.3	3.4	1.0	0.0	0.0	-6.4	-0.3
Trade River	-0.5	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Wolf Creek	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lawrence Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Apple River	-0.6	0.9	0.4	1.3	0.0	0.0	-8.7	0.0
Browns Creek	0.0	2.3	0.9	2.9	0.9	0.0	-0.3	0.0
Willow River	0.5	7.9	9.2	2.2	0.0	0.0	-5.8	-0.6
Valley Branch	0.0	2.3	1.5	0.7	1.1	0.0	-0.3	0.0
Kinnickinnic River	0.0	2.0	2.3	2.4	0.0	0.0	0.2	-0.2
Adjacent Small Streams	-0.3	14.6	0.8	0.4	0.0	0.0	-9.8	-0.6
SCRB Contributing	**-7.0**	**35.5**	**22.7**	**14.0**	**2.0**	**0.0**	**-141.0**	**-9.8**

Table C4. Land cover change (in hectares) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2001 to 2006) (cont).

	NLCD Change Area (Hectares)						
Tributary	**Mixed Forest**	**Shrub/ Scrub**	**Grassland/ Herba-ceaous**	**Pasture/ Hay**	**Cultivated Crops**	**Woody Wetlands**	**Emergent Herba-ceous Wetlands**
Namekagon River	-10.8	4.1	83.9	-1.0	0.9	-48.3	2.1
Upper St Croix River	-6.9	-4.1	0.0	0.0	7.4	-6.2	21.5
Chases Brook	0.0	-0.3	-0.2	0.1	0.0	0.0	1.1
Upper Tamarack River	0.0	-2.1	0.0	0.3	0.0	-2.9	6.4
Yellow River	-0.2	0.0	5.0	-0.7	0.0	-4.3	1.2
Lower Tamarack River	0.0	-0.2	0.0	0.0	0.0	-9.0	11.7
Crooked Creek	0.0	0.0	-0.1	2.3	2.4	-20.7	22.0
Clam River	-0.8	0.2	0.6	4.1	1.0	-4.1	12.7
Sand Creek	-0.7	1.4	0.0	0.0	0.5	-15.8	22.0
Bear Creek	-0.4	0.0	0.0	0.0	0.0	-1.0	2.3
Kettle River	-1.7	-4.3	-0.9	2.3	21.3	-62.2	69.2
Redhorse Creek	0.0	0.0	0.0	0.0	0.0	-2.7	5.5
Snake River	-0.5	0.8	-1.1	6.8	2.3	-26.2	34.7
Wood River	0.0	1.4	-1.4	0.6	3.5	0.0	-2.6
Rock Creek	0.0	0.2	-0.2	0.0	-1.2	0.0	0.0
Rush Creek	0.0	-0.4	-1.4	-3.6	-1.1	-0.6	-0.2
Goose Creek	0.0	5.4	-4.6	0.0	0.3	0.0	0.0
Sunrise River	-0.4	2.7	-8.1	-2.2	9.6	-8.8	6.8
Trade River	-0.1	0.1	0.0	0.0	0.0	0.0	0.4
Wolf Creek	0.0	0.0	-0.2	0.0	0.0	0.0	0.0
Dry Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lawrence Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Apple River	0.0	0.0	0.0	3.2	-1.8	9.4	-4.0
Browns Creek	0.0	-0.1	-1.4	-0.8	-4.4	0.0	0.0
Willow River	2.8	0.0	-3.1	-4.5	-8.5	1.4	-1.5
Valley Branch	0.0	0.1	-0.6	-2.3	-2.3	0.0	-0.2
Kinnickinnic River	0.4	-0.2	0.0	-0.3	-6.7	0.0	0.0
Adjacent Small Streams	-1.0	4.0	-3.7	-7.8	0.6	0.0	2.9
SCRB Contributing	**-20.3**	**8.8**	**62.7**	**-3.3**	**23.9**	**-202.1**	**213.8**

Table C5. Land cover (percent cover) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2001).

	NLCD 2001 (percent of riparian area)							
Tributary	**Open Water**	**Developed, Open Space**	**Developed, Low Intensity**	**Developed, Medium Intensity**	**Developed, High Intensity**	**Barren**	**Deciduous Forest**	**Evergreen Forest**
Namekagon River	0.222	4.156	0.828	0.125	0.021	0.000	41.221	4.679
Upper St Croix River	0.052	2.220	1.347	0.129	0.003	0.000	49.024	4.912
Chases Brook	0.052	2.134	0.363	0.000	0.000	0.000	74.249	1.574
Upper Tamarack River	0.196	1.295	0.276	0.000	0.000	0.000	46.848	0.261
Yellow River	0.183	4.620	0.590	0.101	0.002	0.000	49.126	2.049
Lower Tamarack River	0.265	1.197	0.126	0.000	0.000	0.000	34.460	0.660
Crooked Creek	0.221	1.937	0.149	0.043	0.000	0.000	33.139	0.361
Clam River	0.145	3.901	0.115	0.014	0.000	0.000	55.231	1.188
Sand Creek	0.241	2.091	0.208	0.000	0.000	0.000	22.601	0.284
Bear Creek	0.052	1.821	0.089	0.000	0.000	0.000	18.173	0.156
Kettle River	0.182	3.243	0.607	0.073	0.027	0.000	17.940	1.653
Redhorse Creek	0.718	0.391	0.000	0.000	0.000	0.000	32.811	0.000
Snake River	0.072	3.120	0.720	0.050	0.014	0.000	28.065	0.548
Wood River	0.086	5.182	0.339	0.104	0.013	0.000	27.632	4.567
Rock Creek	0.031	3.954	0.960	0.245	0.050	0.000	13.688	0.741
Rush Creek	0.025	6.558	1.373	0.376	0.025	0.000	8.063	1.718
Goose Creek	0.070	4.671	0.597	0.151	0.000	0.000	21.300	0.694
Sunrise River	0.065	3.727	1.923	0.614	0.130	0.000	24.051	1.133
Trade River	0.083	4.543	0.454	0.044	0.006	0.032	37.286	1.011
Wolf Creek	0.031	2.608	0.016	0.016	0.000	0.000	35.350	0.628
Dry Creek	0.000	2.697	0.205	0.000	0.000	0.000	25.250	0.771
Lawrence Creek	0.104	3.883	0.521	0.417	0.000	0.000	21.006	3.935
Apple River	0.094	4.105	0.645	0.132	0.029	0.001	45.163	2.165
Browns Creek	0.031	4.182	5.050	1.239	0.000	0.000	18.494	1.022
Willow River	0.035	3.901	0.721	0.127	0.018	0.000	31.661	1.278
Valley Branch	0.107	9.147	8.463	4.569	2.285	0.000	35.318	2.334
Kinnickinnic River	0.021	4.414	1.766	0.319	0.047	0.004	19.534	1.131
Adjacent Small Streams	0.242	2.870	1.306	0.660	0.186	0.020	46.973	2.694
SCRB Contributing	**0.134**	**3.530**	**0.850**	**0.197**	**0.051**	**0.002**	**33.769**	**1.984**

Table C5. Land cover (percent cover) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2001) (cont).

