Comprehensive Plan to Assess and Prioritize Wetland Restoration Opportunities in the Middle Mississippi River Watershed

Minnesota Board of Water and Soil Resources
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BOARD OF WATER AND SOIL RESOURCES

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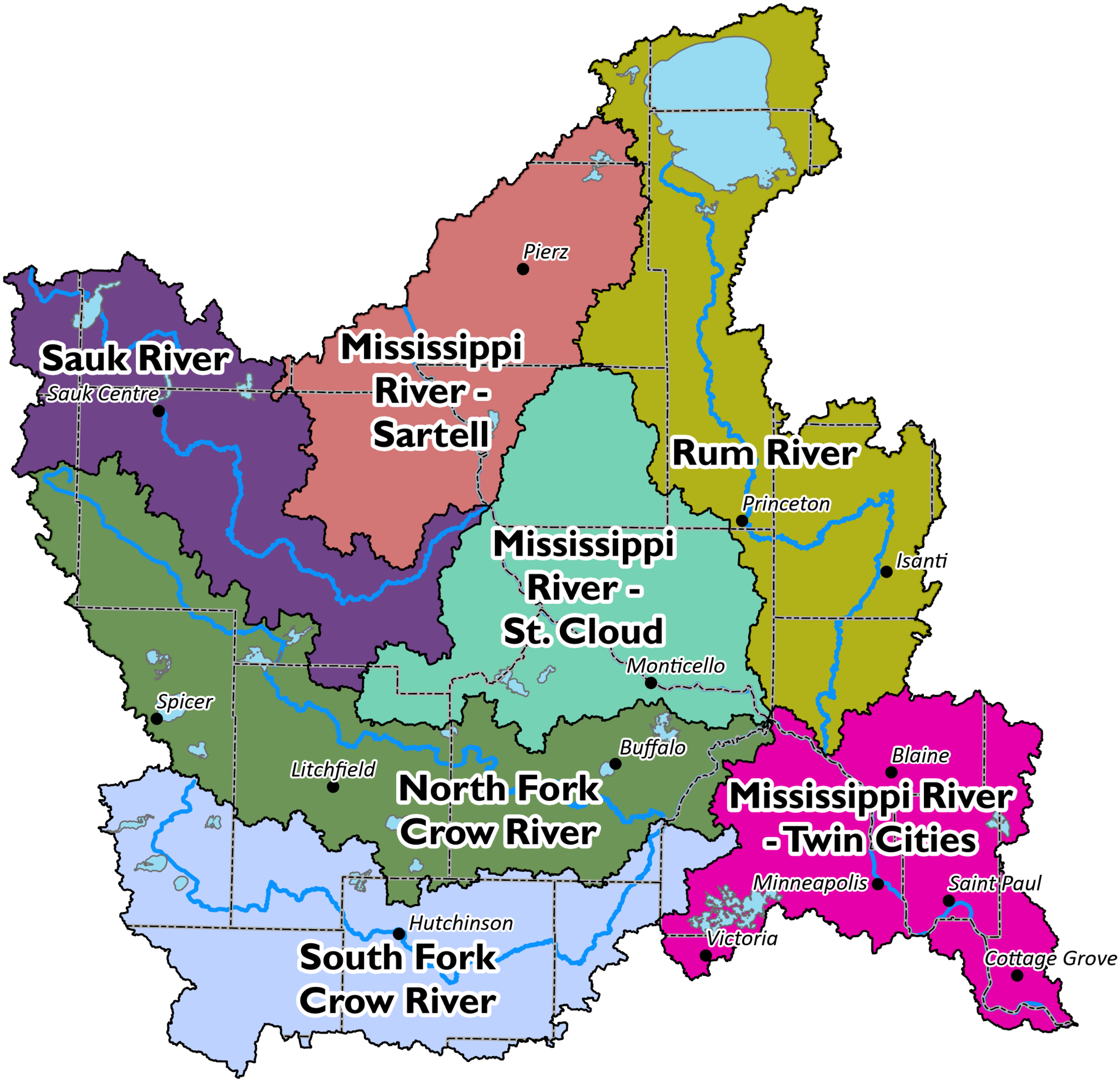
Overview

The Middle Mississippi Watershed encompasses approximately 8,500 square miles in central Minnesota roughly from the Swan River in the north to the confluence with the St. Croix River in the south. The term “Middle Mississippi River Watershed” was created when the area associated with the 4-digit hydrologic unit code (HUC) for the Upper Mississippi River (0701) was split by the regulatory agencies in Minnesota to create two smaller geographic areas for wetland mitigation purposes. It is unique to the regulatory programs and should not be confused with other watershed labels using the same name. In general, the Middle Mississippi River Watershed (MMRW) occupies the southern half of the 4-digit HUC which is dominated more by agricultural and urban land uses as opposed to the lakes and forests that dominate the northern half (which is designated as bank service area 5 in Minnesota). The MMRW contains seven major watersheds as defined by the Minnesota Department of Natural Resources (MNDNR). The major watersheds are show on Figure 1 and described generally in the following paragraphs.

Figure 1: Major Watersheds



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Middle Mississippi River Watershed Wetland Restoration Planning Study - Study Area -

Legend: City County River Lake

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Mississippi River – Sartell

The Mississippi River–Sartell watershed includes approximately 656,115 acres (1,025 square miles) in the northern part of the MMRW. Major land uses include crops (60%), forest (17%), and wetlands (11%). The population in the watershed in 2010 was 68,089, an increase of 10,426 (18%) from the 2000 census. The largest cities include Sartell (13,630), Saint Joseph (6.534), Watab (3,093), Albany (2,561), and Saint Wendel (2,150).

Mississippi River – St. Cloud

The Mississippi River – St. Cloud watershed is located in the central part of the MMRW and begins at the confluence of the Mississippi River and the Sauk River in the City of St. Cloud. The watershed covers 717, 376 acres (1,121 square miles) consisting primarily of cropland (55%), forest (17%), and developed land (11%). The population grew 25% between 2000 and 2010 (from 162,360 to 202,415) with the greatest change clustered around the southern extent of the Interstate 94 corridor as it approaches the Twin Cities. The largest cities in the watershed include St. Cloud (52,661), Elk River (22,974), Otsego (13,571), Sauk Rapids (12,773), and Monticello (12,759).

Sauk River

The Sauk River watershed is located in the northwestern portion of the MMRW originating in Douglas County and extending to the southeast at the confluence with the Mississippi River. The watershed covers 666,749 acres (1,042 square miles) and is dominated by agriculture with 74% of the watershed area in crops. The population increased by 11% between 2000 and 2010 (from 53,105 to 58,896). The largest cities are Waite Park (6,715), Sauk Centre (4,317), Cold Spring (4,025), Melrose (3,598), and Rockville (2,448).

North Fork Crow River

The North Fork Crow River Watershed is centrally located in the MMRW and extends from the western border of the watershed to its confluence with the Mississippi River north of Rogers, Minnesota. The South Fork Crow River watershed is a contributing drainage area to this major watershed joining the North Fork near Rockford, Minnesota. The watershed covers 944,857 acres (1,476 square miles) and is dominated by agriculture with 69% of the land area classified as cropland. The population grew by approximately 27% between 2000 and 2010 (from 99,095 to 125,611) with most of the growth occurring in the extreme eastern portion of the watershed. The largest cities are Saint Michael (16,399), Buffalo (15,453), Rogers (8,597), Litchfield (6,726), and Rockford (3,890).

South Fork Crow River

Located in the southwestern corner of the MMRW, the South Fork Crow River watershed covers 818,102 acres (1,278 square miles). It combines with the North Fork Crow River north of Rogers to form the Crow River. This watershed has the highest amount of land dedicated to agriculture (81%) and the least amount identified as wetland (2%). Relative to other major watersheds in the MMRW, population growth was less in the South Fork Crow watershed between 2000 and 2010 growing by only 7% during this period. The largest cities are Hutchinson (14,178), Minnetrista (6,384), Glencoe (5,631), Delano (5,464), and Watertown (4,205).

Mississippi River – Twin Cities

The Mississippi River - Twin Cities watershed is at the outlet of the MMRW and receives inputs from the six other major watersheds. It extends from the confluence of the Mississippi River with the Crow River in the northwest to the confluence of the Mississippi River and the St. Croix River in the southeast. As expected, land use in the watershed is dramatically different that the other watersheds in the MMRW with 54% of the 644,322 acres (1,007 square miles) of land identified as developed and an additional 17% identified as cropped. Population density is also significantly different than the other watersheds with most of the metro area having densities of 500 people per square mile or more. However, the net gain in population between 2000 and 2010 of approximately 5% was less than others in the MMRW (from 1,809,029 to 1,895,187).

Rum River

The Rum River major watershed is located in the northeastern portion of the MMRW and also makes up half of its eastern boundary. The Rum River Watershed is an 8-digit HUC watershed situated within the Upper Mississippi River Basin. The watershed covers 1,013,793 acres (1,584 square miles) stretching from Mille Lacs Lake in the north to the confluence with the Mississippi River in the city of Anoka. Major land uses include crops (34%), forest (24%), wetland (16%), and water (15%). The population in the watershed in 2010 was 143,863, an increase of 22,177 (18%) from 2000. The largest cities include Ramsey (23,668), Anoka (17,142), Cambridge (8,111), Oak Grove (8,031), and Saint Francis (7,218).

Ecological Classification

The Ecological Classification was developed by the MNDNR and the US Forest Service for mapping and classifying landscape ecosystems. The system provides a nested set of classification units which, from broadest to most detailed, includes: Provinces, Sections, Subsections and Land Type Associations. The provinces, sections, and subsections for each major watershed are identified in Table 1 and are shown on Figures 2, 3, and 4. A brief description of each subsection is provided in the following paragraphs.

Table 1 Ecological Classification System Provinces, Sections, and Subsections in the Middle Mississippi River Watershed													
	Province			Sections			Subsections						
Major Watershed	Laurentian Mixed Forest	Eastern Broadleaf Forest	Prairies Parkland Province	Minnesota & NE Iowa Morainal	Western Superior Uplands	North Central Glaciated Plains	Mille Lacs Uplands	Hardwood Hills	Anoka Sand Plain	Big Woods	Minnesota River Prairie	St. Paul-Baldwin Plains	Oak Savannah
Miss.- Sartell	39.1	60.9	--	60.9	39.1	--	39.1	36.2	24.7	--	--	--	--
Sauk	--	62	38	62	--	38	--	60.3	1.7	--	38	--	--
Miss. - St. Cloud	23.9	76.1	--	76.1	23.9	--	23.9	16.5	45.4	14.2	--	--	--
North Fork Crow	--	50.7	49.3	50.7	--	49.3	--	7	0.9	42.8	49.3	--	--
South Fork Crow	--	36.6	63.4	36.6	--	63.4	--	--	--	36.6	63.4	--	--
Miss. – Twin Cities	--	100	--	100	--	--	--	--	29	34.2	--	36.3	0.5
Rum	68.8	31.2	--	31.2	68.8	--	68.8	--	31.2	--	--	--	--

Mille Lacs Uplands Subsection. Gently rolling till plains and drumlin fields are the dominant landforms in this ecoregion. In the southern portion, upland hardwood forests consisting of northern red oak, sugar maple, basswood, and aspen-birch were common before settlement. Presently, forestry, recreation, and some agriculture are the most common land uses. The climate in this subsection has little moderation from Lake Superior. Total annual precipitation ranges from 27 inches in the west to 30 inches in the east, with growing-season precipitation ranging from 12 to 13 inches. Growing-season length is quite variable, ranging from 97 to 135 days, with the longest growing season in the south and the shortest on the outwash plains at the northern edge of the subsection (Dept. of Soil Science, Univ. of Minnesota 1977, 1980b).

Anoka Sand Plain. This subsection consists of a flat, sandy lake plain and terraces along the Mississippi River. Low moraines are locally exposed above the outwash and there are small dune features (Wright 1972). There are also ice block depressions and southwest trending tunnel valleys on the sand plain (Albert 1995). The major landform is a broad sandy lake plain, which contains small dunes, kettle lakes, and tunnel valleys. Topography is level to gently rolling. There are small inclusions of ground moraine and end moraine (Wright 1972). The other important landform is a series of sandy terraces associated with historic levels of the Mississippi River. Terraces are also associated with major tributaries of the Mississippi. Total annual precipitation ranges from 27 inches in the west to 29 inches in the east, with growing-season precipitation ranging from 12 to 13 inches. The growing season length ranges from approximately 136 to 156 days, with the longest growing season in the south.

Hardwood Hills. Steep slopes, high hills and lakes formed in glacial end moraines and outwash plains characterize this subsection. Presettlement vegetation included maple-basswood forests interspersed with oak savannas, tallgrass prairies, and oak forests. Much of this region is currently farmed. Where lakes are present, tourism is common. Total annual precipitation ranges from 24 inches in the west to 27 inches in the east. Growing season precipitation ranges from 10.5 to 11.5 inches. The growing season ranges from approximately 122 days in the north to 140 days in the south.

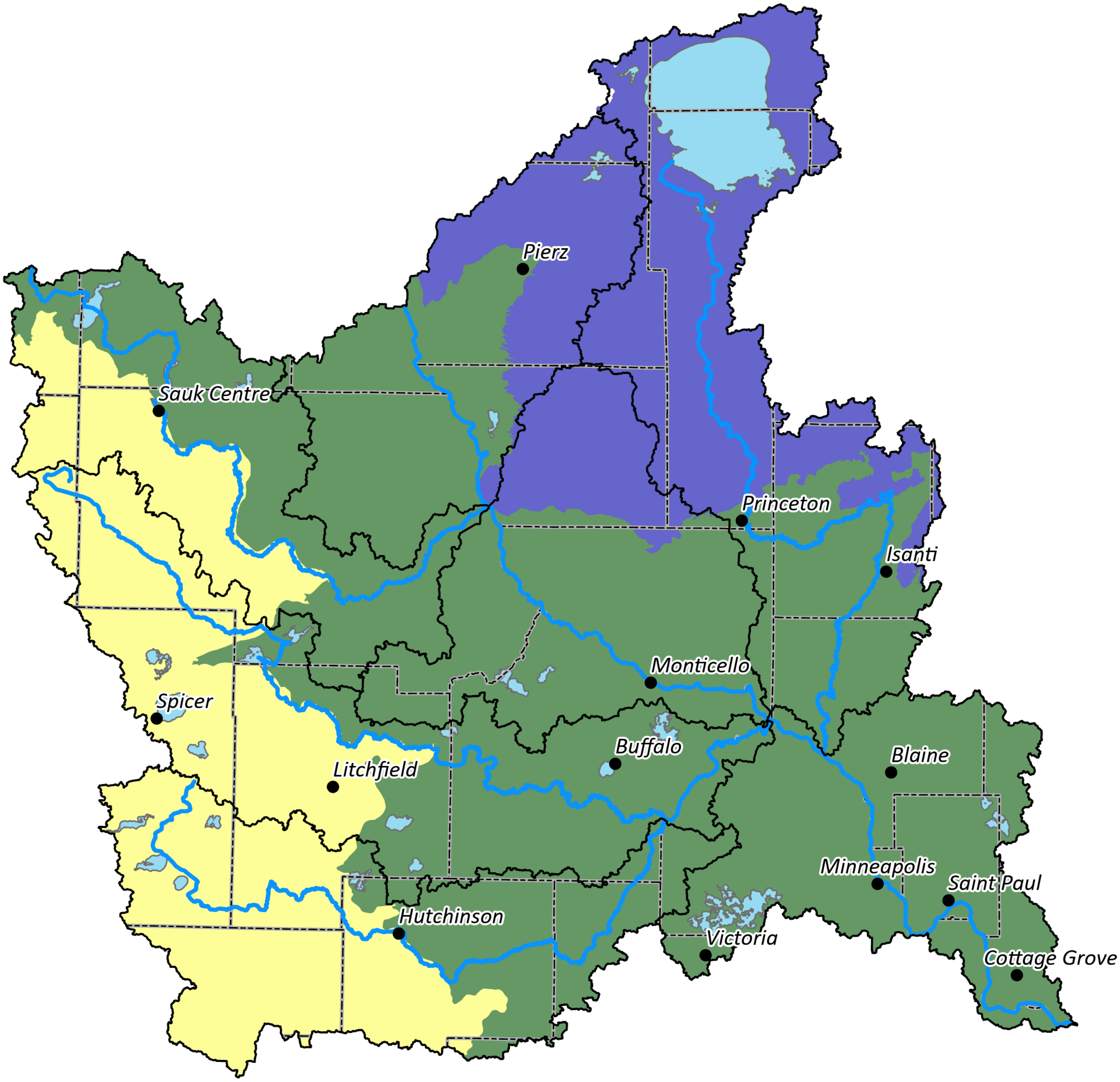
Big Woods. This subsection coincides with a large block of deciduous forest present at the time of Euro-American settlement. West of the subsection, tallgrass prairie was the primary vegetation, suggesting basic differences in climate, topography, and natural disturbance. East of the subsection, savanna and tallgrass prairie communities reflect differences in topography and fire regimes, as well as parent material. To the north, the Mississippi River and a fairly extensive outwash and lake plain defines the boundary. Annual precipitation ranges from 29 inches in the west to 31 inches in the east, with growing season precipitation ranging from 12 to 13 inches.

Minnesota River Prairie. This subsection consists of a gently rolling ground moraine about 60 miles wide (Hobbs and Goebel, 1982). The Minnesota River occupies a broad valley that splits the subsection in half. The presettlement vegetation was primarily tallgrass prairie, with many islands of wet prairie (Kratz and Jensen 1983, Marschner, 1974). Forests of silver maple, elm, cottonwood, and willow grew on floodplains along the Minnesota River and other streams. Today, agriculture is the dominant land use within this subsection as it occupies the area referred to as the Minnesota Corn Belt.

St. Paul-Baldwin Plains. This subsection is small and continues into Wisconsin. Although it is topographically low in comparison to other areas in the state, the subsection is dominated by a large moraine and areas of outwash plain. Topography is rolling to hummocky on the moraine (steep, short complex slopes) and level to rolling on the outwash. A mosaic of vegetation occurred in the subsection. Oak and aspen savanna were the primary communities, but areas of tallgrass prairie and maple-basswood forest were common.

Oak Savannah. Much of this subsection is a rolling plain of loess-mantled ridges over sandstone and carbonate bedrock and till. Topography is gently rolling and there are few lakes. Bur oak savanna was the primary vegetation, but areas of tallgrass prairie and maple-basswood forest were common.

Figure 2: Ecological Provinces



- Eastern Broadleaf Forest Province
- Laurentian Mixed Forest Province
- Prairie Parkland Province

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- Study Area -

Legend: City, County, River, Lake

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Figure 3: Ecological Sections