	NLCD 2001 (percent of riparian area)						
Tributary	**Mixed Forest**	**Shrub/ Scrub**	**Grassland/ Herba-ceaous**	**Pasture/ Hay**	**Cultivated Crops**	**Woody Wetlands**	**Emergent Herba-ceous Wetlands**
Namekagon River	14.468	1.374	0.368	1.345	0.411	29.262	1.520
Upper St Croix River	11.747	5.966	0.479	0.641	0.133	23.094	0.253
Chases Brook	0.860	6.588	0.694	1.699	0.466	10.990	0.331
Upper Tamarack River	0.918	6.630	0.688	0.823	0.191	39.586	2.288
Yellow River	12.265	0.495	0.472	6.234	1.537	15.391	6.935
Lower Tamarack River	0.288	1.867	0.275	1.040	0.139	40.952	18.733
Crooked Creek	0.096	0.683	0.159	2.879	0.904	37.850	21.579
Clam River	4.976	0.104	0.749	12.492	3.775	10.914	6.396
Sand Creek	0.244	1.158	0.109	5.281	2.068	42.663	23.053
Bear Creek	0.275	1.487	0.275	10.829	3.114	36.472	27.256
Kettle River	0.752	2.560	0.332	8.624	1.809	38.679	23.519
Redhorse Creek	0.000	0.783	0.000	0.000	0.000	49.250	16.047
Snake River	0.378	1.247	2.831	14.314	5.858	18.272	24.511
Wood River	3.061	0.805	5.526	13.589	13.092	4.400	21.603
Rock Creek	0.803	8.818	1.167	26.083	28.066	5.008	10.387
Rush Creek	1.655	5.066	0.577	20.502	22.476	13.774	17.812
Goose Creek	0.296	0.495	6.522	19.912	20.827	5.414	19.051
Sunrise River	0.155	0.367	7.027	14.991	18.564	2.923	24.331
Trade River	0.908	0.360	3.252	16.607	11.168	3.809	20.437
Wolf Creek	0.189	0.393	8.720	25.625	8.138	4.478	13.810
Dry Creek	0.719	0.000	5.137	23.452	34.575	0.950	6.242
Lawrence Creek	1.016	0.078	3.727	29.763	27.548	0.886	7.115
Apple River	1.292	0.174	3.194	13.850	7.007	7.954	14.194
Browns Creek	0.000	4.337	8.953	35.068	5.886	0.527	15.211
Willow River	0.080	0.199	2.280	31.247	22.069	1.674	4.711
Valley Branch	0.140	4.908	4.124	17.544	7.052	1.163	2.846
Kinnickinnic River	0.070	0.408	0.655	12.953	51.346	6.361	0.971
Adjacent Small Streams	0.785	2.887	2.754	7.100	5.699	14.349	11.474
SCRB Contributing	**3.481**	**1.747**	**1.894**	**10.708**	**7.688**	**19.897**	**14.066**

Table C6. Land cover (percent cover) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2006).

	NLCD 2006 (percent of riparian area)							
Tributary	**Open Water**	**Developed, Open Space**	**Developed, Low Intensity**	**Developed, Medium Intensity**	**Developed, High Intensity**	**Barren**	**Deciduous Forest**	**Evergreen Forest**
Namekagon River	0.224	4.153	0.828	0.128	0.021	0.000	41.054	4.653
Upper St Croix River	0.057	2.220	1.347	0.129	0.003	0.000	48.864	4.902
Chases Brook	0.052	2.134	0.363	0.000	0.000	0.000	74.166	1.574
Upper Tamarack River	0.201	1.295	0.276	0.000	0.000	0.000	46.748	0.261
Yellow River	0.183	4.616	0.600	0.115	0.002	0.000	49.082	2.049
Lower Tamarack River	0.236	1.197	0.126	0.000	0.000	0.000	34.416	0.660
Crooked Creek	0.187	1.937	0.149	0.043	0.000	0.000	32.832	0.385
Clam River	0.142	3.901	0.115	0.014	0.000	0.000	55.080	1.181
Sand Creek	0.231	2.091	0.208	0.000	0.000	0.000	22.341	0.284
Bear Creek	0.052	1.821	0.089	0.000	0.000	0.000	18.091	0.156
Kettle River	0.166	3.243	0.607	0.073	0.027	0.000	17.852	1.644
Redhorse Creek	0.587	0.391	0.000	0.000	0.000	0.000	30.920	0.000
Snake River	0.066	3.120	0.722	0.052	0.014	0.000	27.981	0.541
Wood River	0.063	5.182	0.339	0.104	0.013	0.000	27.609	4.570
Rock Creek	0.031	3.954	0.973	0.314	0.050	0.000	13.688	0.741
Rush Creek	0.031	6.834	1.592	0.433	0.025	0.000	8.006	1.718
Goose Creek	0.070	4.671	0.597	0.151	0.000	0.000	21.236	0.694
Sunrise River	0.070	3.757	1.969	0.627	0.130	0.000	23.966	1.130
Trade River	0.065	4.543	0.454	0.044	0.006	0.032	37.292	1.011
Wolf Creek	0.063	2.608	0.016	0.016	0.000	0.000	35.350	0.628
Dry Creek	0.000	2.697	0.205	0.000	0.000	0.000	25.250	0.771
Lawrence Creek	0.104	3.883	0.521	0.417	0.000	0.000	21.006	3.935
Apple River	0.086	4.117	0.649	0.148	0.029	0.001	45.050	2.165
Browns Creek	0.031	4.957	5.359	2.230	0.310	0.000	18.401	1.022
Willow River	0.043	4.012	0.849	0.157	0.018	0.000	31.580	1.269
Valley Branch	0.107	9.353	8.603	4.635	2.384	0.000	35.294	2.334
Kinnickinnic River	0.021	4.459	1.819	0.375	0.047	0.004	19.538	1.127
Adjacent Small Streams	0.239	3.032	1.316	0.664	0.186	0.020	46.864	2.687
SCRB Contributing	**0.129**	**3.556**	**0.867**	**0.207**	**0.053**	**0.002**	**33.666**	**1.977**

Table C6. Land cover (percent cover) within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2006) (cont).

	NLCD 2006 (percent of riparian area)						
Tributary	**Mixed Forest**	**Shrub/ Scrub**	**Grassland/ Herba-ceaous**	**Pasture/ Hay**	**Cultivated Crops**	**Woody Wetlands**	**Emergent Herba-ceous Wetlands**
Namekagon River	14.402	1.399	0.886	1.339	0.416	28.963	1.533
Upper St Croix River	11.649	5.908	0.479	0.641	0.237	23.007	0.556
Chases Brook	0.860	6.557	0.673	1.709	0.466	10.990	0.456
Upper Tamarack River	0.918	6.514	0.688	0.838	0.191	39.426	2.645
Yellow River	12.261	0.495	0.590	6.218	1.537	15.290	6.963
Lower Tamarack River	0.288	1.862	0.275	1.040	0.139	40.695	19.067
Crooked Creek	0.096	0.683	0.154	3.004	1.034	36.745	22.752
Clam River	4.967	0.106	0.756	12.540	3.786	10.867	6.546
Sand Creek	0.218	1.207	0.109	5.281	2.088	42.085	23.858
Bear Creek	0.245	1.487	0.275	10.829	3.114	36.391	27.449
Kettle River	0.744	2.539	0.328	8.636	1.911	38.383	23.849
Redhorse Creek	0.000	0.783	0.000	0.000	0.000	47.293	20.026
Snake River	0.376	1.251	2.826	14.350	5.870	18.131	24.699
Wood River	3.061	0.847	5.484	13.608	13.193	4.400	21.528
Rock Creek	0.803	8.830	1.155	26.083	27.984	5.008	10.387
Rush Creek	1.655	5.041	0.483	20.251	22.401	13.730	17.799
Goose Creek	0.296	0.818	6.248	19.912	20.843	5.414	19.051
Sunrise River	0.150	0.403	6.919	14.962	18.692	2.805	24.421
Trade River	0.905	0.363	3.252	16.607	11.168	3.809	20.449
Wolf Creek	0.189	0.393	8.688	25.625	8.138	4.478	13.810
Dry Creek	0.719	0.000	5.137	23.452	34.575	0.950	6.242
Lawrence Creek	1.016	0.078	3.727	29.763	27.548	0.886	7.115
Apple River	1.292	0.174	3.194	13.892	6.984	8.075	14.143
Browns Creek	0.000	4.306	8.488	34.789	4.368	0.527	15.211
Willow River	0.119	0.199	2.237	31.184	21.951	1.693	4.690
Valley Branch	0.140	4.916	4.066	17.338	6.838	1.163	2.829
Kinnickinnic River	0.078	0.404	0.655	12.947	51.193	6.361	0.971
Adjacent Small Streams	0.774	2.931	2.713	7.013	5.706	14.349	11.506
SCRB Contributing	**3.466**	**1.754**	**1.940**	**10.706**	**7.706**	**19.750**	**14.222**

Table C7. Land cover change in percent cover within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2001 to 2006).