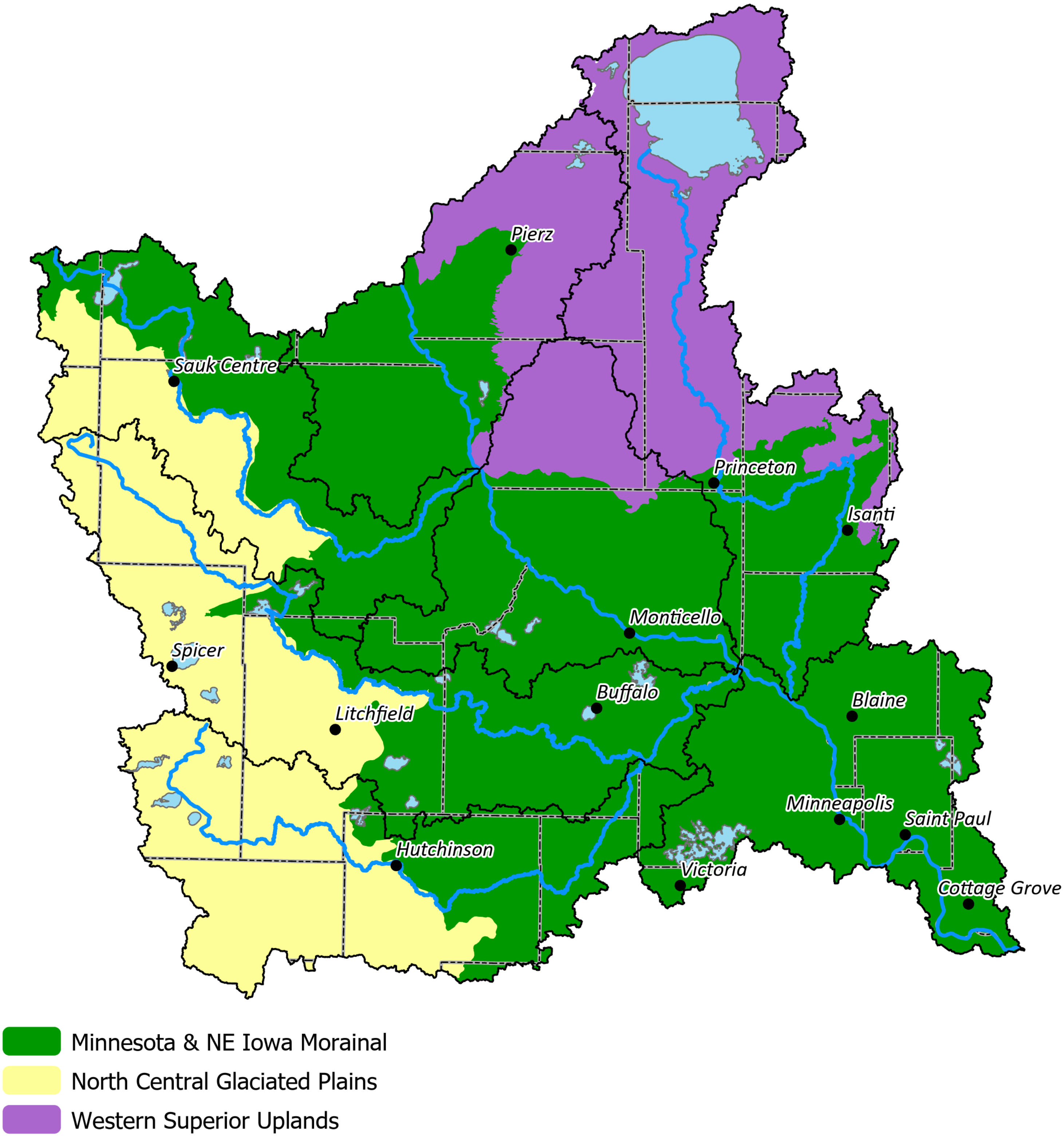

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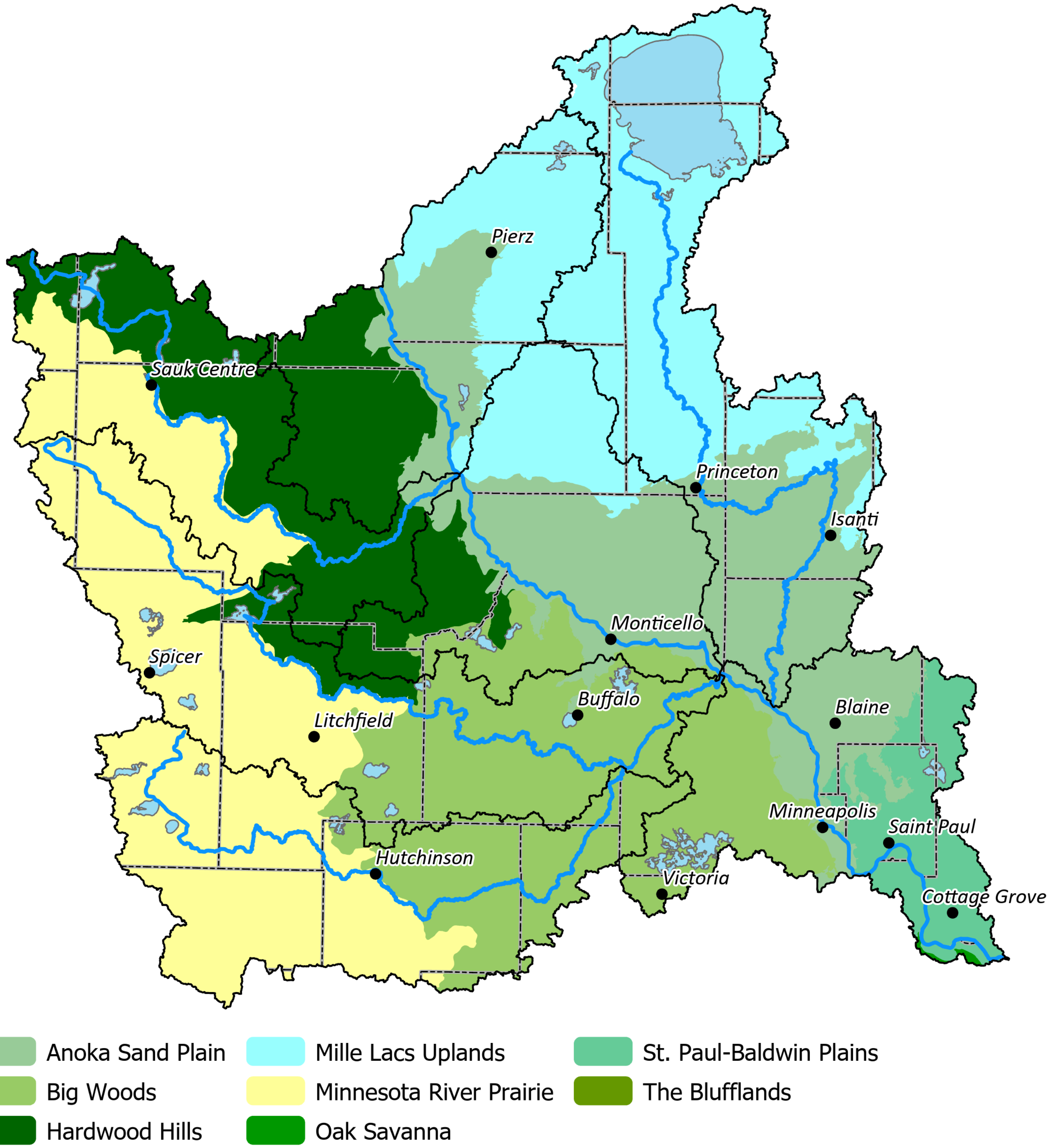
Figure 4: Ecological Subsections



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Middle Mississippi River Watershed Wetland Restoration Planning Study

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Baseline Conditions

Pre-settlement Vegetation

The Watershed Health Assessment Framework (WHAF) compiled by the MNDNR contains an interpretation of Marschner's Early-European Settlement Vegetation Map based on Public Land Survey notes from the 1890s. These maps provide an insight into the distribution of vegetation before European settlement resulted in significant changes to the landscape. A summary of the vegetative cover by Marschner land class in each major watershed is provided in Table 2.

Consistent with the ecological classification subsections for the major watersheds the Marschner data indicates that there were several distinct zones present within the MMRW in the 1890s. These are still present today but exist in an altered or degraded condition due to anthropogenic disturbances. One of the more obvious distinctions in the MMRW is the transition from forested communities in the east to a prevalence of prairie in the west. Similarly, the occurrence of conifer bogs and swamps is unique to the northern portions of the MMRW with very little of this community type found outside of the Mississippi River - Sartell, Mississippi River - St. Cloud, and Rum River watersheds. Finally, the presence of Lake Mille Lacs in the Rum River watershed is unique relative to other major watersheds because of the amount of total area it encompasses and the effect it has on land use.

Table 2
Marschner's Pre-European Settlement Land Cover

Major Watershed	Oak openings and barrens	Big woods – Hardwoods (oak, maple, basswood, hickory)	Wet prairie	Prairie	Lakes (open water)	Aspen-Oak land	River bottom forest	Conifer bogs and swamps	Mixed hardwood and pine (maple, white pine, basswood, etc.)	Aspen-birch (trending to conifers)	Aspen-birch (trending to hardwoods)	Mixed white pine and red pine	Brush prairie
Miss. River - Sartell	19.1	-	8.3	4.8	-	16.1	-	12.7	1.8	3.4	-	3.3	3.2
Sauk River	7.2	13.8	5.9	34.7	3.5	26.9	0.6	1.4	-	-	0.4	-	5.4
Miss. River - St. Cloud	37.1	22.7	7.9	7.5	1.8	17	0.6	4.2	-	-	-	-	1.2
North Fork Crow River	3.7	34.7	9.2	31.4	4.3	13.3	1.4	-	-	-	-	-	1.9
South Fork Crow River	0.9	20.8	11.6	50.9	3.7	7.9	0.7	0.1	-	-	-	-	3.5
Miss. River - Twin Cities	43.2	25.5	12.0	7.9	4.0	3.4	2.1	1.9	0.1	-	-	-	-
Rum River	18.9	25.4	4.9	-	14.2	6.6	-	15.2	2.8	6.3	-	3.4	-

Wetlands

Information on the extent of wetlands in the MMRW was obtained from the National Wetland Inventory (NWI) Update for Minnesota. This represents the most current wetland mapping for the watershed and a useful tool for evaluating the resources remaining in the MMRW and the extent of loss across the major watersheds. The wetland acreage and the percentage of the total land area as wetland in each major watershed is summarized in Table 3. Figures showing mapped wetlands for each of the major watersheds are provided in Appendix A. Based on the NWI mapping, the MMRW has less wetlands as a percentage of total watershed area relative to the rest of the state (15.9% versus 19.1% statewide). On a major watershed basis, only the Mississippi River - Sartell and Rum River watersheds exceed the statewide average with the Rum River watershed having the highest percentage of land area as wetlands in the MMRW at 23.7%. The major watershed with the lowest percentage of wetland area is the highly agricultural South Fork Crow watershed along the southern boundary of the MMRW with an estimated percentage wetland area of 7.9%. With respect to wetland types, the vast majority of wetlands are identified as emergent (61%) followed by scrub shrub (18%) and forested (16%). Not surprisingly given the percentage of wetlands by area and general land use characteristics in the MMRW, forested (39% of the total) and scrub shrub (45% of the total) wetlands are most abundant in the Rum River watershed which forms a portion of the northern and eastern boundaries of the MMRW.

Table 3
MMRW Summary of NWI Palustrine Class Wetlands

Major Watershed	Watershed Acres	Wetland Acres[1]	Wetland Area %	Emergent (acres)	Forest (acres)	Scrub Shrub (acres)	UB[2] & Aquatic Bed (acres)
Miss. River - Sartell	656,546	131,080	20.0	77,991	18,418	30,779	3,892
Sauk River	666,750	84,070	12.6	60,067	7,511	11,748	4,745
Miss. River - St. Cloud	717,376	122,053	17.0	74,310	21,294	20,311	6,138
North Fork Crow River	944,858	140,465	14.9	102,849	18,556	11,412	7,647
South Fork Crow River	818,103	64,303	7.9	50,503	7,630	2,440	3,731
Miss. River - Twin Cities	644,323	81,820	12.7	50,644	12,983	8,654	9,539
Rum River	1,013,294	240,438	23.7	109,400	55,391	69,093	6,554
Total	*5,461,251*	*864,227*	*15.9*	*525,763*	*141,782*	*154,436*	*42,246*

[1] – Wetland acreage identified as palustrine in the NWI.
[2] – Unconsolidated bottom.

Lakes

The MMRW contains 341,817 acres classified as lakes which is approximately six percent of the total land area. The most significant lake resource in the MMRW is Lake Mille Lacs in the Rum River watershed. Minnesota's second largest lake spans 132,000 surface acres and is renowned for its walleye and small mouth bass fisheries. The lake's outlet is the origin of the Rum River which then flows south along the eastern boundary of the MMRW to the Mississippi River. Other noteworthy lake resources in the MMRW by major watershed include Osakis Lake (Sauk River, 6,768 acres), Clearwater Lake (Mississippi River – St. Cloud, 3,158 acres), and Lake Minnetonka (Mississippi River – Twin Cities, 14,528 acres). A summary of the lake resources in each major watershed is provided in Table 4.

Table 4
MMRW Summary of Lake Resources

Major Watershed	Total Acres	Total Number	Number Larger than 100 acres	Number Larger than 500 acres
Miss. River - Sartell	12,524	91	33	4
Sauk River	28,764	158	44	10
Miss. River - St. Cloud	21,835	164	52	6
North Fork Crow River	60,978	311	114	25
South Fork Crow River	29,210	142	54	18
Miss. River - Twin Cities	41,991	195	73	10
Rum River	146,515	134	50	10
Total	*341,817*	*1,195*	*420*	*83*

Watercourses

The MNDNR Rivers and Streams dataset was used to create a general inventory of all watercourses within each major watershed. The total amount of mapped watercourses along with the length identified as ditched and the flow regime (intermittent or perennial) is provided for comparison. A measure of the density of watercourses in each major watershed (the number of miles of mapped watercourses divided by the watershed area) was also calculated to assess variability in the presence of the tributary network throughout the MMRW. This information is presented in Table 5. Additional information on the condition of watercourses, and water quality in general, is provided in subsequent sections.

Table 5 MMRW Watercourses Summary[1]					
Major Watershed	**Drainage Ditches**	**Intermittent**	**Perennial**	**Total**	**Watercourse Density[2]**
Miss. River - Sartell	185 (14.6)	665 (52.4)	421 (33.1)	1,270	1.2
Sauk River	195 (13.6)	952 (66.3)	288 (20.1)	1,436	1.4
Miss. River - St. Cloud	375 (30.4)	416 (33.7)	442 (35.8)	1,233	1.1
North Fork Crow River	482 (31.3)	711 (46.2)	346 (22.5)	1,538	1.0
South Fork Crow River	859 (65.4)	256 (19.5)	198 (15.1)	1,313	1.0
Miss. River - Twin Cities	112 (13.5)	360 (43.3)	359 (43.1)	832	0.8
Rum River	402 (26.9)	481 (32.2)	609 (40.8)	1,493	0.9
Total	*2,609* *(28.6)*	*3,841* *(42.1)*	*2,664* *(29.2)*	*9,114*	*1.1*

[1] – All information presented in miles. Numbers in parentheses indicate percentage of total for the major watershed.
[2] – Watercourse density is the total watercourse length divided by the major watershed area.

Altered Watercourses

The Minnesota Statewide Altered Watercourse Project was used to summarize the nature and extent of changes to natural streams and rivers in the watershed. This dataset classifies streams and rivers mapped by the National Hydrography Dataset (NHD) into four categories based on review of aerial photography. Altered watercourses are natural and artificial streams that have been compromised through hydrological alteration such as ditching, straightening, widening, etc. Impounded watercourses are streams with flow that has been dammed for human purposes. Watercourses classified as no definable channel include features such as swales or shallow waterways that were incorrectly identified as streams by the NHD, wetland and lakes where no evidence of draining or impounding is present, or streams that have disappeared or are now subterranean. Streams that do not meet the criteria to be classified as altered, impounded, or no definable channel are considered natural.

Table 6 provides a summary of altered watercourses by major watershed. South Fork Crow River and Mississippi River - Twin Cities major watersheds contain the greatest percentage of impacted streams and have only 12.4 percent and 7.7 percent of their natural streams remaining. Mississippi River - Sartell and Rum River major watersheds contain the greatest percentage of natural streams, but the percentage is roughly a third of the total stream length. These results are consistent with dominant land uses in the watersheds, whereas watersheds with a higher percentage of land in development or agricultural uses tend to have more impacted watercourses and watersheds with a lower percentage of land in these uses tend to have more natural watercourses.

Altered watercourses are a concern from a watershed health perspective because changes to the pattern, profile, and dimension of streams and rivers reduces the ability of an aquatic resource to provide important functions (transport of water and nutrients, water storage, sediment and wood transport, processing of organic matter and nutrients, and habitat). Impacts to streams that result in a loss of function also affect other natural resources (wetlands and riparian areas) that are linked via floodplain or groundwater interactions.

Table 6
MMRW Altered Watercourses Summary[1]

Major Watershed	Altered	Impounded	No Definable Channel	Natural
Miss. River - Sartell	634 (45.4)	47 (3.4)	229 (16.4)	486 (34.8)
Sauk River	826 (50)	48 (2.9)	389 (23.5)	391 (23.7)
Miss. River - St. Cloud	554 (41.9)	45 (3.4)	312 (23.6)	409 (31)
North Fork Crow River	753 (44.8)	10 (0.6)	429 (25.6)	487 (29)
South Fork Crow River	979 (67.7)	42 (2.9)	246 (17)	180 (12.4)
Miss. River - Twin Cities	467 (35.4)	123 (9.3)	629 (47.7)	101 (7.7)
Rum River	708 (39.3)	6 (0.3)	443 (24.6)	645 (35.8)
Total	*4,921 (46.3)*	*321 (3)*	*2,678 (25.2)*	*2,699 (25.4)*

[1] – All information presented in miles. Numbers in parentheses indicate percentage of total for the major watershed.

Water Quality

The Minnesota Pollution Control Agency's (MPCA) list of assessed and impaired waters was used to summarize water quality in the MMRW. These lists are prepared by the MPCA on a biennial basis to determine whether streams and lakes in the state meet water quality standards. The 2018 version of the lists were reviewed to determine the nature and extent of water quality impairments in the MMRW.

Sixteen impairment parameters are present in the MMRW. Stakeholder feedback indicated that a number of the impairment parameters were not relevant to wetland restoration or mitigation and should not be included as it relates to that goal. A complete list of the impairment parameters present in the MMRW and whether each impairment parameter was factored into the percentage of waters not meeting water quality standards is provided in Table 7.

Impaired waters are summarized for the MMRW in Table 8. The assessed values represent the area or length of lakes or streams that were evaluated for impairments for the 2018 listing. The impaired values represent the area or length of lakes or streams that are listed for at least one of the impairment parameters identified in Table 7. The percent impaired value is the proportion of assessed waters that were identified as impaired. Similar to other criteria in this document, lakes and streams in the more developed and agricultural portions of the MMRW tend to have the highest amounts of impaired waters. In the worst watershed, the South Fork Crow River, 80% of the assessed lakes and streams were identified as being impaired. On the opposite end of the spectrum, the Rum River watershed has 2% of its lakes and 16% of its streams identified as impaired for one of the water quality impairments in Table 8.

Table 8
Water Quality Impairments in MMRW

Major Watershed	Lakes			Rivers and Streams		
	Assessed[1]	Impaired[1, 2]	% Impaired	Assessed[3]	Impaired[2, 3]	% Impaired
Miss. River - Sartell	8,293	3,535	43%	306	30	10%
Sauk River	22,717	15,384	68%	322	135	42%
Miss. River - St. Cloud	16,126	6,125	38%	425	197	46%
North Fork Crow River	44,364	19,892	45%	453	230	51%
South Fork Crow River	20,988	16,967	81%	431	346	80%
Miss. River - Twin Cities	40,198	12,749	32%	343	242	71%
Rum River	141,696	3,271	2%	484	78	16%
Total	*294,380*	*77,923*	*26%*	*2,764*	*1,258*	*46%*

[1] – Values are presented in acres.
[2] – Quantity of assessed waters identified as impaired for dissolved oxygen, fishes bioassessments, aquatic macroinvertebrate bioassessments, nitrates, nutrient/eutrophication biological indicators, turbidity, or total suspended solids.
[3] – Values are presented in miles.

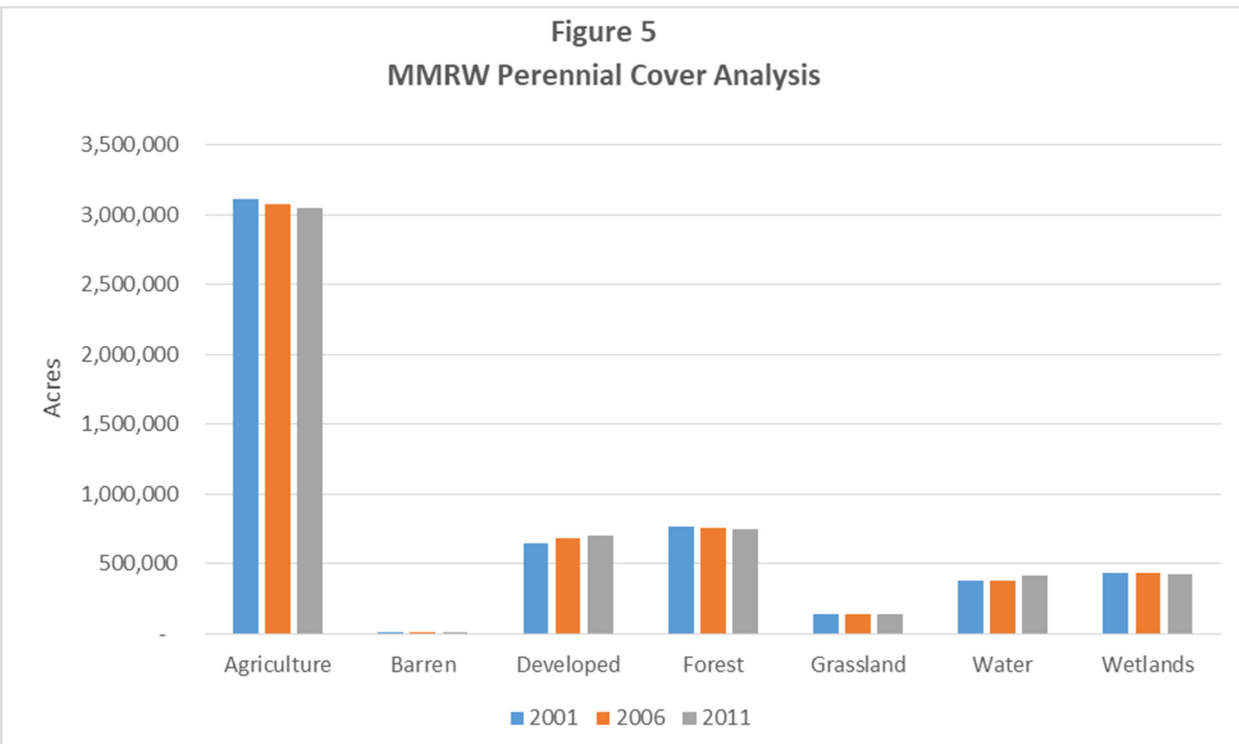
Land Cover

The National Land Cover Dataset (NLCD) was used to characterize land cover in the MMRW. There are 20 land cover classes present in the NLCD, of which 15 classes are present in the study area. For purposes of this study these land cover classes were simplified into 7 classes: agriculture, barren, developed, forest, grassland, water, and wetlands.

Land cover using these simplified classes was summarized for the MMRW using the 2001, 2006, and 2011 editions of the NLCD, as shown in Figure 5. Agriculture is the dominant land cover in the MMRW, accounting for more than half of its total area. Forest and developed land cover classes make up a considerable portion of the watershed along with water and wetlands. Grassland and barren land make up little area in the watershed. Major changes in land cover over this time period are difficult to identify at this scale but there is a general trend in the loss of agriculture and natural areas (forest, wetlands, and grassland) and an increase in developed land. The increase in water, and perhaps the decrease in wetlands, could be due to differences in climatic conditions at the time the data was collected, although this hasn't been investigated further. Additional detail, including tables and maps for each major watershed, is provided in Appendix B.

Perennial Cover and Impervious Surface

The NLCD data was used to assess the degree to which development in the watershed has removed perennial vegetation. Vegetative cover is an important characteristic when assessing watershed health because as perennial vegetation is removed there is greater potential for erosion, soil loss, flooding, water quality degradation, and loss of habitat. For this analysis, perennial cover was identified as any of the following: deciduous forest, evergreen forest, mixed forest, shrub/scrub, grassland/herbaceous, pasture/hay, woody wetlands, or emergent herbaceous wetlands. All other land use classes were considered to be non-perennial cover. The results of the perennial cover analysis are shown on Figure 5. Figures showing perennial and non-perennial land cover for each of the major watersheds are provided in Appendix C.



To further assess the degree to which development in the watershed has affected watershed health the amount of impervious surface in each major watershed was obtained from the MNDNR WHAF. Impervious surfaces prevent infiltration, lead to increased flow on land surfaces and faster delivery to streams and tributaries. In response, watersheds with high amounts of impervious surface generally exhibit higher peak discharges in receiving waters and have greater potential for streambank erosion, channel instability, and changes to in-stream habitat and biota. Wetlands adjacent to tributaries may also be adversely affected if streams are destabilized and tributary/floodplain interactions are altered. If channel incision occurs tributaries could function more as drainage features and remove hydrology from adjacent wetlands. Impacts to stream health can be observed in watersheds with very small amounts of impervious surface (less than 5%) while more visible changes are evident when impervious surfaces exceeds 5%. The WHAF health score for impervious surfaces is based on the inverse of the percent impervious surface applying a 4% threshold to represent a score of 0, meaning all catchments where impervious surfaces cover more than 4% of the total area were assigned a health score of 0. Imperviousness values between 0 and 4% were scaled from 100 (highest score) to 0 (lowest score).

The results of the perennial cover analysis and WHAF Impervious Cover Health Score for each major watershed is provided in Table 9. Since impervious cover can vary greatly throughout a major watershed this variable was also assessed at the catchment level to identify areas where impervious cover may be more of an issue. This information is also provided in Table 9. Not surprisingly, the Mississippi River - Twin Cities major watershed scores very low for both the percent perennial cover and for cover by impervious surfaces. Based on the WHAF assessment, 82% of the catchments in this major watershed exceed the 4% threshold used by the MNDNR. The percentage of catchments with low impervious scores in other major watersheds ranged from 8 to 14 percent with the lowest amount in the Mississippi River - Sartell and South Fork Crow River watersheds.

Table 9
Perennial Cover Percentage and Impervious Cover WHAF Scores in MMRW

Major Watershed	% Perennial Cover	WHAF Impervious Cover Health Scores				
		Mean WHAF Score	Min WHAF Score	Max WHAF Score	Standard Deviation	Catchments with WHAF scores of 0
Miss. River - Sartell	65	70.45	0	98	27.18	9/109
Sauk River	41	69.37	0	100	28.37	15/142
Miss. River - St. Cloud	49	61.89	0	100	31.45	23/166
North Fork Crow River	32	60.67	0	97	28.96	28/243
South Fork Crow River	18	63.81	0	99	26.5	14/177
Miss. River - Twin Cities	31	9.64	0	98	23.41	148/180
Rum River	71	69.96	0	99	28.45	21/166

Sensitive Species and Plant Communities

Identification of sensitive plant communities was based on Minnesota's Native Plant Community Classification (NPC; Version 2.0). The classification is hierarchical and based strongly on plant species composition developed through an analysis of extensive field data collected from forests, prairies, wetlands, and other habitats. The NPC types and subtypes recognized in Minnesota have been assigned conservation status ranks (S-ranks) that reflect the risk of elimination of the community from Minnesota. There are five ranks:

S1 = critically imperiled
S2 = imperiled
S3 = vulnerable to extirpation
S4 = apparently secure; uncommon but not rare
S5 = secure, common, widespread, and abundant

A range in rank (for example, S1S2) indicates there is uncertainty in conservation status but it falls within a given range. Possible S-ranks (for example, S1 or S2) are listed for NPC subtypes based on the S-rank of the NPC type.

These ranks are determined using methodology developed by the conservation organization NatureServe and its member natural heritage programs in North America. S-ranks were assigned to Minnesota's NPC types and subtypes based on information compiled by MNDNR plant ecologists on: 1) geographic range or extent; 2) area of range occupied; 3) number of occurrences; 4) number of good occurrences, or percent area of occurrences with good viability and ecological integrity; 5) environmental specificity; 6) long-term trend; 7) short-term trend; 8) scope and severity of major threats; and 9) intrinsic vulnerability.

The analysis of NPC types for the CPF focused on the subtypes assigned a ranking of S3, S2, or S1. There are 58,815.3 acres of native plant communities that have been assigned one of these conservation status ranks in the MMRW. The Rum River watershed has the most total acres designated (18,000.4 acres) followed by the North Fork Crow River (13,405.3 acres), Mississippi River – St. Cloud (7,535.1 acres), Mississippi River – Twin Cities (6,551.6 acres), Mississippi River – Sartell (6,251.2 acres), Sauk River (4,357.2 acres) and the South Fork Crow River (2,750.6 acres). The Rum River watershed also had the largest amount of wetland NPCs designated S1, S2, or S3 with 11,654.8 acres attributable primarily to the *Basswood – Black Ash Forest* (MHc47a) and *Black Ash – Yellow Birch – Red Maple – Basswood Swamp* (WFn55b). A summary of the wetland NPCs with S1, S2, or S3 rankings is provided in Table 10. Maps showing the location of these areas are provided in Appendix D.

Table 10 Native Plant Community Classification Acreage								
Native Plant Community	**S-rank**	**Miss River-Sartell**	**Sauk River**	**Miss River-St. Cloud**	**North Fork Crow River**	**South Fork Crow River**	**Miss River-Twin Cities**	**Rum River**
APn91b - Graminoid Poor Fen (Basin)	S3	30		3.3				196.3
CTs12a - Dry Sandstone Cliff (Southern)	S2						10.4	
FDc23a2 - Jack Pine - (Yarrow) Woodland, Bur Oak - Aspen Subtype	S1S2	16.3						
FDc25b - Oak- Aspen Woodland	S2	333						862.4
FDn43a - White Pine - Red Pine Forest	S2							20.7
FDs27b - White Pine - Oak Woodland (Sand)	S1						19	
FDs36a - Burr Oak - Aspen Forest	S3S4							
FDs37b - Pin Oak - Bur Oak Woodland	S3	1413.1	2768.9	999.3	351.9		16.2	502.1
FFs59a - Silver Maple - Green Ash - Cottonwood Terrace Forest	S3	153.9	85.3	167.7	0.8	47		937.9
FFs59c - Elm - Ash - Basswood Terrace Forest	S2			231	93.9		234.2	
FFs68a - Silver Maple - (Virginia Creeper) Floodplain Forest	S3	37.3		435.5	182.9		1056.2	1856.5
FPn72a - Rich Tamarack Swamp (East central)	S3	90.2						1602.4
FPs63a - Tamarack Swamp (Southern)	S2S3	1677.4	467.2	547.2	102	166.8	908	1743.8
LKi32a - Sand Beach (Inland Lake)	S1							28.2
LKi32b - Gravel/Cobble Beach (Inland Lake)	S2		2.8					
MHc47a - Basswood - Black Ash Forest	S3	535		39.7				3262.4
MHn47a - Sugar Maple - Basswood - (Bluebead Lily) Forest	S3	241.4						763.1
MHs37a - Red Oak - White Oak Forest	S3						826.7	
MHs38a - White Pine - Oak - Sugar Maple Forest	S3						88	22.5
MHs38b - Basswood - Bur Oak - (Green Ash) Forest	S3		286		5468.5	601.5		
MHs38c - Red Oak - Sugar Maple - Basswood - (Bitternut Hickory) Forest	S3	45.8	119.3	1011.8	610.7	24.4	1266.6	413.6
MHs39a - Sugar Maple - Basswood - (Bitternut Hickory) Forest	S2				413.2	186.4	151.3	

Table 10
Native Plant Community Classification Acreage

Native Plant Community	S-rank	Miss River-Sartell	Sauk River	Miss River-St. Cloud	North Fork Crow River	South Fork Crow River	Miss River-Twin Cities	Rum River
MHs39b - Sugar Maple - Basswood - Red Oak - (Blue Beech) Forest	S3	108.4						
MHs39c - Sugar Maple Forest (Big Woods)	S2	6.8		366.1	534.7	399.3	616.2	32.5
MHs49a - Elm - Basswood - Black Ash - (Hackberry) Forest	S3	18.7	7.8	23	28.2	372.5	108.7	
MRn83a - Cattail - Sedge Marsh (Northern)	S2		1.2	19.6	2.6	11.2	147.2	181.2
MRn83b - Cattail Marsh (Northern)	S2		7.6		81.6			
MRn93a - Bulrush Marsh (Northern)	S3	15.4				291.7		
MRn93b - Spikerush - Bur Reed Marsh (Northern)	S2	1.8					12.7	36.2
MRp83a - Cattail - Sedge Marsh (Prairie)	S1			355.8	541.6			
MRp83b - Cattail Marsh (Prairie)	S1				2626.2	71.9		
MRp93b - Spikerush - Bur Reed Marsh (Prairie)	S1					4.8		
OPn93a (Spring Fen)	S2	9.2						
OPp91a - Rich Fen (Mineral Soil)	S3		163.6		407.6			
OPp91b - Rich Fen (Peatland)	S3			1.7				
OPp91c - Rich Fen (Prairie Seepage)	S3		44.6		117.3			
OPp93b - Calcareous Fen (Southwestern)	S1				4.8	1.5		
OPp93c - Calcareous Fen (Southeastern)	S1		104.5		7.5			
ROs12b - Crystalline Bedrock Outcrop (Transition)	S2	6.4	39.9	74.5				
RVx32b2 - Sand Beach/Sandbar (River), Permanent Stream	S3						6.2	
UPn12b - Dry Sand - Gravel Prairie (Northern)	S2				17.5			
UPn13b - Dry Barrens Oak Savanna ((Northern)	S1				516.6			
UPn13d - Dry Hill Oak Savanna (Northern)	S1				74.3			
UPn23b - Mesic Prairie (Northern)	S2					3.7		
UPs13a - Dry Barrens Prairie (Southern)	S1S2	104.6		21.7			102.27	
UPs13b - Dry Sand - Gravel Prairie (Southern)	S2	39	39.9	56.4			197.5	

Table 10 Native Plant Community Classification Acreage								
Native Plant Community	**S-rank**	**Miss River-Sartell**	**Sauk River**	**Miss River-St. Cloud**	**North Fork Crow River**	**South Fork Crow River**	**Miss River-Twin Cities**	**Rum River**
UPs13d - Dry Hill Prairie (Southern)	S2					4	58.7	
UPs14a - Dry Barrens Oak Savanna (Southern)	S1S2	3.5		173.5				
UPs14a2 - Dry Barrens Oak Savanna (Southern), Oak Subtype	S1S2	99.5		2218.7			342.8	429.5
UPs14b - Dry Sand - Gravel Oak Savanna (Southern)	S1S2	350.7	10.7	561.8			18.1	8.6
UPs14c - Dry Hill Oak Savanna (Southern)	S1				0.9			
UPs23a - Mesic Prairie (Southern)	S2		105.4	73.75	646.4	465.4	17.1	
WFn53b - Lowland White Cedar Forest (Northern)	S3	29.5						475.6
WFn55b - Black Ash - Yellow Birch - Red Maple - Basswood Swamp	S3	460	9	39.4			329.1	4440.9
WFs57a - Black Ash - (Red Maple) Seepage Swamp	S1S2	264.3	3.5	32.4	17.6		5.8	184
WMp73a - Prairie Meadow/Carr	S3				9.2	3.4		
WMs83a - Seepage Meadow/Carr	S3	124	1.6	40.7	430.8	19	5.8	
WMs83a1 - Seepage Meadow/Carr, Tussock Sedge Subtype	S3				11.5			
WMs83a2 - Seepage Meadow/Carr, Aquatic Sedge Subtype	S3					0.5		
WMs92a - Basin Meadow/Carr	S2		0.2	0.6				
WPs54b - Wet Prairie (Southern)	S2		88.2	39.9	104.5	75.6	6.8	
TOTAL ACRES WITH S1, S2, or S3 RANKING		6215.2	4357.2	7535.05	13405.3	2750.6	6551.57	18000.4
TOTAL WETLAND ACRES WITH S1, S2, OR S3 RANKING		2893	976.5	1914.8	4742.4	693.4	2705.8	11654.8
WETLAND ACRES AS S1		264.3	108	388.2	3197.7	78.2	5.8	184
WETLAND ACRES AS S2		1952.7	567.9	870.7	402.2	253.6	1314.7	2145.2
WETLAND ACRES AS S3		2617.7	771.3	1235.5	1262.1	528.4	2299.1	11253.4

Permitting

Issued permits under the Corps' Regulatory Program were reviewed for the 8-year period between October 2009 and September 2017. This review focused on those authorized impacts to wetlands (e.g., filling or draining) that resulted in a permanent loss of the resource. Additional data was available which documented other types of impacts to wetlands such as excavation or impacts that were temporary in nature; however, this data either appeared unreliable or misrepresented the quantity and nature of impacts to wetlands without greater levels of analysis.

Table 11 provides a summary of authorized wetland impacts between 2009 and 2017. It is important to note that this information provides only a subset of wetland impacts over this period. For example, the placement of fill material into a wetland for residential development would be included in this summary. However, the placement of fill material into a wetland for a temporary road which would be restored to its preexisting condition at a later time would not be included in this summary. Lastly, the Corps does not regulate impacts to all wetlands. Certain wetlands that are considered isolated are not regulated by the Corps and would not be included in this summary. Considering these caveats, the Mississippi River - Twin Cities watershed experienced the greatest amount of wetland impacts over this period. This appears reasonable as this portion of the MMRW has experienced the greatest amount of development. The Rum River watershed, which has the greatest amount of current wetlands, saw the second greatest amount of wetland impacts. The Mississippi River - St. Cloud watershed experienced wetland impacts at a medium level which is likely a response to increased development. Lower amounts of wetland impacts were seen in the highly agricultural and wetland poor watersheds of Mississippi River - Sartell, Sauk River, North Fork Crow River, and South Fork Crow River.

Table 11
Authorized Wetland Impacts Between 2009 and 2017[1]

Major Watershed	Total Acres	Acres Per Year
Mississippi River - Sartell	29	3.6
Sauk River	11	1.4
Mississippi River - St. Cloud	32	4
North Fork Crow River	26	3.3
South Fork Crow River	23	2.9
Mississippi River - Twin Cities	121	15.1
Rum River	52	6.5
Total	*295*	*36.9*

[1] – Authorized fill impacts to wetlands resulting in a permanent loss of the resource.

Aquatic Resource Loss

Anderson and Craig (1984) estimated the area of pre-settlement and current wetlands for each county in the State of Minnesota using soils mapping. There are 25 counties located wholly or partly in the MMRW. A summary of pre-settlement wetlands area, current wetlands area, and wetland loss by county is provided in Table 12.

Wetland loss was also calculated for the MMRW using soils mapping and the NWI. Area of historic wetlands was determined for each soil map unit using the hydric rating value assigned from the soil survey, which were aggregated for the major watersheds and MMRW. Current wetland area was calculated using mapped wetlands from the NWI, excluding lakes. Table 13 shows the results of this analysis for the MMRW. Maps showing historic wetlands are provided in Appendix G.

Table 12 MMRW Historic Wetland Loss by County				
County	**Percent Area of County Within MMRW**	**Presettlement Wetland Acres[1]**	**Current Wetlands Acres[1]**	**Wetland Loss**
Aitkin	10%	62,900	57,300	9%
Anoka	84%	72,240	51,240	29%
Benton	100%	63,000	41,000	35%
Carver	39%	9,360	1,560	83%
Chisago	2%	1,120	720	36%
Crow Wing	8%	12,080	10,480	13%
Dakota	9%	2,520	360	86%
Douglas	13%	4,420	1,560	65%
Hennepin	81%	23,490	7,290	69%
Isanti	82%	49,200	39,360	20%
Kanabec	4%	2,760	2,400	13%
Kandiyohi	53%	112,360	11,130	90%
McLeod	87%	42,630	2,610	94%
Meeker	100%	120,000	26,000	78%
Mille Lacs	86%	79,980	72,240	10%
Morrison	58%	174,000	126,440	27%
Pope	14%	8,400	1,960	77%
Ramsey	100%	3,000	1,000	67%
Renville	26%	62,140	260	100%
Sherburne	100%	43,000	31,000	28%
Sibley	3%	8,700	180	98%
Stearns	100%	146,000	32,000	78%
Todd	23%	48,530	25,760	47%
Washington	38%	5,320	2,280	57%
Wright	100%	27,000	6,000	78%
Total	--	*3,036,000*	*1,540,000*	53%

[1] – Wetland acres for each county were adjusted to represent the area within the MMRW by multiplying the values from Anderson and Craig (1984) by the percent area of the county within the watershed.

Table 13 MMRW Historic Wetland Loss Summary[1]			
Major Watershed	**Historic Wetlands**	**Current Wetlands**	**Wetland Loss**
Miss. River - Sartell	236,156	131,080	105,076 (44)
Sauk River	225,039	84,070	140,969 (63)
Miss. River - St. Cloud	202,515	122,053	80,463 (40)
North Fork Crow River	364,615	140,465	224,150 (61)
South Fork Crow River	458,284	64,303	393,982 (86)
Miss. River - Twin Cities[2]	145,459	81,820	63,640 (44)
Rum River	345,032	240,438	104,594 (30)
Total	*1,977,101*	*864,227*	*1,112,874 (56)*

[1] – All information presented in acres. Numbers in parentheses indicate percentage.
[2] – Wetland loss in the highly developed Mississippi River Twin Cities watershed are not accurately represented by this analysis. It is expected that wetland loss is similar in amount to the more impacted portions of the MMRW.

Both of these wetland loss analyses suggest the MMRW has lost at least 50% of its historic wetlands, including significant losses in wetland quantity in the southern and western portions of the watershed. These results are consistent with land use in these areas, which are dominated by agriculture and development. The least impacted areas of the watershed from a wetland loss perspective are located in the north, which is more forested and experiences less agricultural land uses.

Wetland Banking Analysis

Since passage of the Clean Water Act in 1972 and the Minnesota Wetland Conservation Act (WCA) in 1991 most wetland impacts are regulated by one or both programs and frequently require mitigation to offset the functions lost as a result of the authorized impacts. Today, credits obtained from wetland mitigation banks are the primary source of mitigation although project-specific mitigation remains an agency accepted option provided sequencing criteria are satisfied and the site meets other policy and technical eligibility requirements. To assess how wetland banking credits are being used to offset wetland impacts in the MMRW an analysis of wetland banking activity and the status of the private market and LGRWRP accounts was completed. The analysis relied on data obtained from the State of Minnesota Wetland Bank from 2014 through 2018 primarily through the processing of wetland bank withdrawal applications.

Focusing exclusively on credit withdrawals outside of agricultural wetland banking, the MMRW is the most active bank service area (BSA) in Minnesota with an average credit withdrawal rate of 81.6 credits per year over this five-year period.[1] This accounts for approximately 23% of the withdrawals statewide each year. The average number of withdrawal transactions completed in the MMRW during this same period was approximately 103. These numbers indicate that the MMRW is a very active BSA for wetland banking activity and that there is strong and consistent demand for wetland bank credits as a form of wetland mitigation. A summary of credit withdrawals from each BSA is provided in Table 14.

Table 14
Wetland Credit Withdrawals by Bank Service Areas 2014-2018[1]

BSA	2014	2015	2016	2017	2018	Total	Average
1	3	17	9	32	30	91	18.2
2	28	26	7	9	6	76	15.2
3	88	38	35	85	14	260	52
4	5	15	0	27	3	50	10
5	41	159	29	82	30	341	68.2
6	10	28	20	6	10	74	14.8
7	75	116	46	75	96	408	81.6
8	78	35	58	45	22	238	47.6
9	62	45	33	54	50	244	48.8
10	0	0	0	1	0	1	0.2
Total	*390*	*479*	*237*	*416*	*261*	*1783*	*356.6*

[1] Withdrawal data obtained from BWSR wetland banking database

As a subset of the information in Table 14, the MMRW is the third most active with respect to road projects (LGRWRP and MNDOT projects) with an average annual credit withdrawal rate of 18 credits which is less than BSA 5 (29 credits) and BSA 8 (21 credits). However, it is important to understand that the average withdrawal rates for road projects may be misleading because they are based on where the credit is acquired and not on the location of the impact. Recent credit shortages for the LGRWRP have increased the frequency of credit use from accounts outside the BSA of impact which confounds any conclusions regarding where demand may be greatest based on the location of the impact. From a qualitative standpoint, higher withdrawal rates for road projects in the MMRW seems accurate because it is consistent with the increase in development in the Twin Cities and the demand for wetland credits outside of road projects.

Current Status

Ledger information for wetland banks in the MMRW was compiled and reviewed to provide a snapshot of the amount and types of credits currently available. This analysis focused solely on credits that were deposited into the Minnesota Wetland Bank as of October 18, 2019 and were identified as federally approved regardless of whether the account holder/sponsor has made them available for purchase.

[1] Agricultural credit use is primarily associated with the wetland conservation provisions of the federal farm program (Swampbuster) and was removed from this analysis.

This information, except for credits in MNDOT and LGRWRP accounts, is provided in Table 15. Since MNDOT and LGRWRP accounts function as single user accounts information on credit balances for those is summarized separately in Table 16.

Table 15
Federally Approved Credits by Major Watershed in the MMRW[1]

	Miss River- Sartell	Sauk River	Miss River- St. Cloud	North Fork Crow River	South Fork Crow River	Miss River- Twin Cities	Rum River	Total
seasonally flooded basin	0	0	0	6.56	0	0	0	6.56
fresh (wet) meadow	0.09	2.6	2.31	2.53	0.16	63.16	0	70.85
wet mesic prairie	0	0	0	0	0	2.02	0	2.02
sedge meadow	0	1.19	0	7.86	0.65	10.78	0	20.47
shallow marsh	0.03	3.11	12.62	14.25	1.94	24.08	0.05	56.07
deep marsh	0	11.12	0.96	13.49	1.66	7.17	0	34.40
shallow open water	0	1.7	0	0	6.88	2.22	0	10.80
shrub carr	14.08	0	0	0	0.19	0	0	14.27
hardwood or coniferous swamp	0	0	0	0	0	5.33	0	5.33
upland	0.15	0	50.49	7.39	0	9.28	0	67.31
Total	*14.35*	*19.72*	*66.38*	*52.08*	*11.48*	*124.04*	*0.05*	*288.08*
Percent of Total Credits	*5*	*6.8*	*23*	*18.1*	*4*	*43.1*	*<1*	*100*

[1]Credit data show in the table is based on reports created on October 18, 2019.