	NLCD Change (percent of riparian area)							
Tributary	**Open Water**	**Developed, Open Space**	**Developed, Low Intensity**	**Developed, Medium Intensity**	**Developed, High Intensity**	**Barren**	**Deciduous Forest**	**Evergreen Forest**
Namekagon River	0.002	-0.003	0.000	0.003	0.000	0.000	-0.167	-0.026
Upper St Croix River	0.005	0.000	0.000	0.000	0.000	0.000	-0.160	-0.010
Chases Brook	0.000	0.000	0.000	0.000	0.000	0.000	-0.083	0.000
Upper Tamarack River	0.005	0.000	0.000	0.000	0.000	0.000	-0.100	0.000
Yellow River	0.000	-0.004	0.010	0.015	0.000	0.000	-0.044	0.000
Lower Tamarack River	-0.028	0.000	0.000	0.000	0.000	0.000	-0.044	0.000
Crooked Creek	-0.034	0.000	0.000	0.000	0.000	0.000	-0.308	0.024
Clam River	-0.003	0.000	0.000	0.000	0.000	0.000	-0.152	-0.006
Sand Creek	-0.010	0.000	0.000	0.000	0.000	0.000	-0.261	0.000
Bear Creek	0.000	0.000	0.000	0.000	0.000	0.000	-0.082	0.000
Kettle River	-0.016	0.000	0.000	0.000	0.000	0.000	-0.088	-0.009
Redhorse Creek	-0.130	0.000	0.000	0.000	0.000	0.000	-1.892	0.000
Snake River	-0.005	0.000	0.002	0.002	0.000	0.000	-0.083	-0.007
Wood River	-0.023	0.000	0.000	0.000	0.000	0.000	-0.023	0.003
Rock Creek	0.000	0.000	0.013	0.069	0.000	0.000	0.000	0.000
Rush Creek	0.006	0.276	0.219	0.056	0.000	0.000	-0.056	0.000
Goose Creek	0.000	0.000	0.000	0.000	0.000	0.000	-0.065	0.000
Sunrise River	0.005	0.030	0.046	0.013	0.000	0.000	-0.085	-0.004
Trade River	-0.018	0.000	0.000	0.000	0.000	0.000	0.006	0.000
Wolf Creek	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dry Creek	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lawrence Creek	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Apple River	-0.008	0.012	0.005	0.016	0.000	0.000	-0.113	0.000
Browns Creek	0.000	0.774	0.310	0.991	0.310	0.000	-0.093	0.000
Willow River	0.008	0.111	0.128	0.030	0.000	0.000	-0.080	-0.009
Valley Branch	0.000	0.206	0.140	0.066	0.099	0.000	-0.025	0.000
Kinnickinnic River	0.000	0.045	0.054	0.056	0.000	0.000	0.004	-0.004
Adjacent Small Streams	-0.003	0.162	0.009	0.004	0.000	0.000	-0.109	-0.007
SCRB Contributing	**-0.005**	**0.026**	**0.017**	**0.010**	**0.001**	**0.000**	**-0.103**	**-0.007**

Table C7. Land cover change in percent cover within riparian areas (within 30 to 85 meters) of contributing water bodies by tributary watershed, NLCD classifications (2001 to 2006) (cont).

	NLCD Change (percent of riparian area)						
Tributary	**Mixed Forest**	**Shrub/ Scrub**	**Grassland/ Herba-ceaous**	**Pasture/ Hay**	**Cultivated Crops**	**Woody Wetlands**	**Emergent Herba-ceous Wetlands**
Namekagon River	-0.067	0.026	0.518	-0.006	0.006	-0.298	0.013
Upper St Croix River	-0.098	-0.057	0.000	0.000	0.104	-0.088	0.303
Chases Brook	0.000	-0.031	-0.021	0.010	0.000	0.000	0.124
Upper Tamarack River	0.000	-0.115	0.000	0.015	0.000	-0.161	0.356
Yellow River	-0.004	0.000	0.118	-0.017	0.000	-0.101	0.027
Lower Tamarack River	0.000	-0.005	0.000	0.000	0.000	-0.257	0.334
Crooked Creek	0.000	0.000	-0.005	0.125	0.130	-1.106	1.173
Clam River	-0.010	0.002	0.007	0.048	0.012	-0.048	0.150
Sand Creek	-0.026	0.049	0.000	0.000	0.020	-0.577	0.805
Bear Creek	-0.030	0.000	0.000	0.000	0.000	-0.082	0.193
Kettle River	-0.008	-0.021	-0.004	0.011	0.102	-0.297	0.330
Redhorse Creek	0.000	0.000	0.000	0.000	0.000	-1.957	3.979
Snake River	-0.002	0.004	-0.006	0.037	0.012	-0.142	0.188
Wood River	0.000	0.042	-0.042	0.018	0.102	0.000	-0.076
Rock Creek	0.000	0.013	-0.013	0.000	-0.082	0.000	0.000
Rush Creek	0.000	-0.025	-0.094	-0.251	-0.075	-0.044	-0.013
Goose Creek	0.000	0.323	-0.274	0.000	0.016	0.000	0.000
Sunrise River	-0.005	0.036	-0.108	-0.029	0.129	-0.118	0.090
Trade River	-0.003	0.003	0.000	0.000	0.000	0.000	0.012
Wolf Creek	0.000	0.000	-0.031	0.000	0.000	0.000	0.000
Dry Creek	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lawrence Creek	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Apple River	0.000	0.000	0.000	0.042	-0.023	0.121	-0.051
Browns Creek	0.000	-0.031	-0.465	-0.279	-1.518	0.000	0.000
Willow River	0.039	0.000	-0.043	-0.063	-0.118	0.019	-0.021
Valley Branch	0.000	0.008	-0.058	-0.206	-0.214	0.000	-0.016
Kinnickinnic River	0.008	-0.004	0.000	-0.006	-0.152	0.000	0.000
Adjacent Small Streams	-0.011	0.044	-0.041	-0.087	0.007	0.000	0.032
SCRB Contributing	**-0.015**	**0.006**	**0.046**	**-0.002**	**0.017**	**-0.147**	**0.156**

Table C8. Detail of land cover change (in hectares and acres) within riparian areas (within 30 to 85 meters) of contributing water bodies in contributing HUC12s in the SCRB, NLCD classifications (2001 to 2006).