The MMRW has a combined total of 288.08 federally approved wetland bank credits. Some of these credits are associated with single-user accounts or are not listed for sale (based on notifications provided to BWSR) but are included in this assessment. The available credits are concentrated primarily in three of the seven major watersheds: the Mississippi River – Twin Cities (124.04 credits), the Mississippi River - St. Cloud (66.38 credits), and the North Fork of the Crow River (52.08 credits). Although not shown in the table, these major watersheds are also where 38 of the 55 wetland banks in the MMRW are located. From a geographic and demographic perspective, the concentration of available credits and quantity of banks in these major watersheds is encouraging since they include the most developed major watershed in the MMRW (Mississippi River - Twin Cities) and the two major watersheds with the highest population increases between 2000 and 2010 (North Fork Crow River at 27% and Mississippi River - St. Cloud at 25%). If it can be assumed that the areas with greater development pressure also have more wetland impacts and loss of function and that siting mitigation in the watersheds were the impacts are occurring is a desired outcome than the wetland banking market has responded and is meeting that need. However, the other side of this response is that the other four major watersheds have low credit supplies and significantly fewer banks from which to draw from if mitigation within the major watershed where the impacts take place is a goal. The Rum River major watershed, for all intents and purposes, would be unable to meet such a goal because it has only one established wetland mitigation bank with only a fraction of a credit remaining.

Table 15 also shows the distribution of credits by wetland plant community type across the major watersheds. Overall, there appears to be a relatively even split throughout the MMRW between the saturated soil wetland types (fresh (wet) meadow, wet mesic prairie, and sedge meadow) and those types with standing water for long periods during the growing season (shallow marsh, deep marsh, and shallow open water). Staff from the Corps of Engineers have expressed concern over the generation and use of credits along the wetter part of the wetland hydrology continuum so a supply of credits that contains a variety of types would appear to be more desirable from a Section 404 program perspective.[2] The distribution of credit types within the major watersheds is not as diverse which is dependent on the number of banks in each watershed with the higher numbers of banks resulting in a greater variety of wetland credits types.

A summary of available credits in the MMRW in accounts dedicated for MNDOT or LGRWRP use is summarized in Table 16.

Table 16
MNDOT and LGRWRP Federally Approved Credits by Major Watershed in the MMRW[1]

	Miss River- Sartell	Sauk River	Miss River- St. Cloud	North Fork Crow River	South Fork Crow River	Miss River- Twin Cities	Rum River	Total
seasonally flooded basin	0	0	0	1.09	0	0	0	1.09
fresh (wet) meadow	0	12.25	0	0	2.17	3.14	3.09	20.65
wet mesic prairie	0	0	0	0	0	0	0	0
sedge meadow	3.47	0	0	0	0	0	0	3.47
shallow marsh	4.76	1.45	0	0	0.44	0	0.47	7.12
deep marsh	0	0	0	0.26	0.53	0	0	0.79
shallow open water	0	0	0	0	0	0	0	0
shrub carr	0	31.06	0	0	0	0	0	31.06
hardwood or coniferous swamp	0	3.64	0	0	0	0	0	3.64
upland	0	0	0	0	0	0	0	0
Total	*8.23*	*48.4*	*0*	*1.35*	*3.14*	*3.14*	*3.56*	*67.82*
Percent of Total Credits	*12*	*71*	*0*	*2*	*5*	*5*	*5*	*100*
[1]Credit data show in the table is based on reports created on October 18, 2019.								

[2] The Wetland Conservation Act does not contain a preference for wetland type when evaluating replacement plan applications.

As Table 16 shows, the majority of the 67.82 wetland credits for road improvement projects in the MMRW are concentrated in the Sauk River major watershed at the Schramel LGRWRP site. The types of credits available have been enough to provide in-kind replacement for most authorized impacts over the past several years. However, the high average annual credit demand in the MMRW (50 credits per year) plus the additional needs from MNDOT projects will exhaust the current supply of credits in less than two years unless other banks are approved and constructed or credits from the public market are purchased and transferred to MNDOT and LGRWRP accounts.

MMRW Trends

Aerial Extent of Wetlands

The US Fish and Wildlife Service's (USFWS) Wetlands Status and Trends project is the monitoring component of the National Wetlands Inventory (NWI) program. It provides information on wetland and deepwater habitat type, location, and trends at a national scale that may also be occurring in the MMRW. The most recent version of the Status and Trends Report examined recent trends in wetland extent and habitat type throughout the contiguous United States between 2004 and 2009. At a national scale, wetland area declined by 62,300 acres between 2004 and 2009 although this number was not statistically significant. Freshwater vegetated wetlands continued to decline but the annual rate of loss declined by nearly 50% relative to the 1998-2004 monitoring period. All freshwater wetland types except for forested wetlands had an increase in total area. Forested wetlands experienced their largest loss since the 1974-1985 time period with approximately 392,600 acres lost to upland land use types or conversion to deepwater and an overall decline of 633,100 acres. Overall, freshwater wetland losses were attributed primarily to urban and rural development and silviculture operations. Gains in freshwater ponds offset losses of vegetated wetland area with an estimated 207,200 acres of ponds created between 2004 and 2009. It is not known whether an increase in the acreage of ponds nationwide can be interpreted as a net gain in function relative to the losses identified in the report.

The State of Minnesota has a similar program to monitor long-term changes in wetland quantity and quality. Modeled after the USFWS program, the Minnesota status and trends monitoring program (WSTMP) assesses changes in wetland acreage and type using remote sensing and photo-interpretation for 4,990 plots over 3-year sampling cycles. The most recent report covers the first two complete sampling cycles, 2006-2008 and 2009-2011.

The WSTMP identified a small but statistically significant net gain in wetland acreage of 123 acres between 2006 and 2011. When extrapolated from the plot scale to a statewide scale, the results indicate a net gain of 2,080 acres during the study period. Much like the USFWS study, the WSTMP identified that most of the observed gains were unconsolidated bottom wetlands (ponds). Another significant finding of the WSTMP was the net conversion of 1,890 acres of emergent wetlands to cultivated fields. Approximately 1,290 acres of this total occurred in the Prairie Parkland province which is a significant component in the Sauk (38%), North Fork Crow (49.3%), and South Fork Crow (63.4%)

major watersheds. The WSTMP did not identify this conversion as a net loss of wetlands but it does not represent a decrease the functions provided by these wetlands.

Wetland Quality

The MPCA is the state agency responsible for monitoring the quality aspect of wetland status and trends monitoring in Minnesota. Their initial efforts were directed at a statewide and regional survey of depressional[3] wetland condition completed between 2007 and 2009. On a statewide basis, the vegetation in almost half (46%) of Minnesota's depressional wetland basins was determined to be in poor condition, 25% was in fair and 29% was in good condition. Vegetation condition varied regionally with higher proportions of good conditions observed in north-central and northeastern Minnesota and more degraded conditions in the western and southern areas of the state, including most of the area within the MMRW.

The MPCA broadened their monitoring of the State's wetlands in with the initiation of the Minnesota Wetland Condition Assessment (MWCA) in 2011. The MWCA was modeled after (and done in conjunction with) the U.S. Environmental Protection Agency's (EPA) National Wetland Condition Assessment (Scozzafava et al. 2011). The goal of the MWCA was to provide an estimate of the current baseline condition of virtually all of Minnesota's wetlands. Overall, the vegetation condition in Minnesota's wetlands was determined to be high. An estimated 49% (± 8%) of the survey target population was in the exceptional condition category while an additional 18% (± 7%) of wetlands statewide were in good condition (vegetation composition and structure were similar to natural communities). Combined, wetlands in exceptional and good conditions totaled approximately two-thirds of the statewide wetland extent. The remaining wetlands were either classified as fair or poor. However, the statewide data masked the variation observed on a regional basis. The Mixed Wood Plains and Temperate Prairies ecoregions where the MMRW is located had significantly lower percentages of wetlands with exceptional conditions and the percentage of wetlands with poor condition was significantly higher. Condition category proportion estimates for these two ecoregions were essentially the same with: 6-7% exceptional, 11-12% good, 40-42% fair, and 40-42% poor (Minnesota Pollution Control Agency 2015). Thus, most of the area within the MMRW, the Mixed Wood Plains and Temperate Prairies ecoregions, have experienced both a significant loss in the extent of wetlands as well as a considerable decrease in condition (vegetative quality).

Wetland Impacts

The amount of Section 404 permitted wetland impacts for each major watershed is provided as a total and as an average annual amount for the period 2009 to 2017 in Table 10. It is clear from the table that the majority of permitted wetland impacts in the MMRW (41%) are occurring in the Mississippi River - Twin Cities watershed. Further analysis of the Section 404 permitting data also suggests that the amount of wetland impact for this watershed, and the MMRW in general, has been increasing. This is

[3] wetlands occurring within a distinct basin in the landscape that have marsh type vegetation and an area of permanent to semi-permanent open water present (e.g., prairie potholes)

not surprising since wetland impacts are typically associated with economic development and the increase in impacts tracks the economic recovery that followed the recession of 2008 and 2009. The amount of wetland impact is expected to remain near the average amounts listed in Table 10 for the foreseeable future provided there are no sudden economic downturns that would reduce the amount of development in the MMRW. As the Twin Cities metropolitan area expands out to the north and west there will likely be more impacts in the major watersheds that border the Mississippi River - Twin Cities watershed including the Rum, North Fork Crow, and South Fork Crow watersheds.

Description of Threats

A qualitative assessment of threats was completed for the MMRW based on the results of the baseline condition work completed for this study and BWSR staff familiarity with the watershed from implementation WCA. A total of three threats were identified for the MMRW. They are briefly described in the following paragraphs.

Agricultural Drainage

Drainage in agricultural areas involves the installation and improvement of surface and subsurface infrastructure (tile, ditches, and pumps) to remove water from the root zone to improve conditions for cropping. These projects have both direct and indirect effects. The direct effects involve the loss of wetlands from the landscape where the drainage projects are completed. The indirect effects are the changes to hydrology at the site, catchment, and watershed scale result from drainage. Many wetland professionals working in the MMRW view the indirect effects as a greater threat to wetland resources than the direct effects. This is primarily because direct impacts are at least partially regulated through WCA and the Swampbuster provisions of the U.S Department of Agriculture farm program while the indirect effects are largely unregulated. Thus, while a direct loss of wetlands could require replacement through the purchase of wetland bank credits, there is no assessment of, and therefore no requirement to mitigate, the effect of drainage tile discharging directly into an existing wetland or a stream. Although there is disagreement about the net indirect effect of agricultural drainage on wetlands and waterways it cannot be disputed that the hydrologic regime of these resources is altered when surface and groundwater flows from adjacent lands are conveyed via tile and ditches. Since alteration of natural hydrology is most frequently viewed as an adverse effect, continued efforts to manage and redirect surface and groundwater through agricultural drainage projects is considered a threat to the quality and quantity of the remaining wetlands in the MMRW.

Diminishing Width of Buffer Around Wetlands

The State of Minnesota acknowledged the importance of buffers with the passage of the statewide Buffer Law in 2015. While this law was significant in requiring buffers on lakes, rivers, streams, and some ditches it did not address the importance of buffers in protecting wetlands. Buffers help filter out phosphorus, nitrogen, and sediment to maintain and improve water quality and provide important habitat for species that move back and forth between wetlands and uplands. Buffers also help to prevent encroachment of non-native vegetation from adjacent lands. In the rapidly developing and agriculturally intense parts of the MMRW BWSR staff have observed that buffer areas around existing wetlands are being reduced such that the width of the buffer may be ineffective in providing the benefits to the adjacent wetland. This is particularly important where surface flows go directly to a wetland and the buffer is needed to maintain the functions and quality of the wetland.

Alteration of Wetland Hydrology in Urban Areas

In urban areas of the MMRW development projects that increase the amount of impervious surface are required to manage stormwater to control changes to the amount and rate of discharge of water from the site. While these stormwater management requirements are necessary, they fail to consider the effects on downstream wetlands and thus compromise the ability of those wetlands to provide a full suite of functions at a high level. Wetlands downstream of stormwater treatment can sometimes be inundated with water much more frequently and consistently than they were prior to adjacent upland development. For example, a wetland that previously was inundated only during wet portions of the growing season but is now surrounded by urban development may be full of water more frequently and for longer periods of time. The floodwater attenuation function of this wetland is likely diminished, and it provides less of this function during the period it is most needed. It is also possible that the hydrology of a wetland is affected the opposite way and hydrology is removed making this wetland less likely to be connected to its surrounding landscape and less likely to provide functions that benefit downstream waters. Changes to hydrology also affect the ecological characteristics of the wetland and could adversely affect the wetland's ability to process nutrients and chemical which in turn can affect downstream water quality.

Stakeholder Involvement

A stakeholder involvement process was initiated as part of the MMRW watershed-based mitigation plan development. Stakeholders invited to participate included all WCA local government units (LGU) within the MMRW as well as the county soil and water conservation districts, watershed districts and watershed management organizations, MNDNR, and MPCA. Staff from the U.S. Army Corps of Engineers Regulatory Branch and the U.S. EPA were also invited to participate. The first set of meetings was held in September of 2018 at three locations across the watershed: St. Cloud (north), Arden Hills (metro area), and Litchfield (west). The purpose of the meetings was to familiarize stakeholders with watershed based mitigation planning and the development of the MMRW plan. BWSR and Corps of Engineers Project Management Division staff also presented information on assessing baseline conditions in the watershed and solicited feedback from the attendees on the adequacy of the criteria presented, the extent to which local ordinances govern wetland mitigation siting in their respective jurisdictions, and on catchment and site prioritization criteria. Attendees at the meeting included staff from the soil and water conservation districts, counties, watershed districts, cities, and consultants who serve as WCA LGUs.

The stakeholders had several specific comments on the baseline condition assessment. First, they believed that impaired waters listed because of atmospheric mercury deposition should be removed from the baseline assessment. This was because this impairment is not attributable to aquatic resource function or functional degradation and therefore could not be addressed through wetland restoration in the watershed. Similar opinions were expressed for other waters listed as impaired for stressors not tied directly to wetland condition or function including fish tissue, PCBs, and E. coli. The stakeholders agreed that impairments associated with phosphorus and TSS should be retained in the assessment since these are directly related to wetlands. Second, there was general agreement that none of the criterion presented directly represents hydrology alteration caused by pattern tiling and drainage completed over the past 5-7 years. Attendees discussed ways this could be represented including the possibility that information currently provided may get at this issue indirectly (water quality, land use, wetland loss). Third, with respect to historic wetland loss, the Saint Paul and Minneapolis areas should be represented with the highest amount of historic wetland loss documented for other catchment(s) in the MMRW. Attendees agreed that spending additional time to determine a more refined estimate of loss was not the worth the effort given the constraints on information and analyses that would be required to complete it. Finally, the attendees recommended that sensitive groundwater areas and perennial cover be included in the MMRW plan development as either a baseline condition assessment criterion or in the subsequent catchment and site prioritization processes.

The input provided by the stakeholders was evaluated by the MMRW planning team and factored into the identification and prioritization process that was the focus of the second set of stakeholder meetings held in January of 2019. Like the outreach conducted in September 2018, three meetings were held across the MMRW including Litchfield (west), St. Cloud (north), and Arden Hills (metro area). The primary objective of these meetings was to solicit final feedback on the prioritization criteria and provide an overview of the survey that would be used to solicit feedback. There was also time on the agenda to review the changes made to the baseline condition report and identify any outstanding issues requiring further discussion/coordination.

In general, the attendees at all three meetings agreed with the changes made to the baseline conditions report in response to the comments provided in September 2018. There was a comment from an attendee at the Arden Hills meeting that impairments attributable to low dissolved oxygen should not be included in the water quality assessment for the study because the management response for this impairment is to ditch the wetland to allow water to move through more rapidly. This was discussed by the planning team and the decision was made to keep this impairment in the study but also to recognize that when the impairment is associated with wetlands around an impaired waterbody or watercourse that there may be wetland focused responses that are not consistent with the goals of the study. There was also a suggestion that we investigate the potential to conduct additional analyses to identify degraded wetlands based on altered hydrology via stormwater discharges. This was considered but ultimately was determined to be outside the scope of this study.

Attendees were also given the opportunity to provide additional input on the prioritization process after listening to a brief overview of the process, proposed criteria, and some preliminary results. There was agreement among all attendees that stakeholder input to the prioritization process should be used only within the major watersheds where the respondent(s) has jurisdiction and that the lake and stream water quality criteria (numbers 7 and 8 in the table provided at the meeting) should be combined into a single criterion. Both recommendations were integrated into the process. The attendees also agreed that consideration should be given to removing catchments from the analysis that are in highly urbanized areas that may appear to be strong candidates for siting mitigation because of their poor overall biological condition but would also have very few opportunities for wetland restoration. A process for determining which catchments to remove was developed and is described in the Section titled "Designation of Priority Catchments" later in the study. Feedback was also provided on the potential for double counting certain resources with criteria 1 and 9, clarifying altered water course data, and on the prioritization outputs for specific catchments in the MMRW where the prioritized catchments were inconsistent with stakeholders' expectations. Each of these was evaluated and, where necessary, addressed without any substantial change to the prioritization process.

In March of 2019 the stakeholders in the MMRW were given the opportunity to respond to a web-based survey regarding the relative importance they put on the prioritization criteria identified for prioritizing the siting of wetland mitigation on the MMRW. The survey also included two yes or no questions asking for views on (1) whether areas with local ordinances requiring replacement in a specified geographic area should be recognized as high priority areas and (2) whether replacement for impacts in the metro area should be allowed to occur anywhere in the MMRW. The survey was open to stakeholders from March 10 through March 27, 2019. A total of 37 complete responses were received prior to the closing date of the survey.

A final set of stakeholder meetings were held in the end of August 2019 to present the results of the weighted and unweighted prioritization process. Meetings were held in Litchfield (west), Blaine (north/metro), and St. Paul (metro). The meetings consisted of a short presentation on the prioritization process including the results of the stakeholder survey, the weighting assigned to each criterion, and am overview of the results for each major watershed. After the presentation, attendees were given the opportunity to view maps of the weighted and unweighted prioritized catchments for each major watershed, ask questions, and provide feedback on the process and results. Overall, the attendees indicated that the weighted results seemed reasonable and that there did not appear to be any prioritized catchments that they would disagree with based on their familiarity with the watersheds. There were some comments/questions raised about several catchments in the Mississippi River - Twin Cities major watershed that were addressed through additional coordination with the stakeholders and through the process to remove some of the more urbanized catchments in the heart of the metro area.

Prioritization Strategy for Selecting and Implementing Mitigation Activities

The geographic scale used to identify priority areas for wetland mitigation in this plan is the catchment. In Minnesota, the MNDNR has defined catchment to be "the smallest delineated and digitized drainage area mapped by the MNDNR Watershed Delineation Project that contains all land area(s), as well as noncontributing inclusions and water features, upstream from, or between Hydrologic Points of Interest (HPOI) defining other DNR Catchments." The catchment scale was selected for two primary reasons. First, the prioritization process can be conducted at a finer scale which allows for more specific identification of areas where wetland mitigation may benefit watershed health. At the same time, the number of catchments in the MMRW is not excessive and the process can be completed in a reasonable amount of time with meaningful results. Second, the MNDNR has developed large amounts of watershed data at the catchment level that can be easily accessed to support the prioritization process which reduces the time associated with the GIS-based analyses.

The MMRW is made up of 1,203 unique catchments distributed across the seven major watersheds as follows: Mississippi River Sartell 109 catchments, Mississippi River St. Cloud 166 catchments, Sauk River 142 catchments, North Fork Crow River 263 catchments, South Fork Crow River 177 catchments, Mississippi River Twin Cities 180 catchments, and the Rum River 166 catchments. The process followed to prioritize catchments where wetland mitigation would have the greatest watershed benefit is described step-by-step in the remainder of this section.

Catchment prioritization criteria were identified through information obtained from stakeholders at the outreach meetings held in 2018 and 2019. BWSR staff with experience in watershed planning and wetland mitigation siting served as facilitators during the stakeholder meetings and provided input to the process. Each criterion identified during the meetings was evaluated to assess the availability and suitability of spatially-explicit GIS data to represent it during the GIS-based process. Input was also obtained from the Corps of Engineers and other agency staff during the plan formulation process. As a rule, a potential criterion must have had the following qualities to be selected.

- The criterion represents a watershed health characteristic that affects or can be affected by the presence/absence of wetlands.
- The criterion represents a watershed characteristic that is generally present throughout the BSA which allows for comparison between and amongst catchments. There must also be enough variation in the criterion throughout the BSA such that comparisons are meaningful.
- GIS data at the catchment level was publicly available for the criterion.

The source of the data for each criterion and the rationales behind their selection are provided in Table 17.

Table 17 Summary of Catchment Prioritization Criteria	
Catchment Prioritization Criteria	**Rationale for Inclusion**
Criterion #1: Areas With More Altered Watercourses	Activities that hydrologically alter watercourses (e.g. channelized, ditched or impounded) affect the way that the landscape stores and releases water and results in increased peak flows, lower base flows, and increased nutrient and sediment concentrations in streams, rivers, and lakes. The altered watercourse score measures the proportion of streams and rivers that have been altered within each catchment watershed (Minnesota Pollution Control's Altered Watercourses Project). This score is the ratio of the length of altered watercourses in the catchment to the total length of watercourses present. The score is the inverse of the percentage.
Criterion #2: Areas With High Potential for Groundwater Recharge	This criterion identifies areas with high potential for groundwater recharge. Wetlands play an important role in storing water and allowing surface water to slowly infiltrate which benefits recharge efforts. The pollution sensitivity of near-surface materials index from the WHAF was used to represent this criterion. The index score is an area weighted average for each catchment's rate of infiltration based on properties of the soil and surficial geology.
Criterion #3: Areas With Low Amounts of Perennial Cover	Vegetative cover is an important characteristic when assessing watershed health because as perennial vegetation is removed there is a greater potential for erosion, soil loss, and flooding, water quality degradation, and loss of habitat. Perennial cover was any land cover not identified as developed or in any form of agricultural use based on the 2011 National Land Cover Data. Hay and pasture was considered to be perennial cover. The amount of land with perennial cover was divided by the total area in each catchment to generate the index score.
Criterion #4: Areas With High Section 404 Permitting Frequency	Areas with higher amounts of permitted wetland impacts may have a greater need for mitigation projects to offset losses. The analysis was the number of permits per catchment divided by the area of wetlands in the catchment using data was provided by the U.S. Army Corps of Engineers Section 404 permit database from 2011 to 2016.
Criterion #5: Areas With Poor Riparian Habitat Connectivity	Riparian refers to the land immediately adjacent to water features such as lakes and rivers. Access to this area is important to aquatic and terrestrial species particularly during seasonal high flow or flood events. Riparian lands are also important year-round as travel corridors and habitat connectors, often providing the only remaining natural land cover in developed landscapes. The Riparian Connectivity Index in the WHAF compares the amount of cropped or developed land cover to the amount of open land in the riparian area. The percent agricultural and developed land relative to the total riparian area was calculated and scored. Scores range from 0 (all lands within 200 meters of streams or in floodplains are in annual cropland or urban cover) to 100 (all lands are neither urban nor annual agriculture).
Criterion #6: Areas Where There Are High Quality/Value Habitats	Wetland mitigation projects completed in areas with high concentrations of high quality habitats have greater potential to benefit Species of Greatest Conservation Need (SGCN). Using information from the MNDNR 2015-2025 Wildlife Action Plan a ratio of the high and medium high scored areas to total area was calculated for each catchment.
Criterion #7: Areas With Higher Amounts of Impaired Lakes and Streams	Water quality impairments are an indicator of lost watershed function, the presence of pollution sources, and the degree of landscape alteration. However, they are limited in that they only are representative of waters that have been assessed by the MPCA and the source of the impairment could be from an upstream area that is not identified as impaired. To address the potential for water

	quality impairments to other waters the WHAF catchment score for non-point source pollution risk was combined with data on lake and stream impairments (dissolved oxygen, fishes bioassessments, aquatic macroinvertebrate bioassessments, nitrates, nutrient/eutrophication biological indicators, turbidity, and total suspended solids) from the MPCA's Water Quality Assessment Database (2018) to calculate a value between 0 and 300 for each catchment with a score of 0 representing no impairments and little risk and a score of 300 representing significant water quality impairments and risk.
Criterion #8: Areas With More Degraded Wetlands	Wetland functions are affected by activities that degrade, but do not necessarily remove, wetlands from the landscape. Assessing the degree to which existing wetlands have been altered by ditching provides insight into the quality of the wetlands remaining in the catchment. The acreage of ditched wetlands in each catchment was determined using the "d" modifier in the NWI. The ditched wetland score was determined by dividing the area of ditched wetlands by the total area of wetlands in the catchment and multiplying the result by 100.
Criterion #9: Areas With Higher Amounts of Historic Wetland Loss	This criterion represents historic wetland loss as a percentage. Historic wetland area was calculated for each catchment using the hydric rating (62% or greater) from the Soil Survey Geographic Database (SSURGO). Historic wetland area does not include map soil units identified as water since these areas are presumed to be lakes and not wetlands. Current wetland area was calculated for each catchment using the NWI. Current wetland area does not include lakes.
Criterion #10: Areas identified as priorities for wetland restoration in other watershed/regional plans	Identification of wetland restoration opportunities in other local/regional plans recognizes the value of planning being done by resource professionals who have more familiarity with the resources in their areas of jurisdiction.

Development of Criterion Maps

GIS transformation of spatially-explicit data characterizing each criterion were normalized through a reclassification process to generate maps that captured the potential for a catchment to improve watershed health through wetland restoration. The geoprocessing for each criterion followed a straightforward and repeatable process (Figure 6).

First, GIS data representing each criterion was obtained and associated with each catchment in the MMRW. If a catchment value had not been assigned (GIS data obtained from the WHAF typically had predetermined criterion scores for each catchment), a value was calculated for each catchment using raw data. For example, the amount of ditched wetlands was determined by dividing the area of NWI wetlands with a "d" modifier by the total area of wetlands in the catchment and multiplying the result by 100. The resulting criterion scores were then normalized from 0 to 100 for each major watershed by dividing each catchment criteria value by the highest value in that major watershed. The normalized results were binned into ten classes using the natural breaks tool in ArcGIS in an ascending order of priority (Step 5 in Figure 6). In other words, low scores are catchments with lower potential for wetland mitigation to improve watershed health and high scores represent areas that would have a higher potential to improve watershed health.

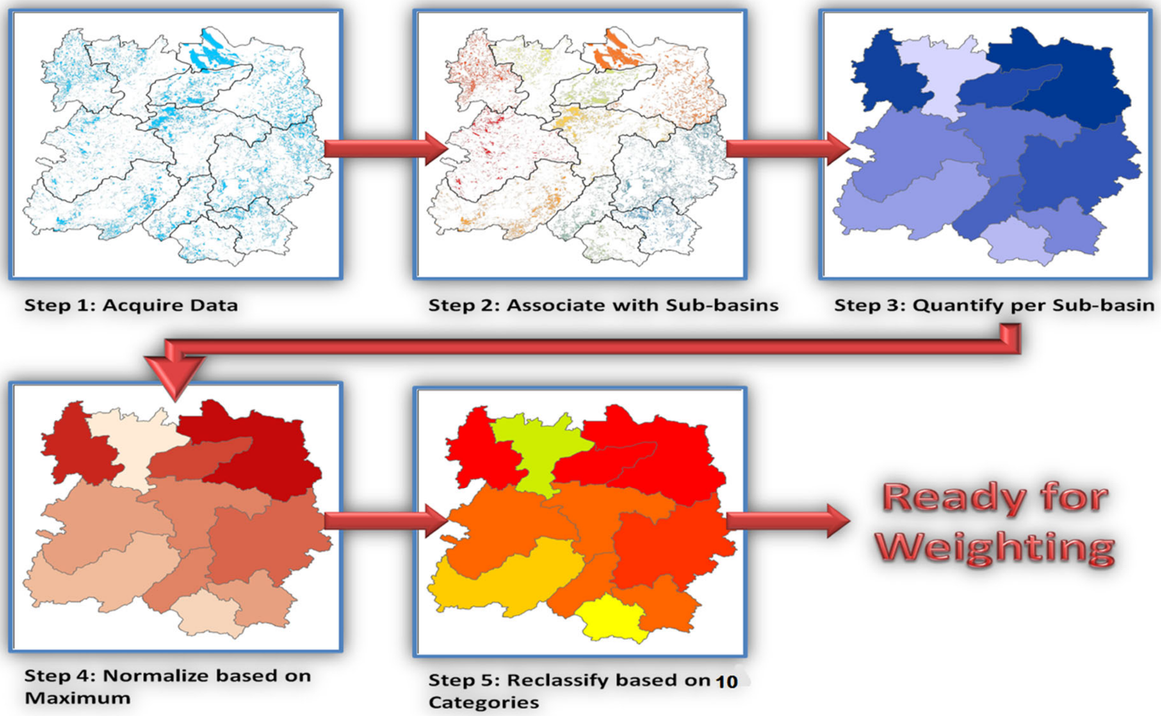


Figure 6. Illustration of the geoprocessing procedures used in the BSA 6 catchment prioritization. In the MMRW the procedures were applied at the catchment scale as opposed to the sub-basin scale referenced in the figure.

The process described above was used for all but the criterion for recognition of wetland restoration in other local and regional plans. For this criterion (identified as C10 in Table 17) each catchment was given a value of 0, 5, 8, or 10 based on the scale at which plans recognizing wetland restoration opportunities were completed. Plans done at a finer scale which identified specific sites or locations for wetland restoration were viewed as better than plans that identified larger areas or regions where wetland restoration in general was viewed as beneficial. If there were two or more plans at any scale within a catchment that specifically called out wetland restoration as a management objective/priority that catchment received a score of 10. To represent this criterion in the prioritization process, a GIS data layer was created showing the geographic areas where plans with restoration identified as a goal, recommendation, or opportunity within the MMRW watershed exist.

Weighting Derived from Stakeholder Input

Although the criteria used in the catchment prioritization could be equally weighted, stakeholders were offered the opportunity to "weight" the individual criteria differently based on "value" preferences – i.e., performing tradeoffs amongst criteria using an approach referred to as Multi-Criteria Decision Analysis (MCDA). MCDA is a set of systematic and tractable procedures that offers a means of combining disparate (non-commensurable) criteria using weighting and straightforward mathematical algorithms (Chee 2004; Malczeski 1999)[4]. To elicit preferences, an internet-based querying tool (SurveyMonkey) was used to gauge stakeholder perceptions of value of each criterion in relation to one another. The results of these elicitations were used as weighting factors in the catchment prioritization. In response to discussions and feedback from the stakeholders early in the formulation process the stakeholder weighting process for the MMRW was done by major watershed using the input from stakeholders with jurisdiction in each major watershed. Limiting the input to those who are actively engaged in managing or regulating resources within each major watershed was viewed as necessary and fair for the MMRW given the significant differences in land use, resource issues, and types of resources within the MMRW.

Over one hundred watershed stakeholders representing LGUs, watershed districts, soil and water conservation districts, and state and federal agencies were invited to participate in the survey. A total of 40 responses were received consisting of 37 complete responses and three partial responses. Partial responses were evaluated and incorporated into the analyses if the response for a section of the survey was complete and not used if it was incomplete for a section. A response that was incomplete for all sections of the survey was not used in the analysis.

In general, the weighting of prioritization criteria was consistent across each watershed. The criteria for areas with low amounts of perennial cover and high Section 404 permitting frequency were least important in every major watershed except for the Mississippi River - Twin Cities where high Section 404 permitting frequency criterion was viewed as more important (rank of 7 and weight of 0.08) and areas with high potential for groundwater was less important (rank of 9 and weight of 0.05). The criteria that were identified as more important by stakeholders throughout the MMRW were areas with high amounts of impaired lakes and streams (C7), areas with higher amounts of historic wetland loss (C9), and areas identified as priorities for wetland restoration in other watershed/regional plans (C10). The results of the weighting process by major watershed are provided in Table 18.

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[4] Each stakeholder who participated in the weighting process was as also asked to straight rank the criteria for comparison purposes.

Table 18 Summary of Stakeholder Weighting of Catchment Prioritization Criteria											
Major Watershed		**C1: Areas With More Altered Watercourses**	**C2: Areas With High Potential for Groundwater Recharge**	**C3: Areas With Low Amounts of Perennial Cover**	**C4: Areas With High Section 404 Permitting Frequency**	**C5: Areas With Poor Riparian Habitat Connectivity**	**C6: Areas Where There Are High Quality/Value Habitats**	**C7: Areas With Higher Amounts of Impaired Lakes and Streams**	**C8: Areas With More Degraded Wetlands**	**C9: Areas With Higher Amounts of Historic Wetland Loss**	**C10: Areas identified as priorities for wetland restoration in other watershed/regional plans**
Miss River- Sartell	weight	0.12	0.11	0.04	0.01	0.08	0.08	0.14	0.13	0.13	0.17
	rank	5	6	9	10	8	7	2	4	3	1
Sauk River	weight	0.13	0.11	0.05	0.01	0.09	0.08	0.15	0.12	0.12	0.15
	rank	3	6	9	10	7	8	2	5	4	1
Miss River- St. Cloud	weight	0.11	0.11	0.05	0.01	0.08	0.09	0.14	0.14	0.15	0.13
	rank	6	5	9	10	8	7	2	3	1	4
North Fork Crow River	weight	0.11	0.10	0.05	0.01	0.09	0.09	0.16	0.14	0.15	0.10
	rank	4	5	9	10	7	7	1	3	2	6
South Fork Crow River	weight	0.13	0.09	0.06	0.04	0.07	0.07	0.15	0.14	0.15	0.10
	rank	4	6	9	10	7	8	1	3	2	5
Miss River- Twin Cities	weight	0.11	0.05	0.05	0.08	0.09	0.08	0.13	0.12	0.15	0.14
	rank	5	9	10	7	6	8	3	4	1	2
Rum River	weight	0.11	0.09	0.04	0.01	0.09	0.10	0.13	0.14	0.15	0.15
	rank	5	7	9	10	8	6	4	3	1	1

The normalized criteria values calculated for each catchment were weighted using the MCDA pairwise comparison weights from Table 18 based on a straightforward algorithm:

$$V_i = \sum_j w_j c_{ij}$$

Where V_i is the prioritization score for the *i*th catchment which is equal to the sum of the values of the *i*th catchment criteria ($c_{ij},$ where j = 1, 2, 3 ….12) multiplied by their normalized weights (w_j). The summed prioritization score was used to generate a map displaying the comparative preference for siting wetland mitigation within each catchment based on these inputs. Maps of the weighted outputs for each major watershed are provided in Appendix F. Maps of the unweighted outputs are shown in Appendix E.

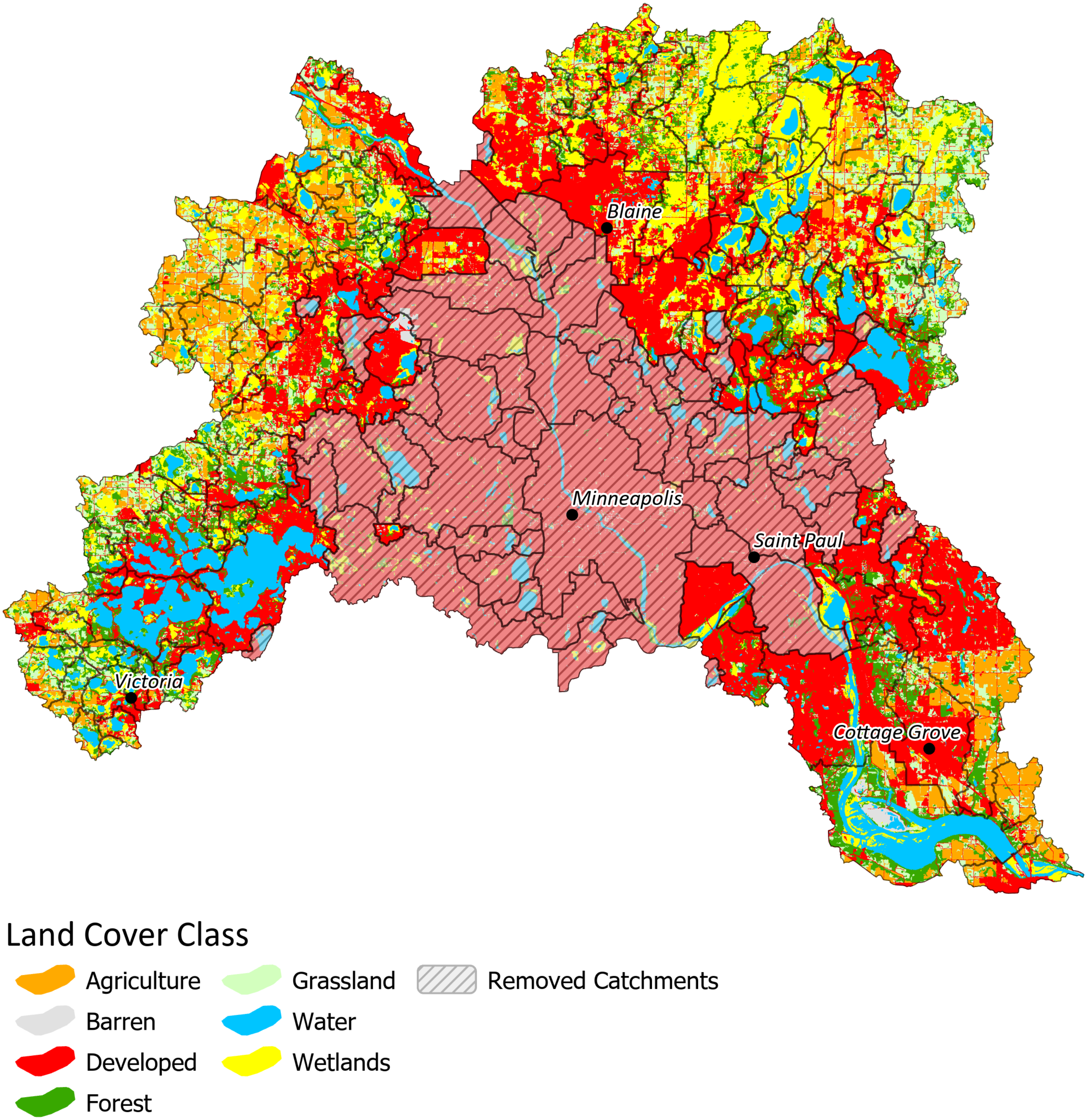
Designation of Priority Catchments

The results of the prioritization process returned to the forefront an issue that had been discussed previously at stakeholder meetings, the treatment of highly urbanized catchments. A highly urbanized catchment is one where the amount of developed land is significantly greater than the combined amount of agricultural, barren, forest, water, grassland, and wetland based on the NLCD. These catchments are characterized by high amounts of impervious surface, fragmented wetland and riparian resources, and few, if any, opportunities for wetland restoration at a scale that is economically viable for wetland banking. Because of the high degree of alteration, they also tend to score high in the catchment prioritization process. However, identifying these catchments as priority areas is not desirable for two reasons. First, as mentioned previously, there is little potential for large scale wetland restoration projects to be sited within their boundaries. Wetland bankers, including BWSR, often target sites that are at least 40 acres in size because there are greater efficiencies associated with larger projects. In many urbanized watersheds there simply are not parcels of this size available and if there were, they likely would be put to a use that is more profitable to the landowner. Second, prioritizing these catchments would be done at the expense of other catchments if urban catchments in the MMRW score high in the prioritization process. If retained in the analysis urban catchments push other catchments down in the comparative rankings and, potentially, out of those identified as prioritized.

As mentioned previously, the issue of how to treat catchments in highly urbanized areas was discussed at stakeholder meetings in 2019. The stakeholders generally agreed that removing highly urbanized catchments seemed reasonable, but no specific criteria were discussed or established. There was also agreement that it would be informative to view the results of the prioritization process for all the catchments before making any decisions about which to remove. The initial results of the prioritization process indicate that the highly developed catchment issue is associated with the Mississippi River – Saint Cloud and Sauk River major watersheds in the Saint Cloud area and the Mississippi River - Twin Cities major watershed. In the St. Cloud area, the number of highly urbanized catchments was limited to two: catchments 1605800 (Sauk River) and 1702201 (Mississippi River – Saint Cloud). Since the removal of one catchment has only a minimal impact on the outcome of the prioritization process these catchments were removed and the prioritization was rerun without the weighted values for these catchments. The removal of these catchments did not result in a change in the number of prioritized catchments for these major watersheds.

The process for removing catchments from the Mississippi River – Twin Cities required a more in-depth analysis. Because the extent of land development and urbanization in the Twin Cities affects a much larger area there was a need to identify a characteristic that could be used to assess each catchment and establish a threshold to remove catchments from the prioritization process. After considering impervious surface, wetlands, and land use the decision was made to use a measure of developed land as the characteristic. For the catchments located within and generally adjacent to the Interstate 694/494 loop around the Twin Cities a percent developed land criteria was calculated by dividing the area of land identified as developed by the total land area in the catchment minus the areas identified as lakes and wetlands. This criterion captured the amount of developed land as a percentage of the total amount of developable land in the catchment (all land use data was obtained from the NLCD). Using the results of this analysis, catchments that had greater than 90% of the potential land identified as developed were removed from the catchment prioritization process. This resulted in the removal of 57 catchments and 327.2 square miles (33% of the total area) from the prioritization process in this major watershed. The catchments removed from the analysis are show in Figure 7.

Figure 7: Twin Cities Catchments Removed From Analysis



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study

Legend: City Catchment River Lake

N

Miles
0 1.75 3.5 7

The next step in the process was to use the weighted catchment prioritization scores to identify the catchments that will be targeted for wetland mitigation projects. This required finding a breakpoint in the prioritization outputs that balanced the need for sufficient wetland mitigation opportunities with maximizing benefits to the watershed. For example, designating only a small number of catchments as high priority areas may not result in any projects when a request for proposal is advertised. Similarly, identifying a large number of catchments as high priority areas may decrease the potential benefits to the watershed because the value of the prioritization process is diluted and sites could be selected in catchments that scored markedly lower than other catchments.

To find a reasonable and defensible breakpoint for identifying high priority catchments the following rules were established for the MMRW process:

- All catchments with weighted prioritization scores in the top third of the distribution for their respective major watershed were identified as a high priority area;

- If the total acreage of restorable wetlands for the top third of the catchments within a major watershed was less than 33% of the total acreage of restorable wetlands for that major watershed then additional catchments were added as high priority areas, based on their weighted prioritization scores, until the total acreage of restorable wetlands reached 33% of the total restorable wetlands for that major watershed.

The acreage of restorable wetlands was obtained from the 2019 Restorable Wetland Inventory (RWI) developed by the Natural Resources Research Institute (NRRI) in collaboration with MNDNR. The RWI was used as an estimate of the amount of restorable wetlands in each catchment. It was not used to eliminate a catchment if the RWI did not identify any restorable wetlands. The RWI was developed to predict location of existing and restorable wetlands based on hydrological, geomorphological, and geological variables.[5] Since the 2019 RWI includes wetlands that are identified as farmed or partially drained or ditched in its definition of a restorable wetlands additional data processing was conducted to include only those areas that represent opportunities for restoration of completely drained or filled former wetlands (re-establishment under the FMR). This was done by exporting all RWI values of 4 and 5 (highest probabilities of being restorable wetlands) from the RWI and then removing all polygons that intersected with NWI wetlands with a “d” (ditched) modifier. The resulting data set was used in the prioritization process and in the evaluation of wetland banking opportunities in each major watershed described later in this document.