2001	2006	Area (Hectares)	Area (Acres)
Cultivated Crops	Deciduous Forest	0.3	0.7
Cultivated Crops	Developed, High Intensity	1.3	3.1
Cultivated Crops	Developed, Low Intensity	7.6	18.7
Cultivated Crops	Developed, Medium Intensity	8.0	19.8
Cultivated Crops	Developed, Open Space	6.5	16.0
Cultivated Crops	Emergent Herbaceous Wetlands	0.7	1.8
Cultivated Crops	Grassland/Herbaceous	1.1	2.7
Cultivated Crops	Mixed Forest	3.2	8.0
Cultivated Crops	Open Water	0.7	1.8
Cultivated Crops	Pasture/Hay	3.0	7.3
Cultivated Crops	Shrub/Scrub	4.6	11.3
Cultivated Crops	Woody Wetlands	8.6	21.3
Deciduous Forest	Cultivated Crops	19.1	47.1
Deciduous Forest	Developed, Low Intensity	3.2	7.8
Deciduous Forest	Developed, Medium Intensity	1.7	4.2
Deciduous Forest	Developed, Open Space	9.2	22.7
Deciduous Forest	Emergent Herbaceous Wetlands	63.4	156.6
Deciduous Forest	Grassland/Herbaceous	26.6	65.8
Deciduous Forest	Mixed Forest	0.2	0.4
Deciduous Forest	Open Water	1.4	3.6
Deciduous Forest	Pasture/Hay	14.8	36.5
Deciduous Forest	Shrub/Scrub	7.5	18.5
Deciduous Forest	Woody Wetlands	6.5	16.0
Developed, Open Space	Developed, Medium Intensity	0.9	2.2
Emergent Herbaceous Wetlands	Cultivated Crops	9.3	22.9
Emergent Herbaceous Wetlands	Developed, Low Intensity	1.7	4.2
Emergent Herbaceous Wetlands	Developed, Medium Intensity	0.4	0.9
Emergent Herbaceous Wetlands	Developed, Open Space	1.3	3.1
Emergent Herbaceous Wetlands	Grassland/Herbaceous	5.0	12.2
Emergent Herbaceous Wetlands	Open Water	1.1	2.7
Emergent Herbaceous Wetlands	Pasture/Hay	3.8	9.3
Emergent Herbaceous Wetlands	Woody Wetlands	16.7	41.4
Evergreen Forest	Cultivated Crops	1.5	3.8
Evergreen Forest	Deciduous Forest	0.8	2.0
Evergreen Forest	Developed, Low Intensity	0.2	0.4
Evergreen Forest	Developed, Open Space	1.4	3.6
Evergreen Forest	Emergent Herbaceous Wetlands	2.5	6.2
Evergreen Forest	Grassland/Herbaceous	3.4	8.5
Evergreen Forest	Pasture/Hay	0.2	0.4
Evergreen Forest	Shrub/Scrub	0.4	0.9
Evergreen Forest	Woody Wetlands	0.8	2.0

Table C8. Detail of land cover change (in hectares and acres) within riparian areas (within 30 to 85 meters) of contributing water bodies in contributing HUC12s in the SCRB, NLCD classifications (2001 to 2006) (cont).

2001	2006	Area (Hectares)	Area (Acres)
Grassland/Herbaceous	Cultivated Crops	8.1	20.0
Grassland/Herbaceous	Deciduous Forest	0.5	1.1
Grassland/Herbaceous	Developed, High Intensity	0.4	0.9
Grassland/Herbaceous	Developed, Low Intensity	0.8	2.0
Grassland/Herbaceous	Developed, Medium Intensity	0.6	1.6
Grassland/Herbaceous	Developed, Open Space	1.4	3.3
Grassland/Herbaceous	Emergent Herbaceous Wetlands	2.2	5.3
Grassland/Herbaceous	Open Water	0.2	0.4
Grassland/Herbaceous	Pasture/Hay	2.2	5.3
Grassland/Herbaceous	Shrub/Scrub	11.9	29.4
Mixed Forest	Cultivated Crops	7.0	17.3
Mixed Forest	Deciduous Forest	3.4	8.5
Mixed Forest	Developed, Low Intensity	0.3	0.7
Mixed Forest	Emergent Herbaceous Wetlands	3.4	8.5
Mixed Forest	Grassland/Herbaceous	5.4	13.3
Mixed Forest	Open Water	0.1	0.2
Mixed Forest	Pasture/Hay	1.4	3.6
Mixed Forest	Shrub/Scrub	2.2	5.3
Mixed Forest	Woody Wetlands	0.7	1.8
Open Water	Cultivated Crops	1.2	2.9
Open Water	Deciduous Forest	2.7	6.7
Open Water	Emergent Herbaceous Wetlands	5.9	14.7
Open Water	Evergreen Forest	0.1	0.2
Open Water	Grassland/Herbaceous	0.2	0.4
Open Water	Pasture/Hay	0.7	1.8
Open Water	Shrub/Scrub	0.2	0.4
Open Water	Woody Wetlands	1.4	3.3
Pasture/Hay	Deciduous Forest	2.7	6.7
Pasture/Hay	Developed, High Intensity	0.4	0.9
Pasture/Hay	Developed, Low Intensity	6.8	16.9
Pasture/Hay	Developed, Medium Intensity	2.4	6.0
Pasture/Hay	Developed, Open Space	14.8	36.5
Pasture/Hay	Emergent Herbaceous Wetlands	1.0	2.4
Pasture/Hay	Evergreen Forest	1.3	3.1
Pasture/Hay	Grassland/Herbaceous	2.3	5.8
Pasture/Hay	Open Water	0.2	0.4
Pasture/Hay	Shrub/Scrub	1.4	3.3

Table C8. Detail of land cover change (in hectares and acres) within riparian areas (within 30 to 85 meters) of contributing water bodies in contributing HUC12s in the SCRB, NLCD classifications (2001 to 2006) (cont).

2001	2006	Area (Hectares)	Area (Acres)
Shrub/Scrub	Cultivated Crops	2.1	5.1
Shrub/Scrub	Deciduous Forest	1.7	4.2
Shrub/Scrub	Developed, Low Intensity	0.2	0.4
Shrub/Scrub	Developed, Open Space	1.0	2.4
Shrub/Scrub	Emergent Herbaceous Wetlands	10.5	26.0
Shrub/Scrub	Evergreen Forest	0.1	0.2
Shrub/Scrub	Grassland/Herbaceous	1.4	3.3
Shrub/Scrub	Mixed Forest	0.3	0.7
Shrub/Scrub	Open Water	0.2	0.4
Shrub/Scrub	Woody Wetlands	1.8	4.4
Woody Wetlands	Cultivated Crops	21.2	52.5
Woody Wetlands	Deciduous Forest	0.4	0.9
Woody Wetlands	Developed, Low Intensity	2.0	4.9
Woody Wetlands	Developed, Open Space	0.9	2.2
Woody Wetlands	Emergent Herbaceous Wetlands	163.4	403.6
Woody Wetlands	Grassland/Herbaceous	45.5	112.3
Woody Wetlands	Open Water	1.4	3.6
Woody Wetlands	Pasture/Hay	3.9	9.6

Table C9. Detail of evaluation of randomly selected riparian areas identified as having changed from 2001 to 2006 to or from a converted cover type.

Accuracy	Change from 2001 to 2006	Area (Hectares)	Percent of Subtotal	Percent of Total
Accurate	Cultivated Crops to Developed, High Intensity	0.4	2.5	1.3
	Cultivated Crops to Developed, Low Intensity	2.2	12.7	6.7
	Cultivated Crops to Developed, Medium Intensity	4.0	22.3	11.7
	Cultivated Crops to Developed, Open Space	1.3	7.1	3.7
	Cultivated Crops to Mixed Forest	1.4	8.1	4.3
	Cultivated Crops to Open Water	0.4	2.5	1.3
	Cultivated Crops to Pasture/Hay	1.1	6.1	3.2
	Cultivated Crops to Woody Wetlands	0.1	0.5	0.3
	Deciduous Forest to Cultivated Crops	0.8	4.6	2.4
	Deciduous Forest to Developed, Low Intensity	0.9	5.1	2.7
	Deciduous Forest to Developed, Medium Intensity	0.5	3.0	1.6
	Deciduous Forest to Developed, Open Space	0.4	2.5	1.3
	Developed, Open Space to Developed, Medium Intensity	0.1	0.5	0.3
	Grassland/Herbaceous to Cultivated Crops	0.1	0.5	0.3
	Grassland/Herbaceous to Developed, High Intensity	0.3	1.5	0.8
	Grassland/Herbaceous to Developed, Low Intensity	0.2	1.0	0.5
	Grassland/Herbaceous to Developed, Medium Intensity	0.2	1.0	0.5
	Mixed Forest to Cultivated Crops	0.7	4.1	2.1
	Pasture/Hay to Developed, Low Intensity	1.3	7.6	4.0
	Pasture/Hay to Developed, Medium Intensity	0.6	3.6	1.9
	Pasture/Hay to Developed, Open Space	0.4	2.0	1.1
	Shrub/Scrub to Developed, Open Space	0.2	1.0	0.5
Subtotal (Accurate)		**17.7**	**100.0**	**52.5**

Table C9. Detail of evaluation of randomly selected riparian areas identified as having changed from 2001 to 2006 to or from a converted cover type (cont).