A total of 383 catchments were identified as high priority areas in the MMRW: 36 in the Mississippi – Sartell watershed, 55 in the Mississippi - Saint Cloud watershed, 47 in the Sauk River watershed, 88 in

[5] This data layer replaces the original NRRI RWI that was developed statewide on a 30m grid using a different methodology.

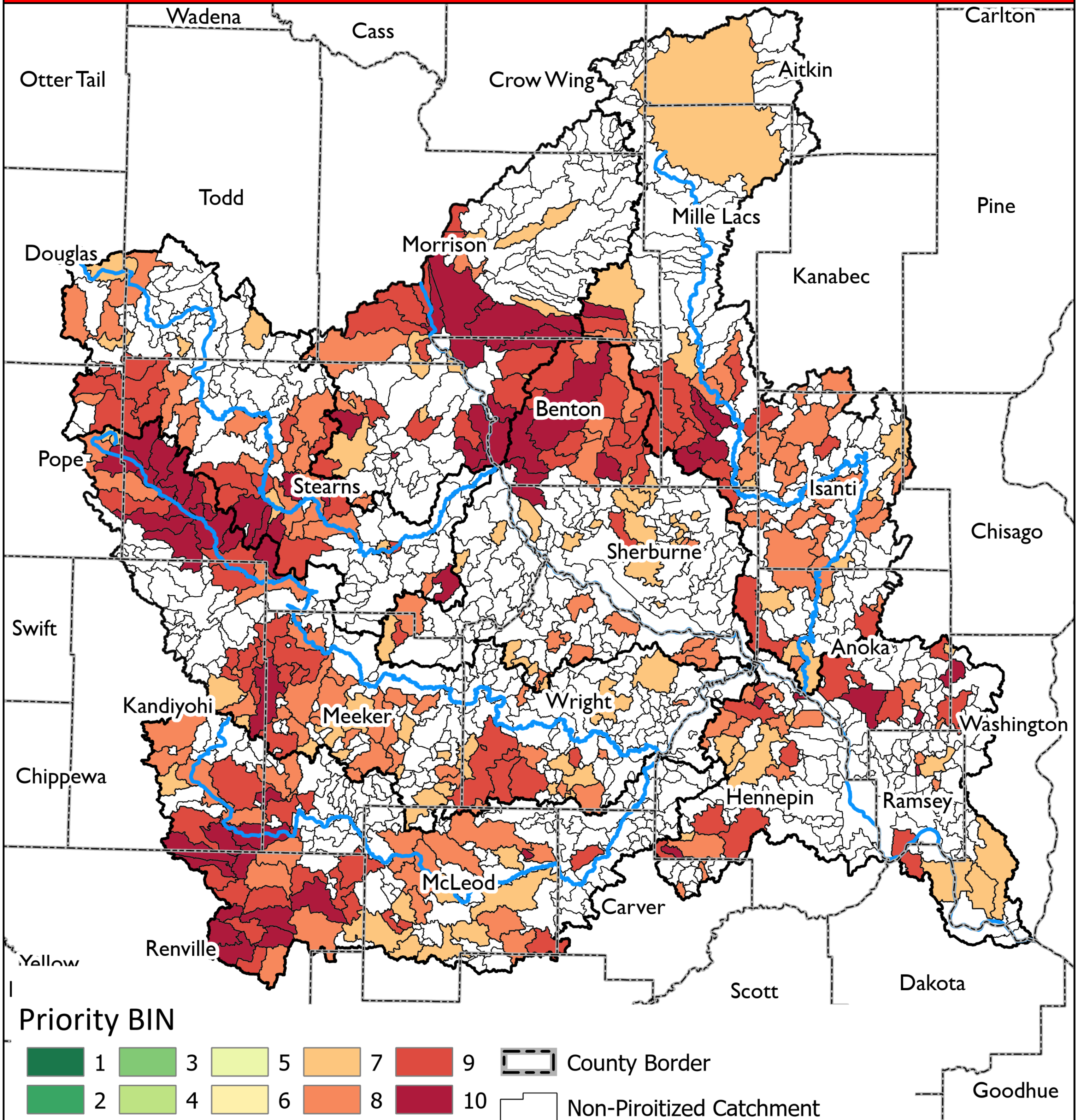
the North Fork Crow River watershed, 59 in the South Fork Crow River Watershed, 43 in the Mississippi – Twin Cities watershed, and 55 in the Rum River watershed. All of the major watersheds had greater than 33% of the restorable wetlands covered within the highest third of the weighted scores so no catchments were added to the prioritized list. Overall the process designated a total of 2,458,935 acres (3,842 square miles) of lands including 77,513 acres of restorable wetlands as high priority in the MMRW. A summary of the prioritized catchments is provided in Table 19. The prioritized catchments in each major watershed are shown in Figures 8.1 through 8.7. As discussed previously, the normalized results were binned into ten classes using the natural breaks tool in ArcGIS (labeled as "BIN" in Figures 8.1 through 8.7). The figures have been edited to display only the BIN values of the prioritized catchments with the higher scores (darker shades) representing the greatest priority based on the analysis and the lower scores the lesser priority with respect to the prioritized catchments. Catchments that were not prioritized are shown as white (blank) in the figures.

Table 19
Summary of MMRW Prioritized Catchments

Major Watershed	Catchments			Restorable Wetlands		Weighted Scores		
	Number Prioritized	Prioritized Area[1] (acres)	Prioritized Acres (% of total)	Prioritized[2] (acres)	Major Watershed (% of total)	range	avg	median
Miss – Sartell	36/109	281,394	43	24,982	40	72.5 -100	83.1	84.5
Miss – St. Cloud	55/166[4]	276,574	39	6,923	55	69.9 - 100	78.7	77.9
Sauk River	47/142[3]	281,909	42	9,338	46	72.4 - 100	80.4	78.4
NFCR	88/263	454,992	48	8,112	65	63.8 – 100	75.0	72.0
SFCR	59/177	450,149	55	9,833	71.7	71.0 – 100	82.4	81.4
Miss – TC	43/123[5]	217,012	50	13,683	41.5	66.0 – 100	74.2	72.3
Rum River	55/166	496,905	49	4,642	36.9	67.5 - 100	77.4	74.7

Notes:
[1] – Prioritized area is the total land area of the prioritized catchments within each major watershed.
[2] – Prioritized acres based on the RWI.
[3] – Catchment 1605800 was removed from consideration as a prioritized catchment but was retained in the summary of this major watershed.
[4] - Catchment 1702201 was removed from consideration as a prioritized catchment but was retained in the summary of this major watershed.
[5] – The number of catchments was reduced from 180 to 123 based on the analysis of the developed areas within the Twin Cities metropolitan area. The number provided in the table are based on 123 catchments and not the original 180 in this major watershed.

Figure 8 - Study Area Prioritized Catchments



BOARD OF WATER AND SOIL RESOURCES

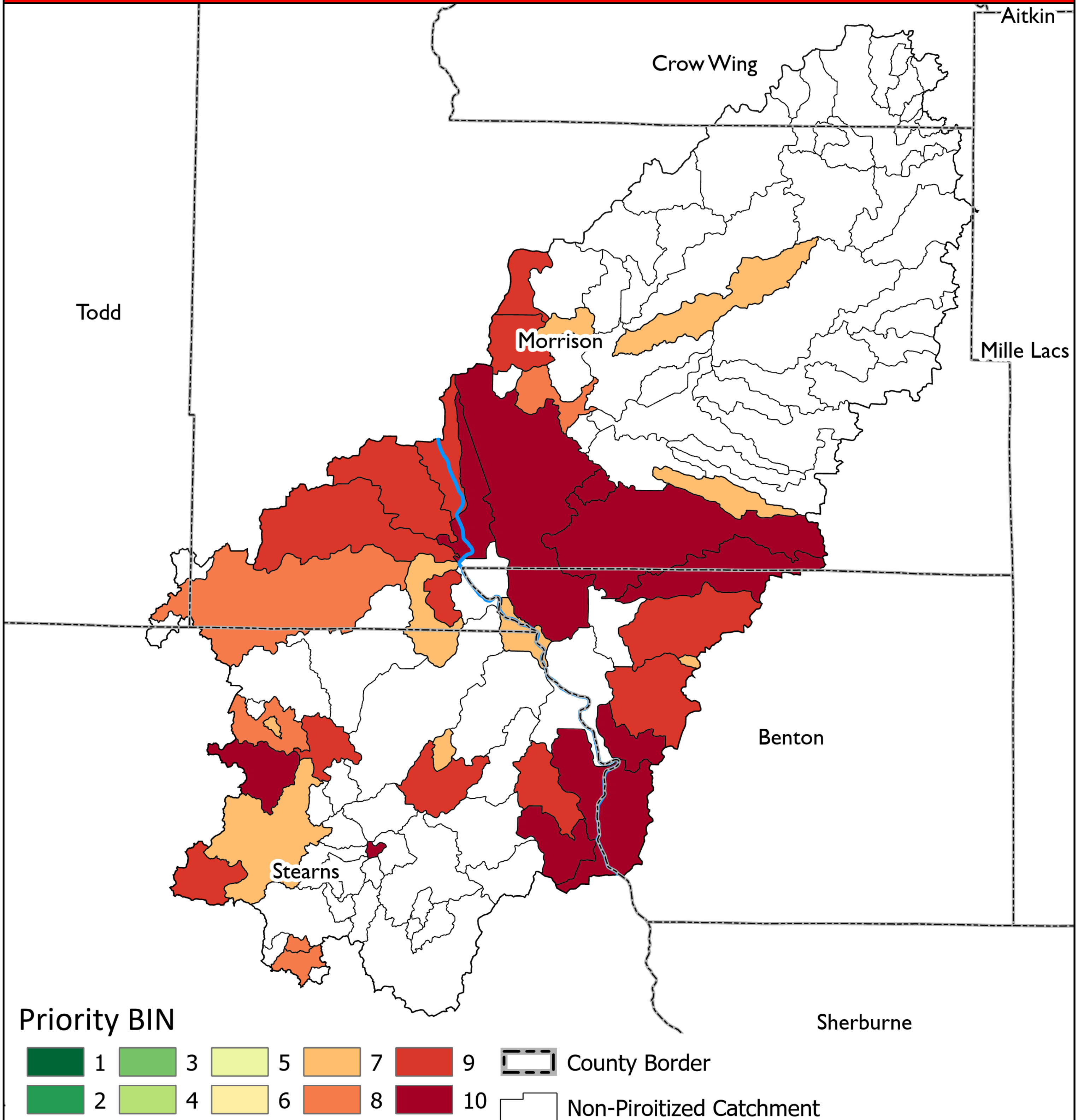
Middle Mississippi River Watershed Wetland Restoration Planning Study - Study Area -

Legend: • City | Watershed | River | Lake

N

Miles
0 4.5 9 18

Figure 8.1 - Mississippi River-Sartell Prioritized Catchments



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Sartell -

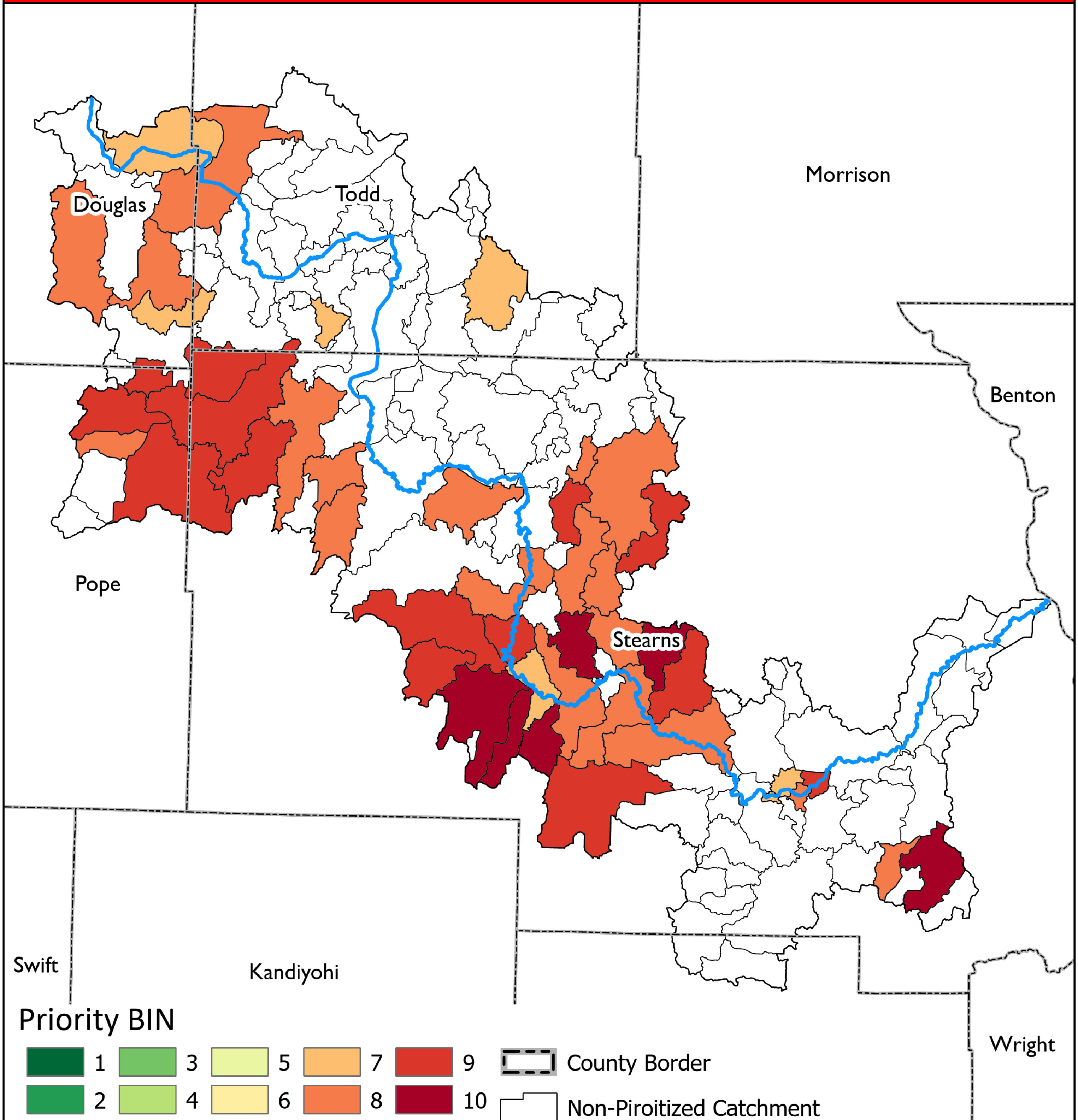
Legend: City Watershed River Lake

N

Miles

0 2 4 8

Figure 8.2 - Sauk River Prioritized Catchments



BOARD OF WATER AND SOIL RESOURCES

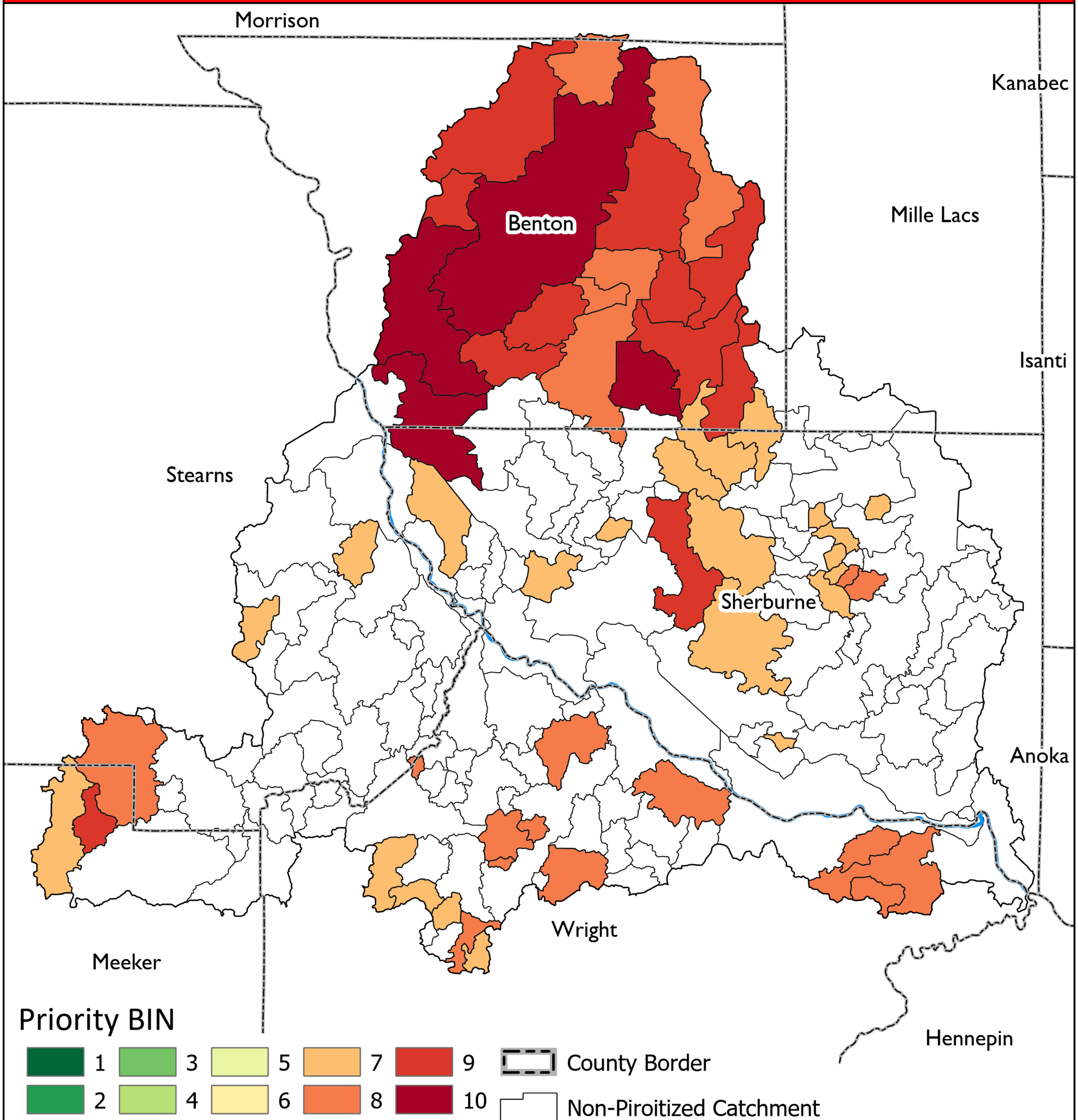
Middle Mississippi River Watershed Wetland Restoration Planning Study - Sauk River -

Legend: City Watershed River Lake

N

Miles
0 2 4 8

Figure 8.3 - Mississippi River-St. Cloud Prioritized Catchments



Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-St. Cloud -

Legend: City Watershed River Lake

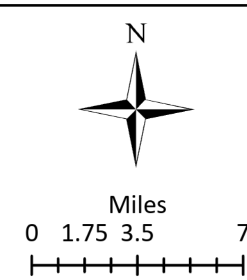
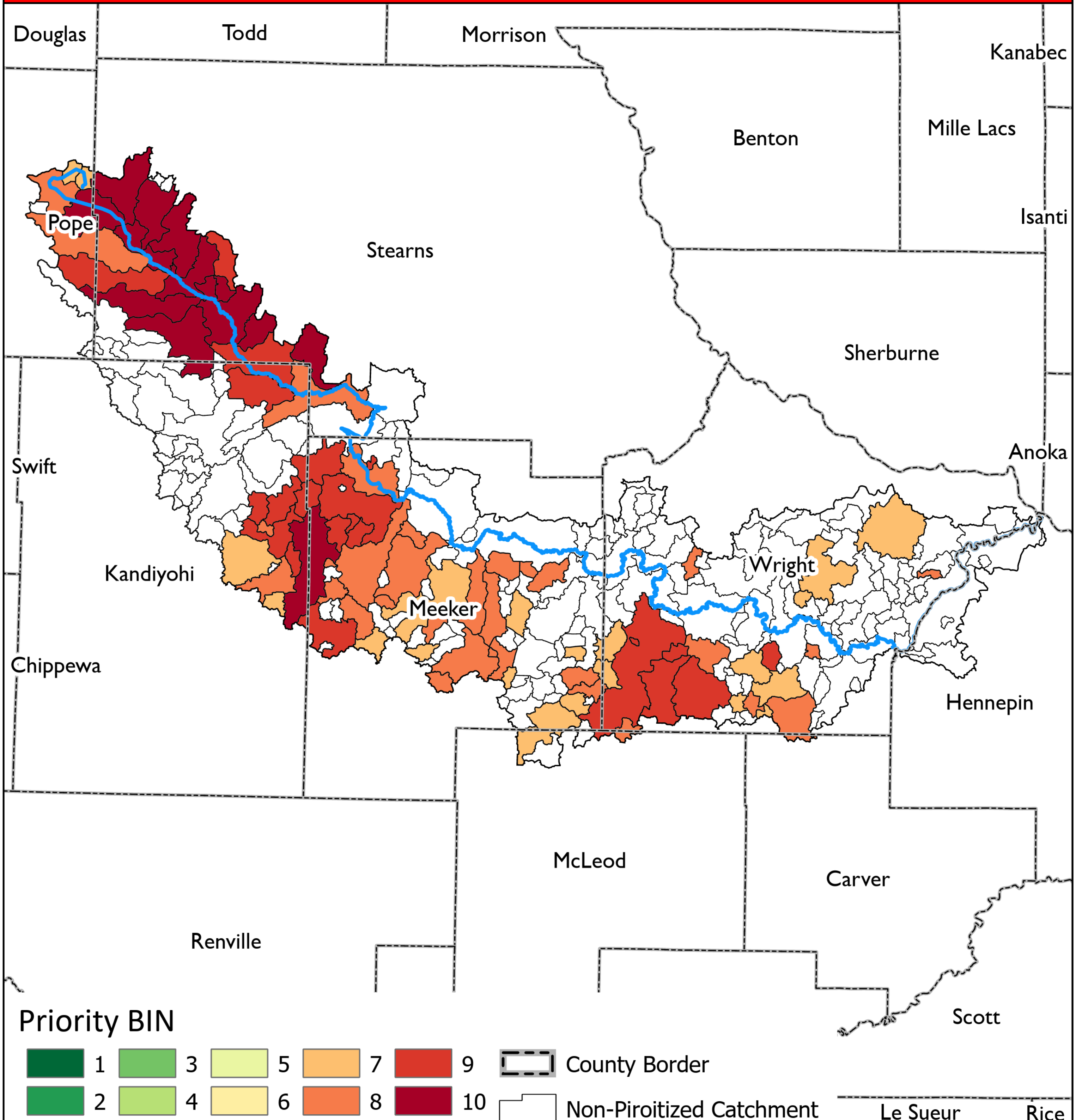