Accuracy	Change from 2001 to 2006	Area (Hectares)	Percent of Subtotal	Percent of Total
Inaccurate	Cultivated Crops to Developed, Low Intensity	0.1	0.6	0.3
	Cultivated Crops to Developed, Open Space	0.1	0.6	0.3
	Cultivated Crops to Woody Wetlands	0.4	2.9	1.3
	Deciduous Forest to Cultivated Crops	2.0	12.6	5.9
	Deciduous Forest to Developed, Low Intensity	0.1	0.6	0.3
	Deciduous Forest to Developed, Open Space	3.0	18.9	8.8
	Emergent Herbaceous Wetlands to Cultivated Crops	1.1	6.9	3.2
	Emergent Herbaceous Wetlands to Developed, Low Intensity	0.1	0.6	0.3
	Evergreen Forest to Cultivated Crops	0.8	5.1	2.4
	Grassland/Herbaceous to Cultivated Crops	1.0	6.3	2.9
	Mixed Forest to Cultivated Crops	0.2	1.1	0.5
	Mixed Forest to Developed, Low Intensity	0.1	0.6	0.3
	Pasture/Hay to Developed, Medium Intensity	0.1	0.6	0.3
	Pasture/Hay to Developed, Open Space	0.6	4.0	1.9
	Shrub/Scrub to Cultivated Crops	0.2	1.1	0.5
	Shrub/Scrub to Developed, Low Intensity	0.1	0.6	0.3
	Woody Wetlands to Cultivated Crops	5.3	33.7	15.7
	Woody Wetlands to Developed, Low Intensity	0.4	2.3	1.1
	Woody Wetlands to Developed, Open Space	0.2	1.1	0.5
Subtotal (Inaccurate)		**15.7**	**100.0**	**46.7**
Unknown	Cultivated Crops to Woody Wetlands	0.3	100.0	0.8
Subtotal (Unknown)		**0.3**	**100.0**	**0.8**
Total Sample Area		**33.7**		

APPENDIX D – Land cover reclassification tables

Dataset: Presettlement Land Cover
Time Frame: Presettlement (mid-late 1800s)
Extent: Minnesota
Source: http://deli.dnr.state.mn.us/

Table D1. Presettlement Land Cover Reclassification.

Presettlement Land Cover	Reclassification
Aspen-Birch (trending to Conifers)	Upland Forest
Aspen-Birch (trending to hardwoods)	Upland Forest
Aspen-Oak Land	Upland Forest
Big Woods - Hardwoods (oak, maple, basswood, hickory)	Upland Forest
Mixed Hardwood and Pine (Maple, White Pine, Basswood, etc)	Upland Forest
Mixed White Pine and Red Pine	Upland Forest
Pine Flats (Hemlock, Spruce, Fir, White Pine, Aspen)	Upland Forest
White Pine	Upland Forest
Brush Prairie	Upland Shrub
Jack Pine Barrens and Openings	Upland Grass
Oak openings and barrens	Upland Grass
Prairie	Upland Grass
Conifer Bogs and Swamps	Lowland Vegetation
River Bottom Forest	Lowland Vegetation
Open Muskeg	Lowland Vegetation
Wet Prairie	Lowland Vegetation
Lakes (open water)	Open Water
Undefined	Unclassified

Dataset: Original Vegetation Cover
Time Frame: Presettlement (mid-late 1800s)
Extent: Wisconsin
Source: ftp://dnrftp01.wi.gov/geodata/

Table D2. Original Vegetation Cover Reclassification.

Original Vegetation	Reclassification
White spruce, balsam fir, tamarack, white cedar, white birch, aspen	Upland Forest
Beech, hemlock, sugar maple, yellow birch, white pine, red pine	Upland Forest
Hemlock, sugar maple, yellow birch, white pine, red pine	Upland Forest
Sugar maple, yellow birch, white pine, red pine	Upland Forest
White pine, red pine	Upland Forest
Jack pine, scrub (hill's), oak forest and barrens	Upland Forest
Aspen, white birch, pine	Upland Forest
Beech, sugar maple, basswood, red oak, white oak, black oak	Upland Forest
Sugar maple, basswood, red oak, white oak, black oak	Upland Forest
Oak -- white oak, black oak, bur oak	Upland Forest
Brush	Upland Shrub
Oak openings -- bur oak, white oak, black oak	Upland Grass
Prairie	Upland Grass
Swamp conifers -- white cedar, black spruce, tamarack, hemlock	Lowland Vegetation
Lowland hardwoods -- willow, soft maple, box elder, ash, elm, cottonwood, river birch	Lowland Vegetation
Marsh and sedge meadow, wet prairie, lowland shrubs	Lowland Vegetation
Open water	Open Water
Not identified	Unclassified

Dataset: GAP Land Cover
Time Frame: 1991-1993
Extent: Minnesota
Source: http://deli.dnr.state.mn.us/

Table D3. GAP Land Cover Reclassification.

GAP Level 4	Reclassification
Aspen/White Birch	Upland Forest
Balsam Fir mix	Upland Forest
Bur/White Oak	Upland Forest
Jack Pine	Upland Forest
Jack Pine-Deciduous mix	Upland Forest
Maple/Basswood	Upland Forest
Northern Pin Oak	Upland Forest
Red Oak	Upland Forest
Red Pine	Upland Forest
Red/White Pine	Upland Forest
Red/White Pine-Deciduous mix	Upland Forest
Redcedar	Upland Forest
Redcedar-Deciduous mix	Upland Forest
Spruce/Fir-Deciduous mix	Upland Forest
Upland Black Spruce	Upland Forest
Upland Conifer	Upland Forest
Upland Conifer-Deciduous mix	Upland Forest
Upland Deciduous	Upland Forest
Upland Northern White-Cedar	Upland Forest
White Pine mix	Upland Forest
White Spruce	Upland Forest
White/Red Oak	Upland Forest
Upland Shrub	Upland Shrub
Grassland	Upland Grass
Prairie	Upland Grass

Table D3. GAP Land Cover Reclassification (cont).

GAP Level 4	Reclassification
Black Ash	Lowland Vegetation
Cottonwood	Lowland Vegetation
Lowland Black Spruce	Lowland Vegetation
Lowland Conifer-Deciduous mix	Lowland Vegetation
Lowland Deciduous	Lowland Vegetation
Lowland Deciduous Shrub	Lowland Vegetation
Lowland Evergreen Shrub	Lowland Vegetation
Lowland Northern White-Cedar	Lowland Vegetation
Silver Maple	Lowland Vegetation
Stagnant Black Spruce	Lowland Vegetation
Stagnant Conifer	Lowland Vegetation
Stagnant Northern White-Cedar	Lowland Vegetation
Stagnant Tamarack	Lowland Vegetation
Tamarack	Lowland Vegetation
Broadleaf Sedge/Cattail	Lowland Vegetation
Floating Aquatic	Lowland Vegetation
Sedge Meadow	Lowland Vegetation
Cropland	Agriculture
Low intensity urban	Developed
Mixed Developed	Developed
High intensity urban	Developed
Transportation	Developed
Barren	Barren
Water	Open Water
Unidentified	Unclassified

Dataset: WISCLAND Land Cover
Time Frame: 1991-1993
Extent: Wisconsin
Source: http://dnr.wi.gov/maps/gis/datalandcover.html

Table D4. WISCLAND Land Cover Reclassification.