Figure 8.4 - North Fork Crow River Prioritized Catchments



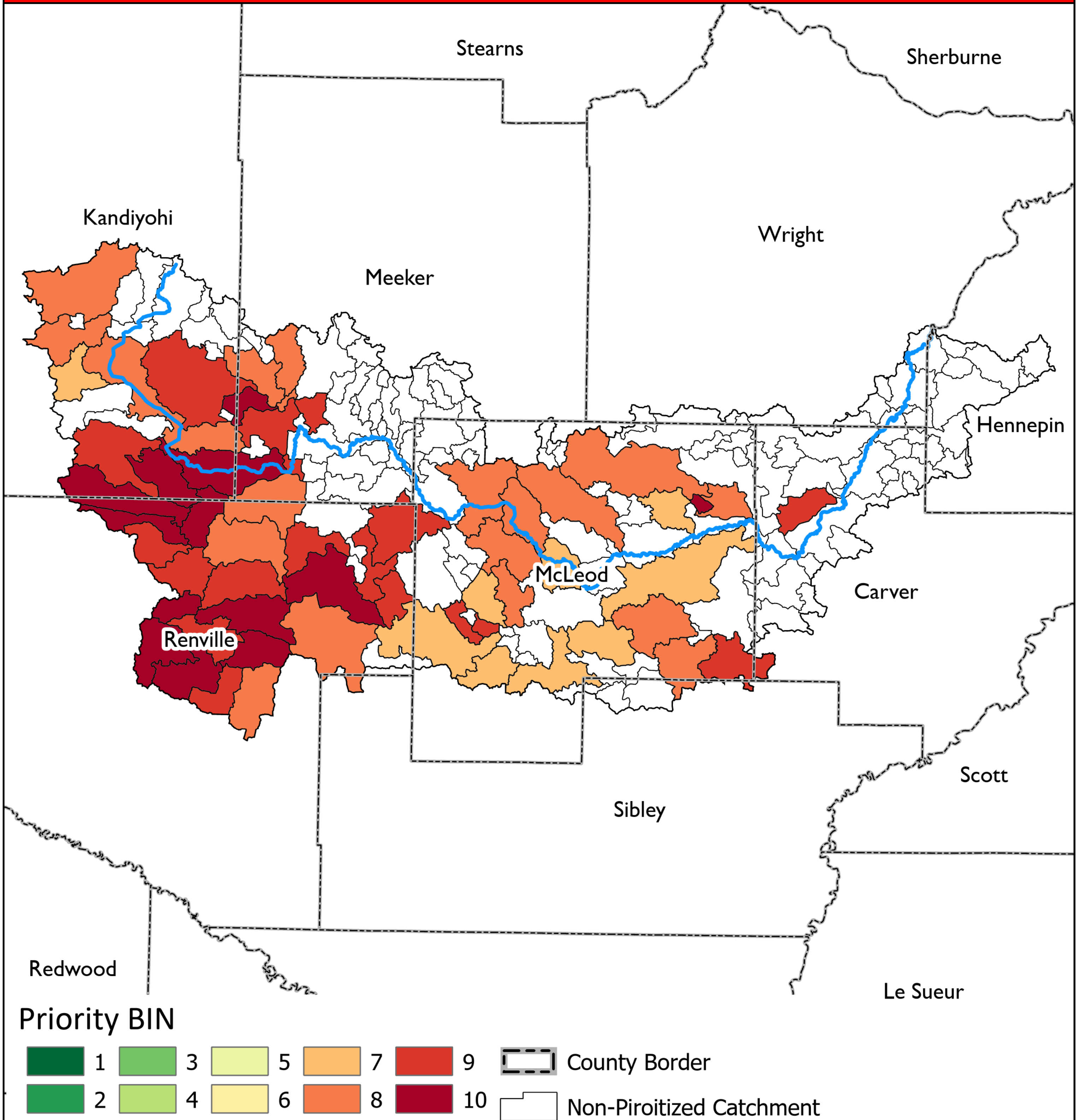
Middle Mississippi River Watershed
Wetland Restoration Planning Study
- North Fork Crow River -

Legend: ● City, Watershed, River, Lake

N

Miles
0 3 6 12

Figure 8.5 - South Fork Crow River Prioritized Catchments

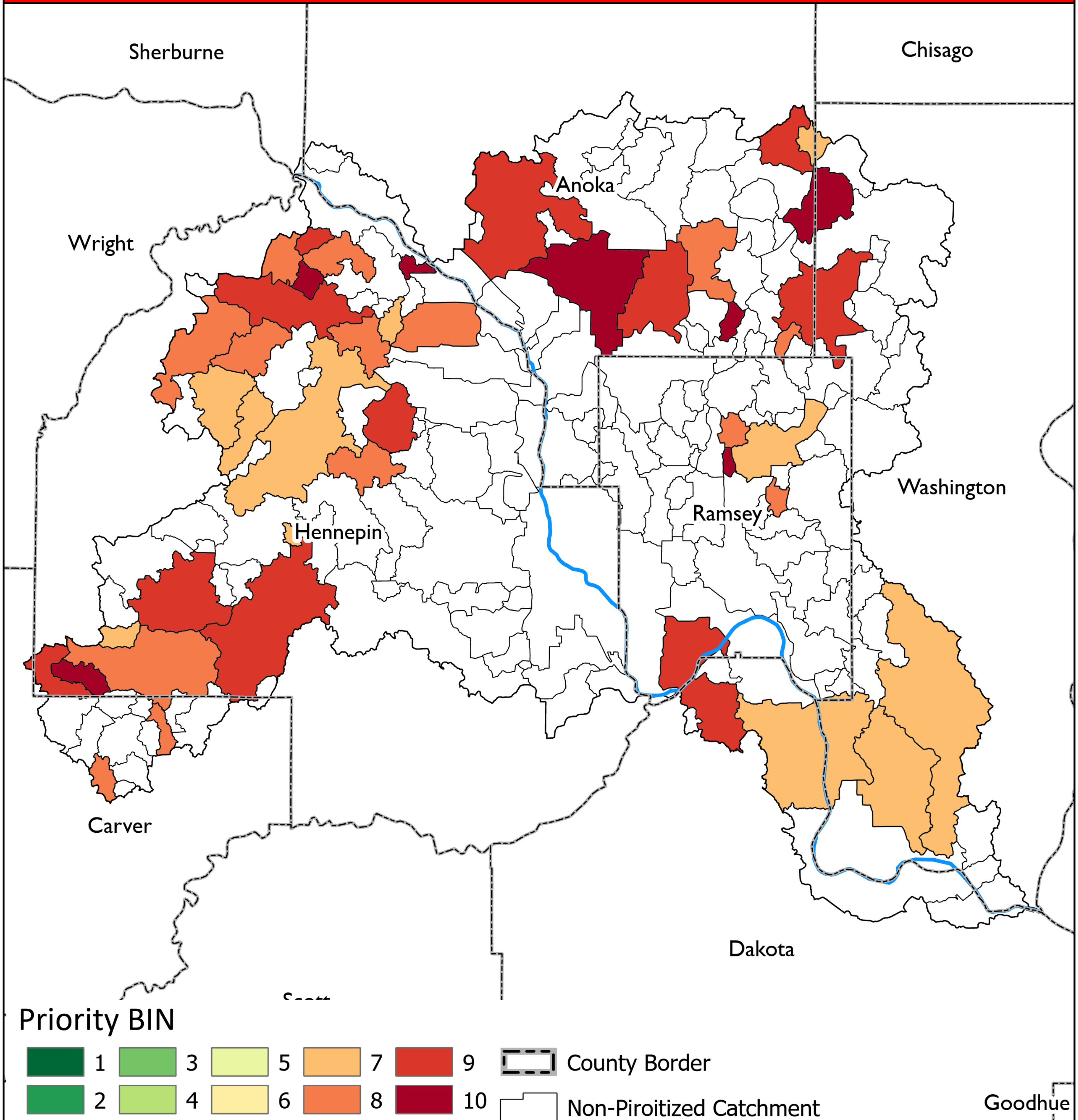


BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - South Fork Crow River -

Legend: City Watershed River Lake

Figure 8.6 - Mississippi River-Twin Cities Prioritized Catchments



BOARD OF WATER AND SOIL RESOURCES

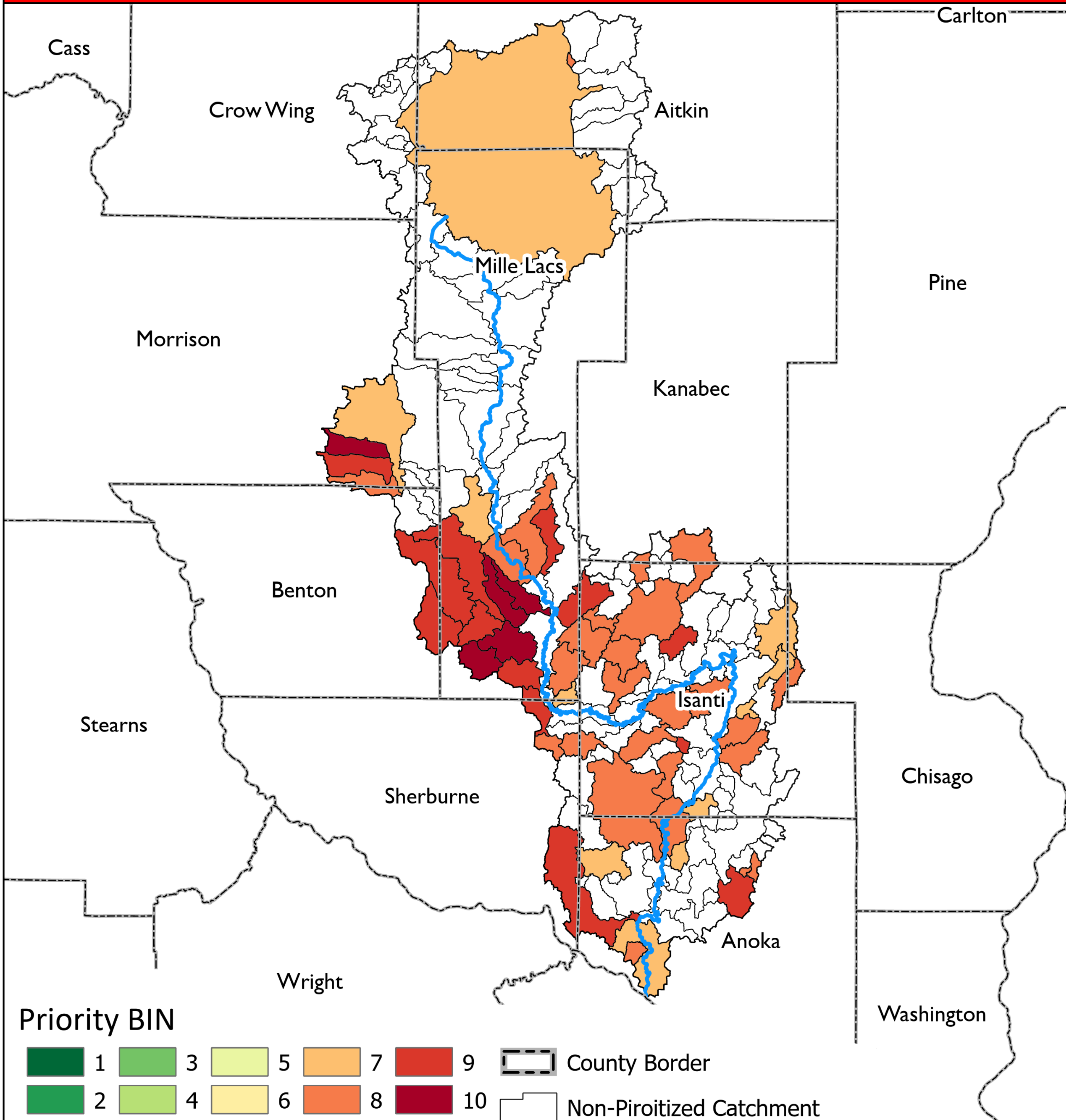
Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Mississippi River-Twin Cities -

Legend: City Watershed River Lake

N

Miles
0 1.75 3.5 7

Figure 8.7 - Rum River Prioritized Catchments



Middle Mississippi River Watershed Wetland Restoration Planning Study - Rum River -

BOARD OF WATER AND SOIL RESOURCES

Legend: City Watershed River Lake

N

Miles
0 3 6 12

References

Albert, D.A. 1995. Regional Landscape Ecosystems of Michigan, Minnesota, and Wisconsin: A Working Map and Classification. GT Report NC-178. USDA Forest Service North Central Forest Experiment Station, St. Paul, MN. 250 pp.

Anderson and Craig. Growing Energy Crops on Minnesota’s Wetlands: The Land Use Perspective. 1984. http://www.cura.umn.edu/sites/cura.advantagelabs.com/files/publications/E1037.pdf

Chee, Yung En. (2004). An ecological perspective on the valuation of ecosystem services. Biological Conservation. 120. 549-565. 10.1016/j.biocon.2004.03.028.

Dept. of Soil Science, University of Minnesota; Soil Conservation Service, U.S. Dept. of Agriculture; and Minnesota Geological Survey. 1977. Minnesota Soil Atlas: Duluth Sheet. Miscellaneous Report 148. Agricultural Experiment Station. University of Minnesota. St. Paul, MN. 1 .lap (1:250,000) + booklet.

Dept. of Soil Science, University of Minnesota; Soil Conservation Service, U.S. Dept. of Agriculture; and Minnesota Geological Survey. 1980b. Minnesota Soil Atlas: Stillwater Sheet. Miscellaneous Report 171. Agricultural Experiment Station. University of Minnesota. St. Paul, MN. 1 map (1:250,000) + booklet.

Hobbs, H.C. and J.E. Goebel. 1982. Geologic Map of Minnesota. Quaternary Geology. 1:500,000. Minnesota Geological Survey, University of Minnesota.

Kratz, T.K. and G.L. Jensen. 1983. Minnesota’s landscape regions. Nat. Areas J. 3:33-44.

Malczewski, J. 1999. GIS and Multicriteria Decision Analysis, 392 pages, ISBN 0-471-32944-4. New York: John Wiley and Sons.

Marschner, F.J. 1974. The Original Vegetation of Minnesota, a map compiled in 1930 by F.J. Marshner from U.S. General Land Office Survey Notes and published in 1974 under the direction of M.L. Heinselman of the U. S. Forest Service. Cartography Laboratory of the Department of Geography, University of Minnesota, St. Paul. 1 map (1:500,000).

Minnesota Pollution Control Agency 2015. Status and Trends of Wetlands in Minnesota: Vegetation Quality Baseline.wq-bwm-1-09 Minnesota Pollution Control Agency, St. Paul, MN.

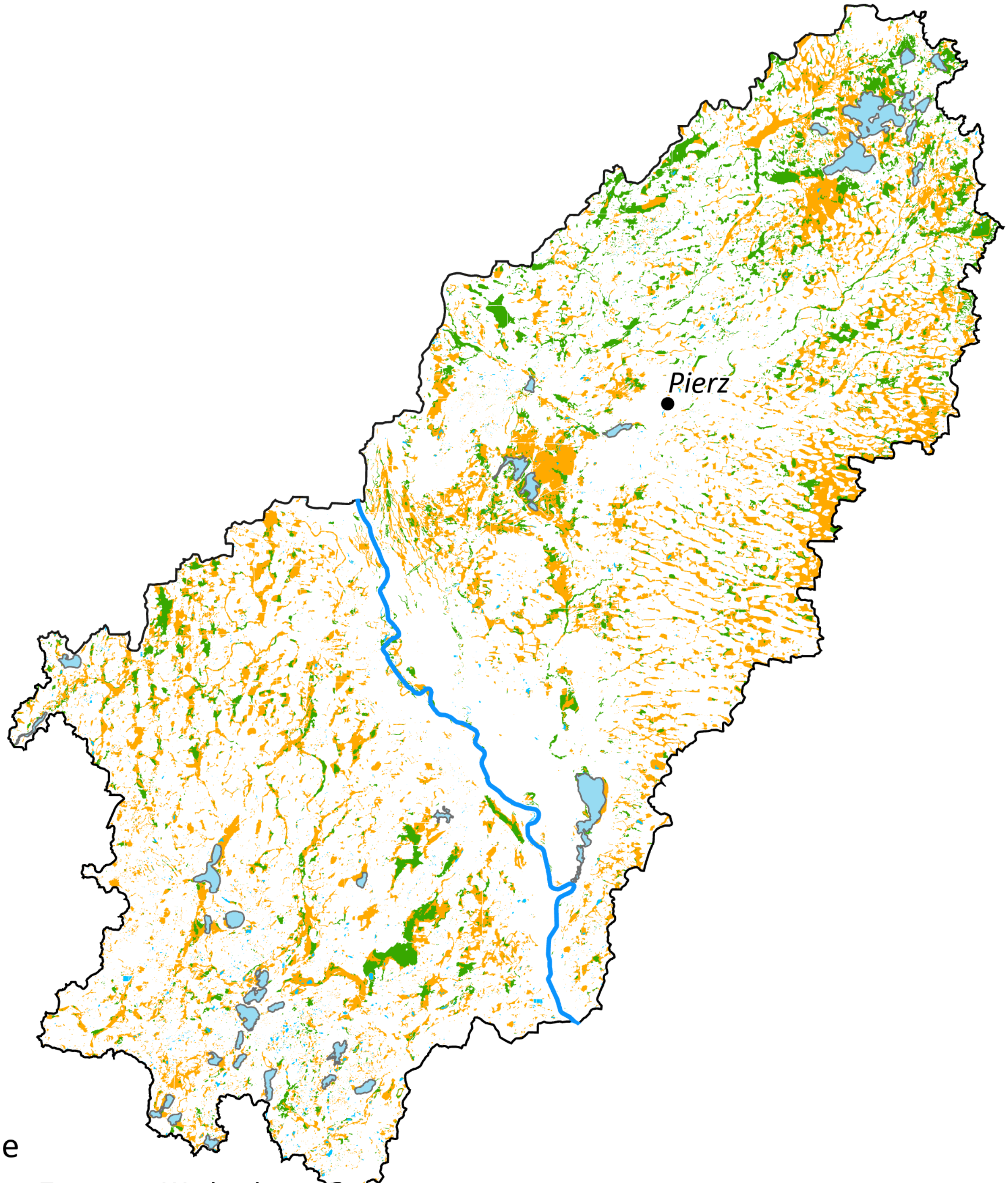
Scozzafava, M., M.E. Kentula, E. Riley, T.K. Magee, G. Serenbetz, R. Sumner, C. Faulkner, and M. Price. 2011. The National Wetland Condition Assessment: National data on wetland quality to inform and improve wetlands protection. National Wetlands Newsletter 33 11:13.

Wright, H.E., Jr. 1972. Quaternary history of Minnesota. In *Geology of Minnesota: A centennial volume in honor of George M. Schwartz,* ed. P.K. Sims and G.B. Morey, 515-547. St. Paul: Minnesota Geological Survey.