WISCLAND Class	Reclassification
FOREST: coniferous	Upland Forest
FOREST: jack pine	Upland Forest
FOREST: red pine	Upland Forest
FOREST: white spruce	Upland Forest
FOREST: mixed/other coniferous	Upland Forest
FOREST: broad-leaved deciduous	Upland Forest
FOREST: aspen	Upland Forest
FOREST: oak	Upland Forest
FOREST: northern pin oak	Upland Forest
FOREST: red oak	Upland Forest
FOREST: maple	Upland Forest
FOREST: sugar maple	Upland Forest
FOREST: mixed/other broad-leaved deciduous	Upland Forest
FOREST: mixed deciduous/coniferous	Upland Forest
SHRUBLAND	Upland Shrub
GRASSLAND	Upland Grass
WETLAND: lowland shrub	Lowland Vegetation
WETLAND: lowland shrub: broad-leaved deciduous	Lowland Vegetation
WETLAND: lowland shrub: broad-leaved evergreen	Lowland Vegetation
WETLAND: lowland shrub: needle-leaved	Lowland Vegetation
FORESTED WETLAND: broad-leaved deciduous	Lowland Vegetation
FORESTED WETLAND: coniferous	Lowland Vegetation
FORESTED WETLAND: mixed deciduous/coniferous	Lowland Vegetation
WETLAND: emergent/wet meadow	Lowland Vegetation
WETLAND: floating aquatic herbaceous vegetation	Lowland Vegetation

Table D4. WISCLAND Land Cover Reclassification (cont).

WISCLAND Class	Reclassification
AGRICULTURE	Agriculture
AGRICULTURE: herbaceous/field crops	Agriculture
AGRICULTURE: primary row crops	Agriculture
AGRICULTURE: corn	Agriculture
AGRICULTURE: other row crops	Agriculture
AGRICULTURE: forage crops	Agriculture
AGRICULTURE: cranberry bog	Agriculture
URBAN/DEVELOPED: high intensity urban	Developed
URBAN/DEVELOPED: low intensity urban	Developed
URBAN/DEVELOPED: golf course	Developed
BARREN	Barren
OPEN WATER	Open Water
CLOUD COVER	Unclassified

Dataset: National Land Cover Dataset (2001 Version 2.0, 2006)
Time Frame: 2001, 2006
Extent: Nationwide
Source: http://www.mrlc.gov/index.php

Table D5. NLCD Reclassification.

Land Cover	Description	Reclassification
Deciduous Forest	Dominated by trees generally over 5 meters tall, and more than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.	Upland Forest
Evergreen Forest	Dominated by trees generally over 5 meters tall, and more than 20% of total vegetation cover. More than 75% of the tree species remain in leaf all year. Canopy is never without green foliage.	Upland Forest
Mixed Forest	Dominated by trees generally over 5 meters tall, and more than 20% of total vegetation cover. Neither deciduous nor evergreen species are more than 75% of total tree cover.	Upland Forest
Shrub/Scrub	Areas dominated by shrubs under 5 meters tall with shrub canopy typically more than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.	Upland Shrub
Grassland/Herbaceous	Areas dominated by graminoid or herbaceous vegetation, generally more than 80% of total vegetation. These areas are not subject to intensive management or tilling, but can be utilized for grazing.	Upland Grass
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or production of seed or hay crops, typically on a perennial cycle. Pasture/hay accounts for more than 20% of total vegetation.	Upland Grass

Table D5. NLCD Reclassification (cont).

Land Cover	Description	Reclassification
Woody Wetlands	Areas where forest or shrub land vegetation accounts for more than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	Lowland Vegetation
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for more than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.	Lowland Vegetation
Cultivated Crops	Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for more than 20% of total vegetation. Includes all land being actively tilled.	Agriculture

Table C5. NLCD Reclassification (cont).

Land Cover	Description	Reclassification
Developed, Open Space	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.	Developed
Developed, Low Intensity	Areas with a mixture of constructed materials and vegetation, impervious surfaces accounting for 20-49% of total cover. These areas most commonly include single-family housing units.	Developed
Developed, Medium Intensity	Areas with a mixture of constructed materials and vegetation, impervious surfaces accounting for 50-79% of the total cover. These areas most commonly include single-family housing units.	Developed
Developed, High Intensity	Highly developed areas where people live or work in high numbers, including apartment complexes, row houses and commercial/industrial zones. Impervious surfaces account for 80-100% of total cover.	Developed
Barren Land (Rock/Sand/Clay)	Bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Vegetation generally accounts for less than 15% of total cover.	Barren
Open Water	All areas of open water, generally with less than 25% cover of vegetation or soil.	Open Water
Unclassified	Areas along the International Border that were not classified.	Unclassified

APPENDIX E - GIS Methodology

Data Dictionary

Counties of Minnesota

Description: Minnesota county boundaries derived from a combination of 1:24,000 scale PLS lines, 1:100,000 scale TIGER, 1:100,000 scale DLG, and 1:24,000 scale hydrography lines. At the time of its development (1993), the largest available scale data were assembled to create the layer.

Source: g:\gdrs\data\pub\us_mn_state_dnr\bdry_counties_in_minnesota\bdry_counties_in_minnesota.gdb\mn_county_boundaries (also available at http://deli.dnr.state.mn.us/)

Counties of Wisconsin

Description: This polygon shapefile represents boundaries of the 72 counties in Wisconsin. The data is derived from 1:24,000-scale sources.

Source: ftp://dnrftp01.wi.gov/geodata/county_bnds/WI_County_Boundaries.zip

GAP Land Cover

Description: This raster dataset is a detailed (1-acre minimum), hierarchically organized vegetation cover map produced by computer classification of combined two-season pairs of early-1990s Landsat 4/5 Thematic Mapper (TM) satellite imagery, as part of the Upper Midwest Gap Analysis Program (UMGAP) of the U.S. Geological Survey. Units of analysis were Minnesota Ecological Classification System (ECS) subsections subdivided by TM scenes. GAP typology and classification protocols are closely comparable across Minnesota, Wisconsin and Michigan.

Source: g:\gdrs\data\pub\us_mn_state_dnr\biota_landcover_gap\biota_landcover_gap.gdb\landcover_gap (also available at http://deli.dnr.state.mn.us/)

NHD Watershed Boundary Dataset, Water Bodies, and Flow Lines

Description: The Watershed Boundary Dataset (WBD) defines the areal extent of surface water drainage to a point, accounting for all land and surface areas. Watershed Boundaries are determined solely upon science-based hydrologic principles, not favoring any administrative boundaries or special projects, nor particular program or agency. The intent of defining Hydrologic Units (HU) for the Watershed Boundary Dataset is to establish a base-line drainage boundary framework, accounting for all land and surface areas. At a minimum, the WBD is being delineated and georeferenced to the USGS 1:24,000 scale topographic base map meeting National Map Accuracy Standards (NMAS). Hydrologic units are given a Hydrologic Unit Code (HUC). For example, a hydrologic region has a 2-digit HUC. A HUC describes where the unit is in the country and the level of the unit.

Source: ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/

NLCD 2001 and 2006 Land Cover

Description: National Land Cover Database 2006 (NLCD2006) is a 16-class land cover classification scheme that has been applied consistently across the conterminous United States at a spatial resolution of 30 meters.
Source: http://www.mrlc.gov/nlcd2001.php and http://www.mrlc.gov/nlcd06_data.php

Original Vegetation Cover

Description: This is a polygon shapefile derived from a 1:500,000-scale map showing the original, presettlement vegetation cover in Wisconsin. The original vegetation cover data was digitized from a 1976 map created from land survey notes written in the mid-1800s when Wisconsin was first surveyed. Linework representing lakes and other hydrographic areas in other data sets were subsequently merged with the original vegetation cover data set to more closely match the source map.
Source: ftp://dnrftp01.wi.gov/geodata/orig_veg_cover/orig_veg_cover.zip

Presettlement Land Cover

Description: Presettlement vegetation of Minnesota based on Marschner's original analysis of Public Land Survey notes and landscape patterns. Marschner compiled his results in map format, which was subsequently captured in digital format.
Source: g:\gdrs\data\pub\us_mn_state_dnr\biota_marschner_presettle_veg\biota_marschner_presettle_veg.gdb\marschner_presettlement_vegetation (also available at http://deli.dnr.state.mn.us/)

Wisconsin Land Cover Grid

Description: This Grid-format data set, known as WISCLAND Land Cover, is a raster representation of land cover of Wisconsin derived from Landsat satellite imagery.
The source data were acquired from the nationwide MRLC (Multi-Resolution Land Characteristics Consortium) acquisition of dual-date Landsat Thematic Mapper (TM) data primarily from 1992. The image processing technique followed was published in the UMGAP Image Processing Protocol (1998).
The original pixel size of the source TM data is 30 meters, however the classified WISCLAND Land Cover data (excluding URBAN) are generalized or 'smoothed' to an area no smaller than four contiguous pixels (equivalent to approximately one acre). The result of this smoothing is that any feature five acres or larger may be resolved in the data (i.e., Minimum Mapping Unit (MMU) of five acres). The Land Cover data are usable at nominal scales of 1:40,000 to 1:500,000 for a wide variety of resource management and planning applications. The classification scheme was designed to be compatible with existing classification schemes such as UNESCO's and Anderson's.
Source: ftp://dnrftp01.wi.gov/geodata/landcover/wiscland_landcover.zip

Geoprocessing

Watershed Level Analysis Workspace: StateOfTheForestReport\Study.gdb

1. Import and process to unique/contiguous watersheds for basin:
    a. Run model "Watershed Boundary Imports": selects HUC_12 boundaries for Basin from NHD Watershed Boundary Dataset for MN and WI, saves to wshd_huc12_wi and wshd_huc12_mn
    b. Run model "Watershed Boundary Merge": merges watersheds from MN and WI for unique sheds, saves to wshd_huc12
    c. Create topology "NAD83_UTM15N_Topology" w/ wshd_huc12 Must Not Overlap and Must Not Have Gaps, repair errors (22 errors fixed)
    d. Delete topology, wshd_huc12_mn, wshd_huc12_wi
2. Group HUC12 by tributary sub-basins in wshd_huc12:
    a. Add Field: TRIB_SUB, Text, Length 50
    b. Using nps_stcroix_watersheds as reference, group sub-basins
    c. Confer with Sue Magdelene on groupings
3. Allocate basins to MN, WI, or SPLIT in wshd_huc12
    a. Add Field: STATE, Text, Length 20
    b. Update as needed
    c. Export each to wshd_huc12_*
4. Import NHD Water Bodies, NHD Flow Lines, and NHD Areas
    a. Run model "Import Water Features", imports from NHD datasets, saves to waterbody*, flowline*, and waterarea* (*mn, *wi, *split)
    b. Run model "Merge Water Features", merges waterbody*, flowline*, and waterarea* and saves to waterbody, flowline, waterarea
5. Dissolve Basins: Dissolve wshd_huc12 to wshd
6. Import Counties:
    a. "Counties of Minnesota" to "bdry_counties_mn"
        i. Select by Location "Counties of Minnesota" that intersect wshd
        ii. Export to bdry_counties_mn
    b. "Counties of Wisconsin" to "bdry_counties_wi"
        i. Select by Location "Counties of Wisconsin" that intersect wshd
        ii. Export to bdry_counties_wi_raw
        iii. Manually edge match bdry_counties_wi_raw to bdry_counties_mn
        iv. Saved to bdry_counties_wi
    c. Merge bdry_counties_mn and bdry_counties_wi to bdry_counties, update CTY_NAME from bdry_counties_wi.COUNTY_NAM, add field STATE, calculate to MN or WI, delete all other fields
7. Create watershed boundary split by state
    a. Intersect wshd and bdry_counties, save to wshd_state_all
    b. Dissolve on STATE field, save to wshd_state

c. Export each state to wshd_mn an wshd_wi
d. Delete wshd_state_all

8. "NLCD 2001 and 2006 Land Cover" to "nlcd2001" and "nlcd2006"
    a. Run model "NLCD Raster Clip": clips "NLCD 2001 and 2006" to watershed extent, saves to nlcd2001_orig and nlcd2006_orig (maintaining original NAD 83 Albers Conical Equal Area projection)
    b. Run model "NLCD Build Raster Tables": builds raster tables for clipped raster datasets nlcd2001_orig and nlcd2006_orig
    c. Run model "NLCD Raster to Poly": converts raster datasets to polygon feature classes, projects polygon feature classes to NAD83 UTM 15N, saves to nlcd2001_extract and nlcd2006_extract
    d. Run model "NLCD Poly Clip": clips polygon feature classes to watershed boundary, saves to nlcd2001 and nlcd2006
    e. Run model "NLCD Add Calc Fields":
        i. Adds and calculates fields from crosswalk_nlcd to nlcd200*_clip
        ii. Output fields:
            1. SHORT_DEF
            2. LONG_DEF
            3. COMP_CLASS
    f. Delete nlcd2001_extract and nlcd2006_extract
9. "GAP Land Cover" to "gap1992"
    a. Run model "GAP Raster Clip": clips "GAP Land Cover" to watershed boundary, saves to gap1992_orig
    b. Run model "GAP Raster To Poly": converts gap1992_orig to polygon (no simplify), saves to gap1992_extract
    c. Run model "GAP Poly Clip": clips gap1992_extract to watershed and Minnesota boundary, saves to gap1992
    d. Run script "Add Calc Fields":
        i. Adds and calculates fields from crosswalk_gap to gap1992
        ii. Output fields:
            1. GAPLVL4TXT
            2. COMP_CLASS
    e. Delete gap1992_extract
10. "Wisconsin Land Cover" to "wiscland1992"
    a. Run model "WISCLAND Raster Clip": clips "Wisconsin Land Cover" to watershed boundary, saves to wiscland1992_orig
    b. Run model "WISCLAND Raster To Poly": converts wiscland1992_orig to polygon (no simplify), saves to wiscland1992_extract
    c. Run model "WISCLAND Poly Clip": clips wiscland1992_extract to watershed and Wisconsin boundary, saves to wiscland1992

   d. Run model “Add Calc Fields”:
      i. Adds and calculates fields from crosswalk_wiscland to wiscland1992
      ii. Output fields:
         1. WISCLAND
         2. COMP_CLASS
11. “Original Vegetation Cover” to “origveg”
   a. Run model “Clip Orig Veg”, clips “Original Vegetation Cover” to watershed and Wisconsin boundary, saves to origveg
   b. Run script “Add Calc Fields”, adds COMP_CLASS field, calculates from crosswalk_origveg
12. “Presettlement Land Cover” to “presettle”
   a. Run model “Clip Presettle”, clips “Presettlement Land Cover” to watershed and Minnesota boundary, saves to presettle
   b. Run script “Add Calc Fields”, adds COMP_CLASS field, calculates from crosswalk_presettle
13. Add 1992 open water areas to presettle and origveg classes
   a. Run model “Open Water to Presettle”
      i. Exports Open Water from 1992 feature classes
      ii. Union of Open Water with Watershed Boundary
      iii. Deletes Open Water from Union
      iv. Clips presettle and origveg to Union
      v. Merge Open Water to Clip
      vi. Saves to origveg_mod and presettle_mod
14. Calculate ACRES and HECTARES and build summary tables.
   a. Run script “Add Calc AC HA”, adds fields for acres and hectares, calculates based on Shape_Area field, which is in square meters. Conversion factors used:
      i. Square meters to Hectares: .0001
      ii. Square meters to Acres: .000247105381
   b. Run script “Summary Tables”
      i. Calculates summary tables for original classifications w/ reclass and original classification, and for reclass only
      ii. Includes statistics for acres and hectares
      iii. Saves to StateOfTheForestReport\Tables\Raw
15. Dissolve “wshd_huc12” to “wshd_tributaries” on TRIB_SUB
16. Create “wshd_contributing”
   a. Export wshd_huc12 to scratch as wshd_huc12_contributing
   b. Delete all from wshd_huc12_contributing where "TRIB_SUB" LIKE '%Non-Contributing'
   c. Dissolve to wshd_contributing
   d. Add field TRIB_SUB, Text, 50, calc to “Non-Contributing”

17. Create contiguous land cover sets for each time period dissolved to COMP_CLASS
    a. Create comp_preveg
        i. Merge presettle_mod and origveg_mod to comp_preveg_merge (scratch)
        ii. Dissolve to comp_preveg_dissolve (scratch)
        iii. Union on wshd and comp_preveg_dissolve to wshd_preveg_union (scratch)
        iv. Copy all shapes w/ no value in COMP_CLASS to comp_preveg_merge
        v. Field calculate copied shapes to COMP_CLASS = 'Unclassified'
        vi. Dissolve comp_preveg_merge on COMP_CLASS to comp_preveg
    b. Create comp_1992
        i. Merge gap1992 and wiscland to comp_1992_merge (scratch)
        ii. Dissolve to comp_1992_dissolve (scratch)
        iii. Union on wshd and comp_1992_dissolve to wshd_1992_union (scratch)
        iv. Copy all shapes w/ no value in COMP_CLASS to comp_1992_merge
        v. Field calculate copied shapes to COMP_CLASS = 'Unclassified'
        vi. Dissolve comp_1992_merge on COMP_CLASS to comp_1992
    c. Create comp_2001
        i. Dissolve nlcd2001 on COMP_CLASS
    d. Create comp_2006
        i. Dissolve nlcd2006 on COMP_CLASS
18. Summarize by Tributary and COMP_CLASS for each time period, pivot tables to get summary of each COMP_CLASS per Tributary
    a. Run script "Summary Tables Tribs Land Cover", creates summary tables by TRIB_ORDER, TRIB_SUB, and COMP_CLASS, then does Pivot Table for each
19. Add percent upland forest to tributaries:
    a. Copy wshd_tributaries to wshd_tributaries_uplandforest
    b. Run script "Add Calc Percent Upland Forest", adds field for acres and percent upland forest and calculates field from pivot table. Field names:
        i. HA_UFPRE, PRCNT_UFPRE
        ii. HA_UF92, PRCNT_UF92
        iii. HA_UF01, PRCNT_UF01
        iv. HA_UF06, PRCNT_UF06
20. Calculate difference between Percent Upland Forest from presettlement to 2006
    a. Run script "Calc Upland Forest Difference", adds field PREV_06_DIF to wshd_tributaries_uplandforest, calculates to PRCNT_UF06 - PRCNT_UFPRE
21. Add percent disturbed to tributaries:
    a. Copy wshd_tributaries to wshd_tributaries_agdev
    b. Run script "Add Calc Percent Ag Dev", adds fields for acres and percent for agriculture and developed, and for ag/dev combined (total disturbed) and

calculates field from pivot table. Given agriculture and developed values are zero, fields were not added for presettlement values. Field names:

i. HA_AG06, PRCNT_AG06 (agriculture)
ii. HA_DV06, PRCNT_DV06 (developed)
iii. HA_AD06, PRCNT_AD06 (agriculture/developed)

22. Given values for presettlement of agriculture and developed lands are zero, percent of each represents increase of each.
23. Analyze distance upstream correlation to percent disturbed
    a. Calculate pour point distance upstream
        i. From NHDH_MN.gdb\Hydrography\NHDFlowline, select "GNIS_Name" = 'Saint Croix River', export to flowline_saint_croix_river
        ii. From NHDH_MN.gdb\Hydrography\HYDRO_NET_Junctions, select points that intersect flowline_saint_croix_river, export to hydro_net_junctions_saint_croix_river
        iii. Copy hydro_net_junctions_saint_croix_river to tributary_pour_points, delete all but tributary pour points
        iv. Add field to tributary_pour_points “TRIB_SUB” type “Text” length 50, update field for each tributary
        v. Copy flowline_saint_croix_river to flowline_saint_croix_river_tributaries, merge each segment between tributary_pour_points
        vi. Add fields to flowline_saint_croix_river_tributaries: UP_TRIB (update as upstream “TRIB_ORDER” point), DOWN_TRIB (update as downstream “TRIB_ORDER” point), END_DIST
        vii. Run script “Calc Accumulated Distance”: calculates distance upstream of DOWN_TRIB (Adjacent Small Streams, which ends as pour point of basin)
        viii. Add field “UPSTR_M” to tributary_pour_points, join to flowline_saint_croix_river_tributaries on TRIB_ORDER to DOWN_TRIB, calc tributary_pour_points.UPSTR_M = [flowline_saint_croix_river_tributaries.END_DIST]
        ix. Add fields “UPSTR_KM” and “UPSTR_MI”, calc as [UPSTR_M]*.001 and [UPSTR_M] *0.000621371192 respectively
        x. Export to tributary_pour_points.dbf
    b. Compare distance upstream to percent disturbance
        i. Add tributary_pour_points.dbf to ChangeComparison.xlsx, create display table referencing this sheet and sheet for percent disturbed, do linear regression analysis

Riparian Level Analysis Workspace: StateOfTheForestReport\Study_Riparian.gdb

1. Create riparian buffer:
    a. Run script "AnalyzeRiparianBuffers1": buffers NHD Flowlines at 0.25 meters, selects NHD Water Bodies that intersect NHD Flowlines, selects areas of NLCD 2001 "SHORT_DEF" = 'Open Water' that intersect either flowlines or water bodies that intersect flowlines, merges and dissolves these datasets as single part features to flowlines to hydro_polys_flowlines
    b. Run script "AnalyzeRiparianBuffers2": backs up hydro_polys_flowlines to hydro_polys_flowlines_all, buffers hydro_polys_flowlines at 60 meters, projects buffer to Albers Conical Equal Area, converts buffer to raster w/ 30 meter cells to "riparian_raster".
2. Create raster datasets for NLCD
    a. Run model "CreateRiparianNlcd": raster calculator outputs from riparian_raster and nlcd_****_orig to nlcd_riparian_01 and _06
3. Create raster of tributaries, run zonal statistics, update AREA field from type "FLOAT" to type "DOUBLE"
    a. Run script "RiparianTablesTribs": creates raster of each tributary watershed in same projection as NLCD dataset as A**_* where * = TRIB_SUB
    b. Run script "RiparianTablesZonal": Runs zonal statistics on nlcd_riparian_** for each tributary raster, saves as nlcd_riparian_zonal_**_***_* where ** = NLCD year, *** = A+TRIB_ORDER, and * = TRIB_SUB
    c. Run script "RiparianTablesFixAreaField": deletes AREA field (type FLOAT), adds AREA field (type DOUBLE), calculates AREA field as COUNT*900
4. Add areas to wshd_tributaries
    a. Run model "RiparianTributaries": copies tributaries where NOT "TRIB_ORDER" = 'NON' to wshd_tributaries_riparian_** where ** = 2-digit year and to wshd_tributaries_riparian_change
    b. Run script "RiparianTablesPivot": pivots zonal statistics table nlcd_riparian_zonal_**_***_* for VALUE field with AREA statistics to pivot_nlcd_riparian_zonal_**_***_*
    c. Run script "RiparianTablesCompile": compiles pivot_nlcd_riparian_zonal_**_***_* to nlcd_riparian_zonal_**
    d. Run script "RiparianTablesJoin": moves fields/data from nlcd_riparian_** to wshd_tributaries_riparian_**
    e. Run script "RiparianTablesConversions": calculates hectares, acres, and percent of total in wshd_tributaries_riparian_**
    f. Run script "RiparianTablesCompClass": groups hectares, acres, and percent of total by comp class.
    g. Run script "RiparianTablesConv": groups hectares, acres, and percent of total by converted and non-converted.

5. Calculate change between 2001 and 2006
    a. Run script “RiparianTablesChange”, calculates difference for each field between wshd_tributaries_riparian_01 and wshd_tributaries_riparian_06
6. Check change of nlcd_riparian_01 and nlcd_riparian_06
    a. Run model “NlcdChangeRaster”: combines nlcd_riparian_01 and nlcd_riparian_06 to nlcd_riparian_01_06_change, adds CHANGE field
    b. Run script “NlcdChageDesc”: calculates CHANGE field to text description of change