Appendix A

National Wetland Inventory

Figure A1: National Wetland Inventory



Wetland Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

BOARD OF WATER AND SOIL RESOURCES

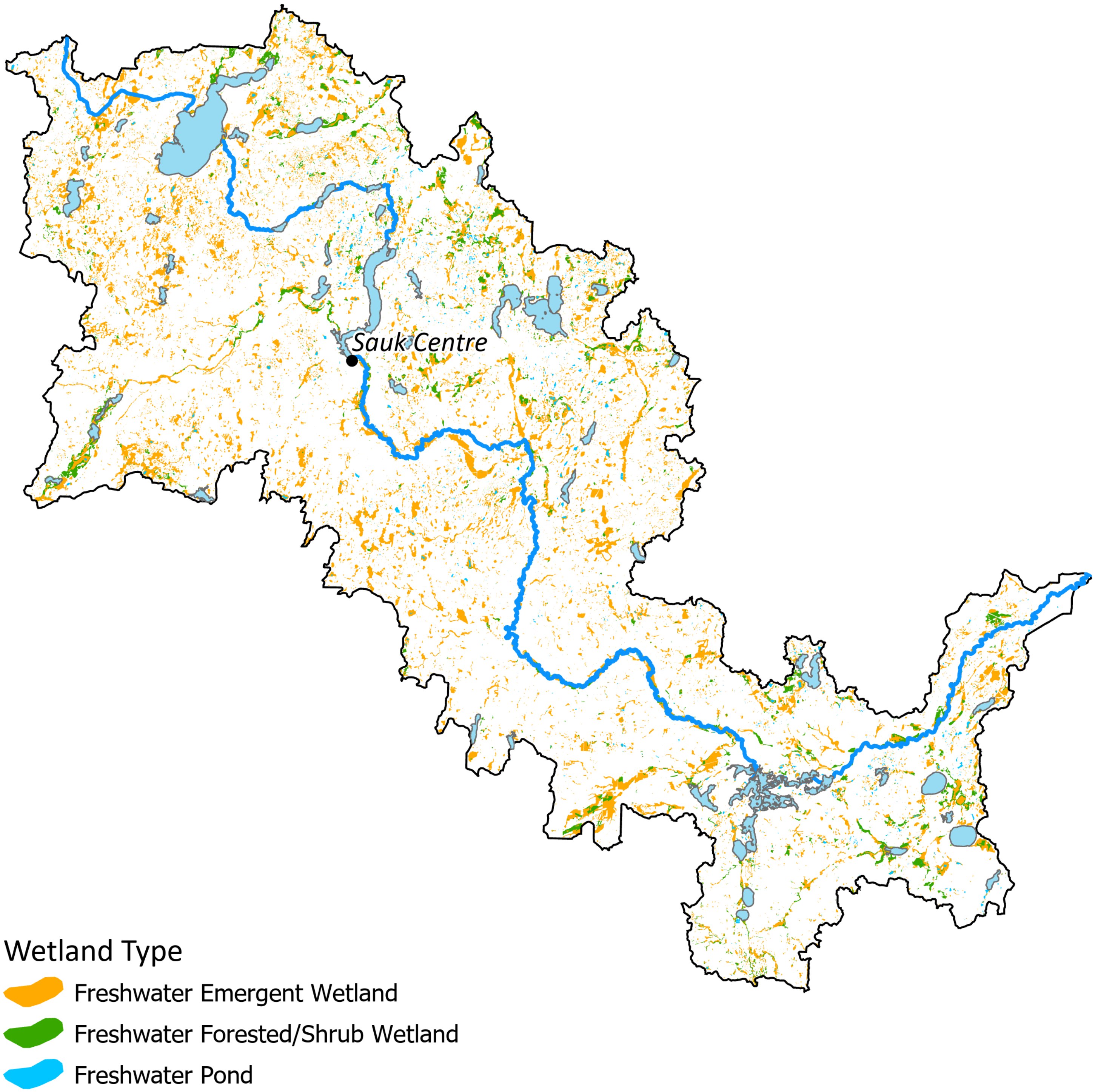
Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Mississippi River-Sartell -

Legend: City Watershed River Lake

N

Miles
0 2 4 8

Figure A2: National Wetland Inventory



BOARD OF WATER AND SOIL RESOURCES

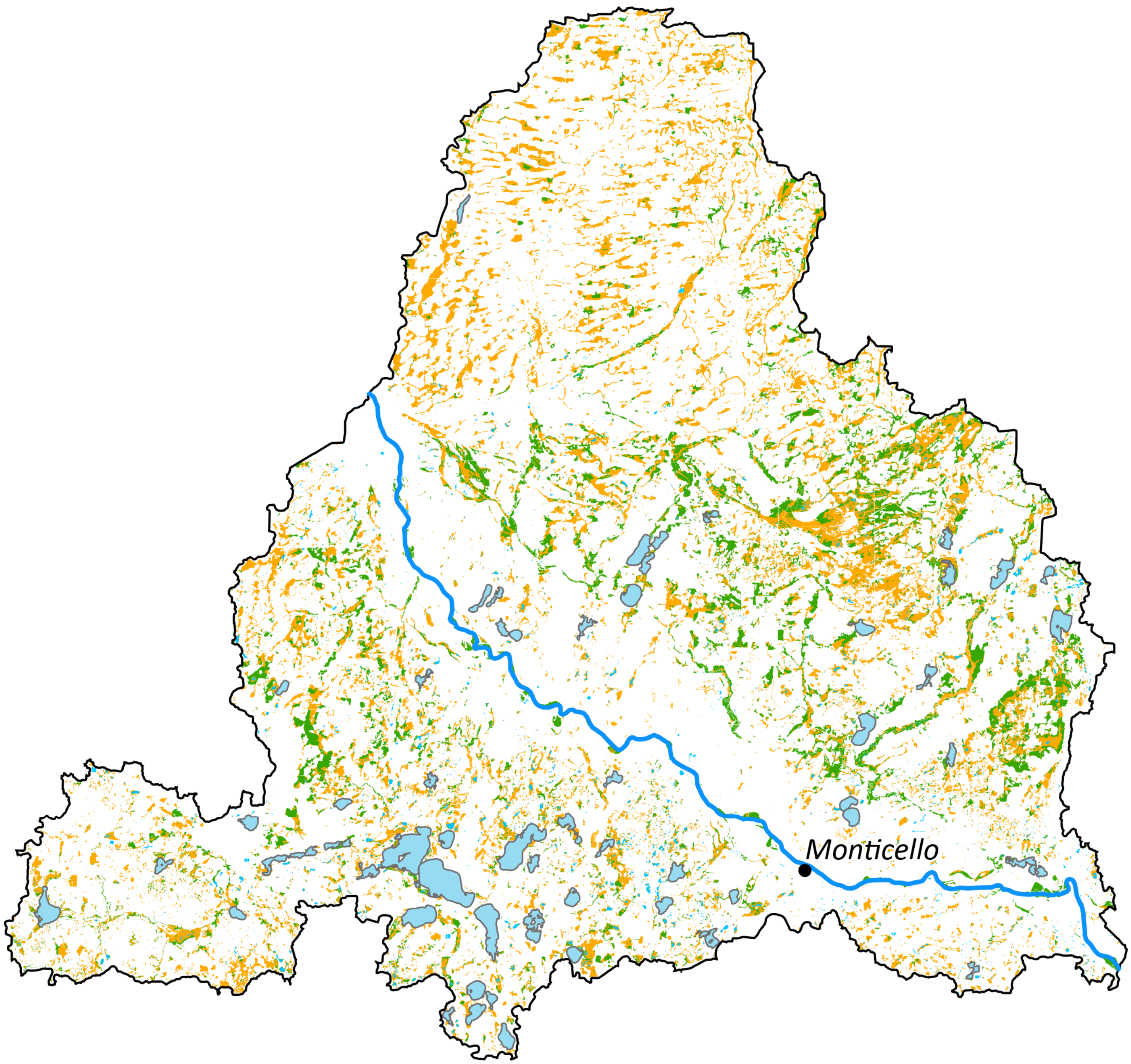
Middle Mississippi River Watershed Wetland Restoration Planning Study - Sauk River -

Legend: City, Watershed, River, Lake

N

Miles
0 2 4 8

Figure A3: National Wetland Inventory



Wetland Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-St. Cloud -

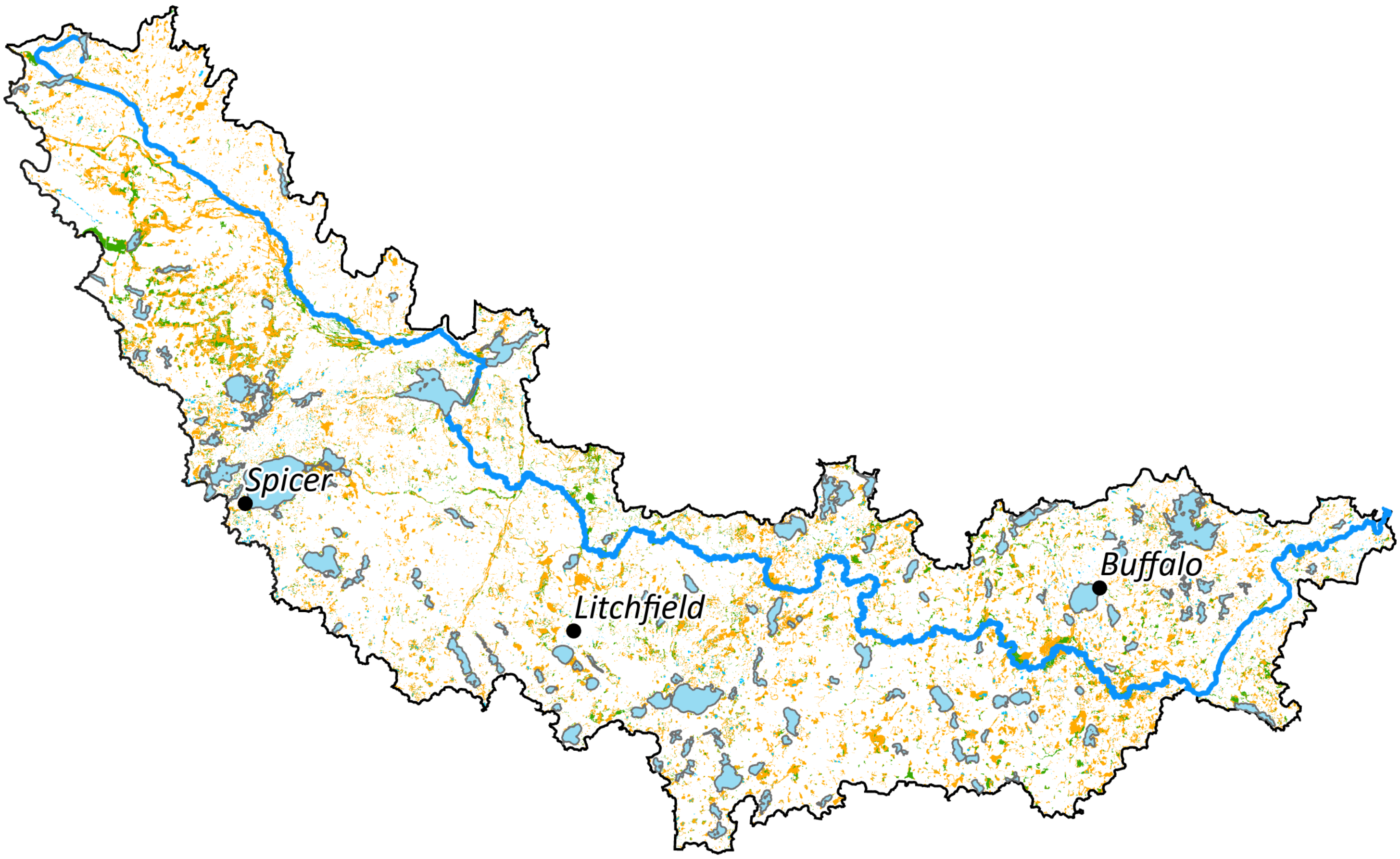
Legend: • City | Watershed | River | Lake

N

Miles

0 1.75 3.5 7

Figure A4: National Wetland Inventory



Wetland Type

Freshwater Emergent Wetland

Freshwater Forested/Shrub Wetland

Freshwater Pond

BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study

- North Fork Crow River -

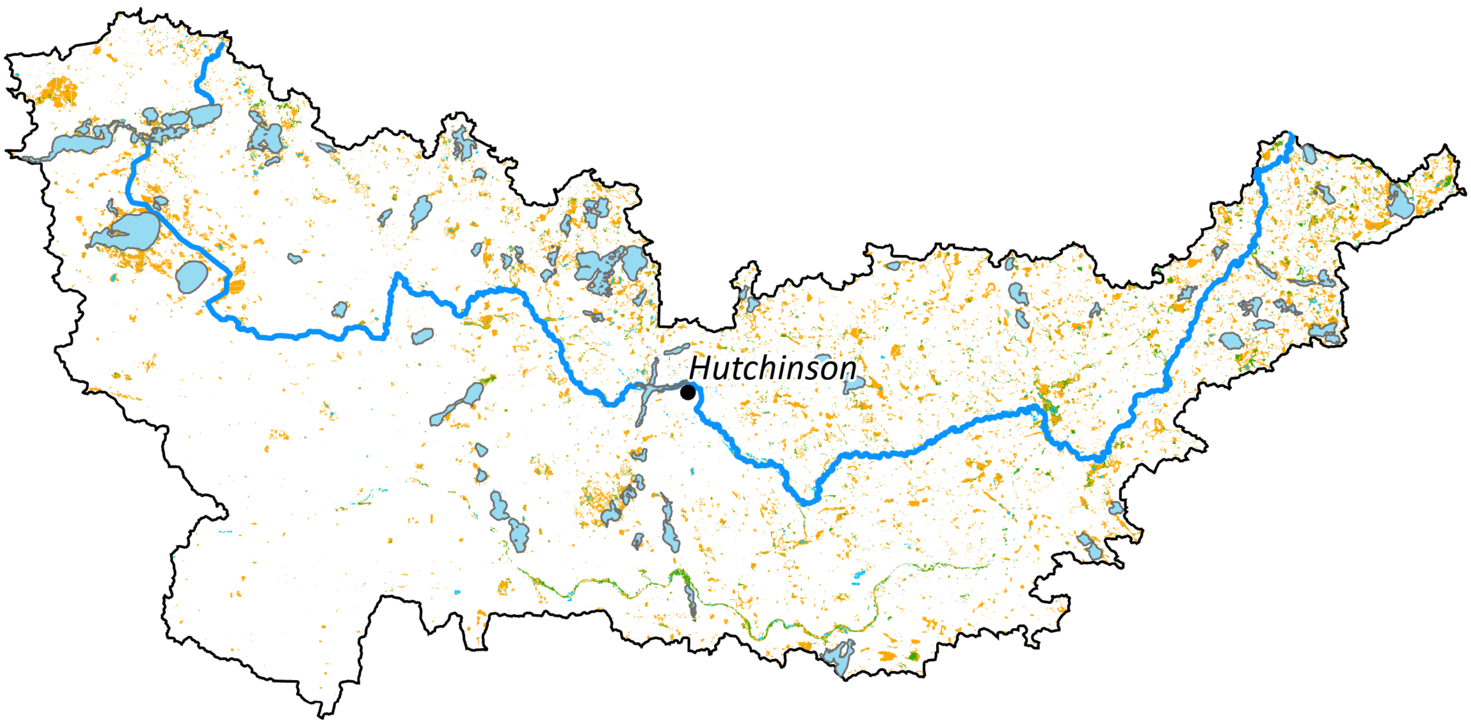
Legend: City, Watershed, River, Lake

N

Miles

0 3 6 12

Figure A5: National Wetland Inventory



Wetland Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

BOARD OF WATER AND SOIL RESOURCES

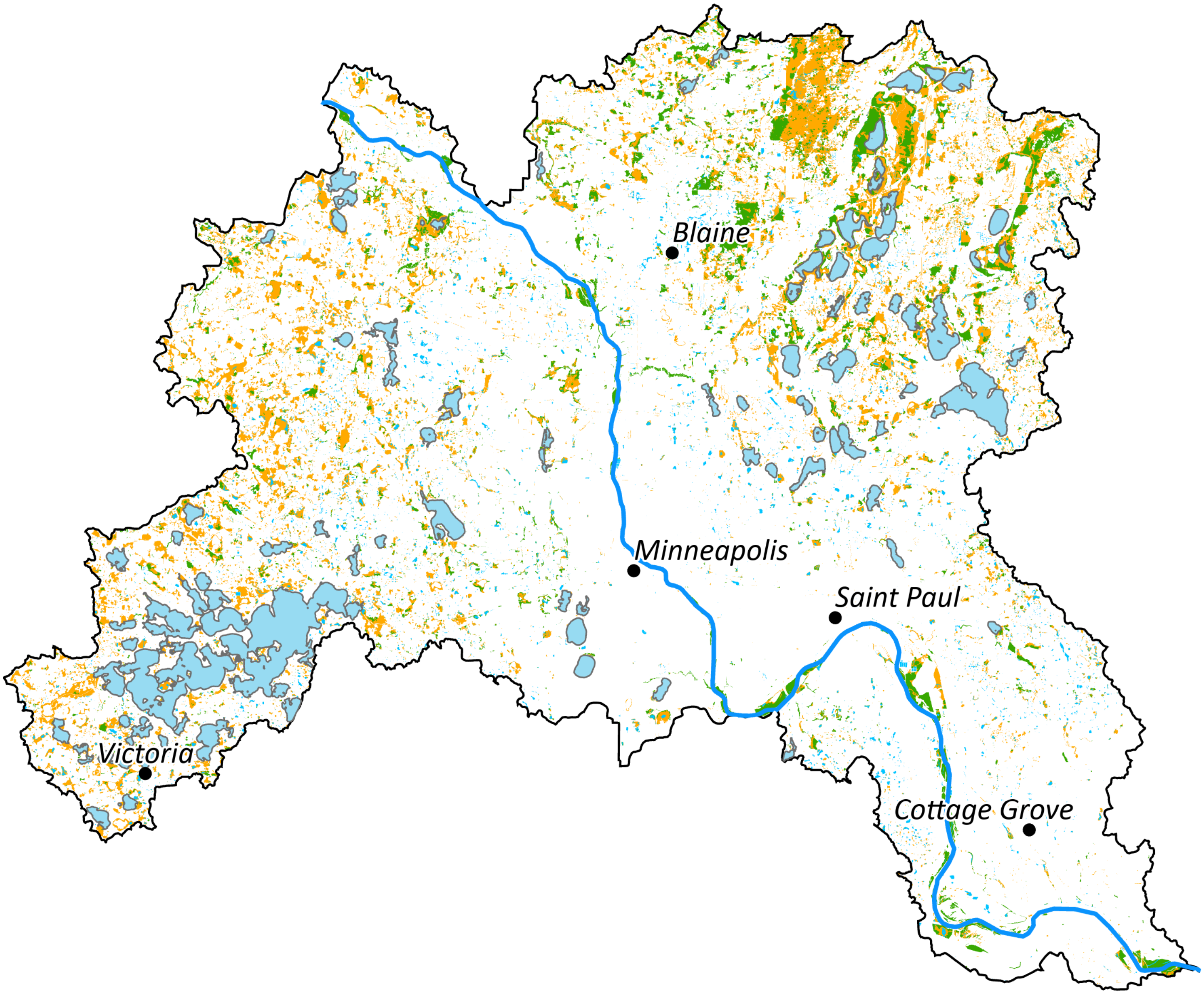
Middle Mississippi River Watershed
Wetland Restoration Planning Study
- South Fork Crow River -

Legend: City, Watershed, River, Lake

N

Miles
0 2.5 5 10

Figure A6: National Wetland Inventory



Wetland Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond

BOARD OF WATER AND SOIL RESOURCES

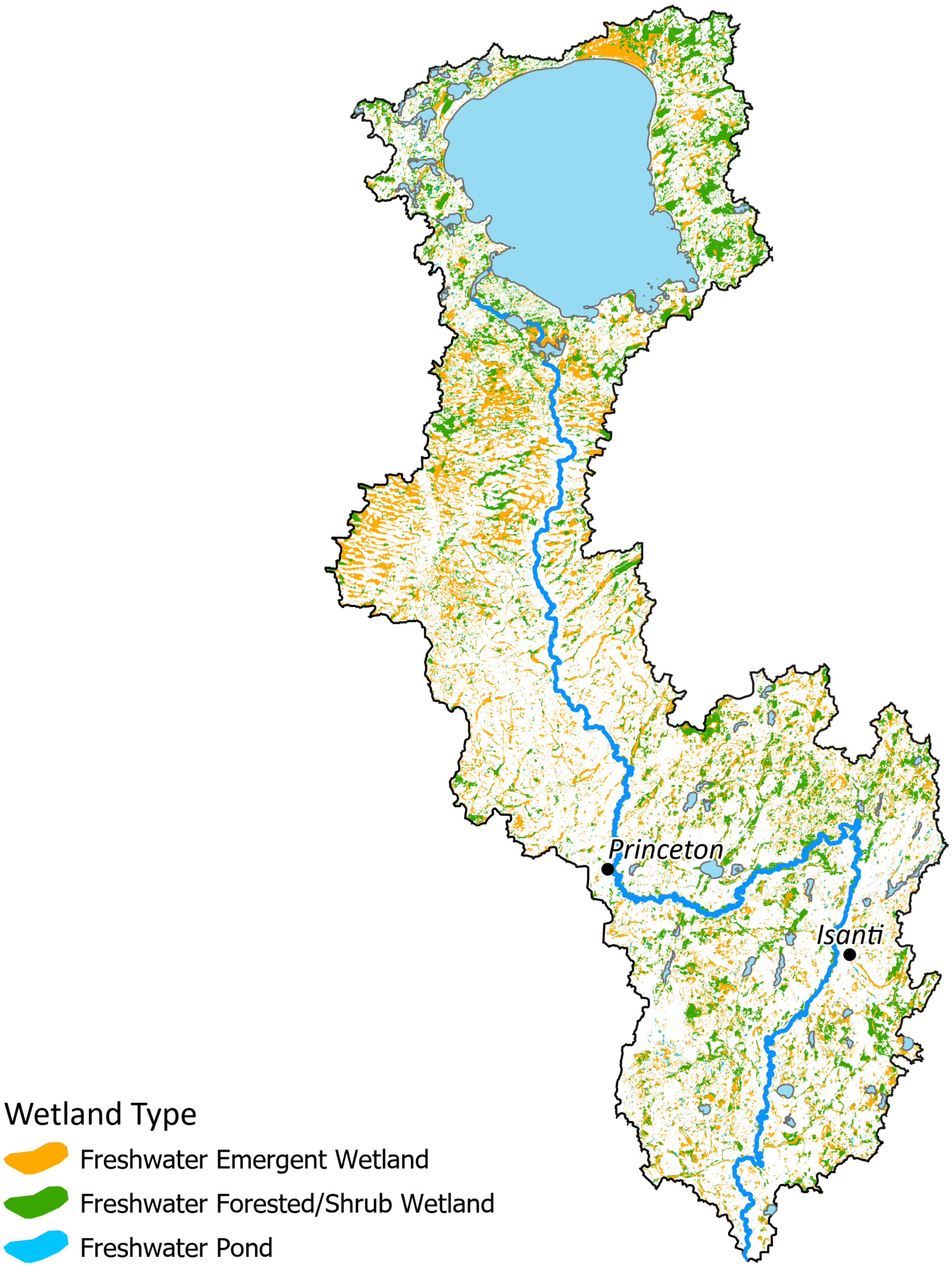
Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Twin Cities -

Legend: City, Watershed, River, Lake

N

Miles
0 1.75 3.5 7

Figure A7: National Wetland Inventory



Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Rum River -

Legend: City, Watershed, River, Lake

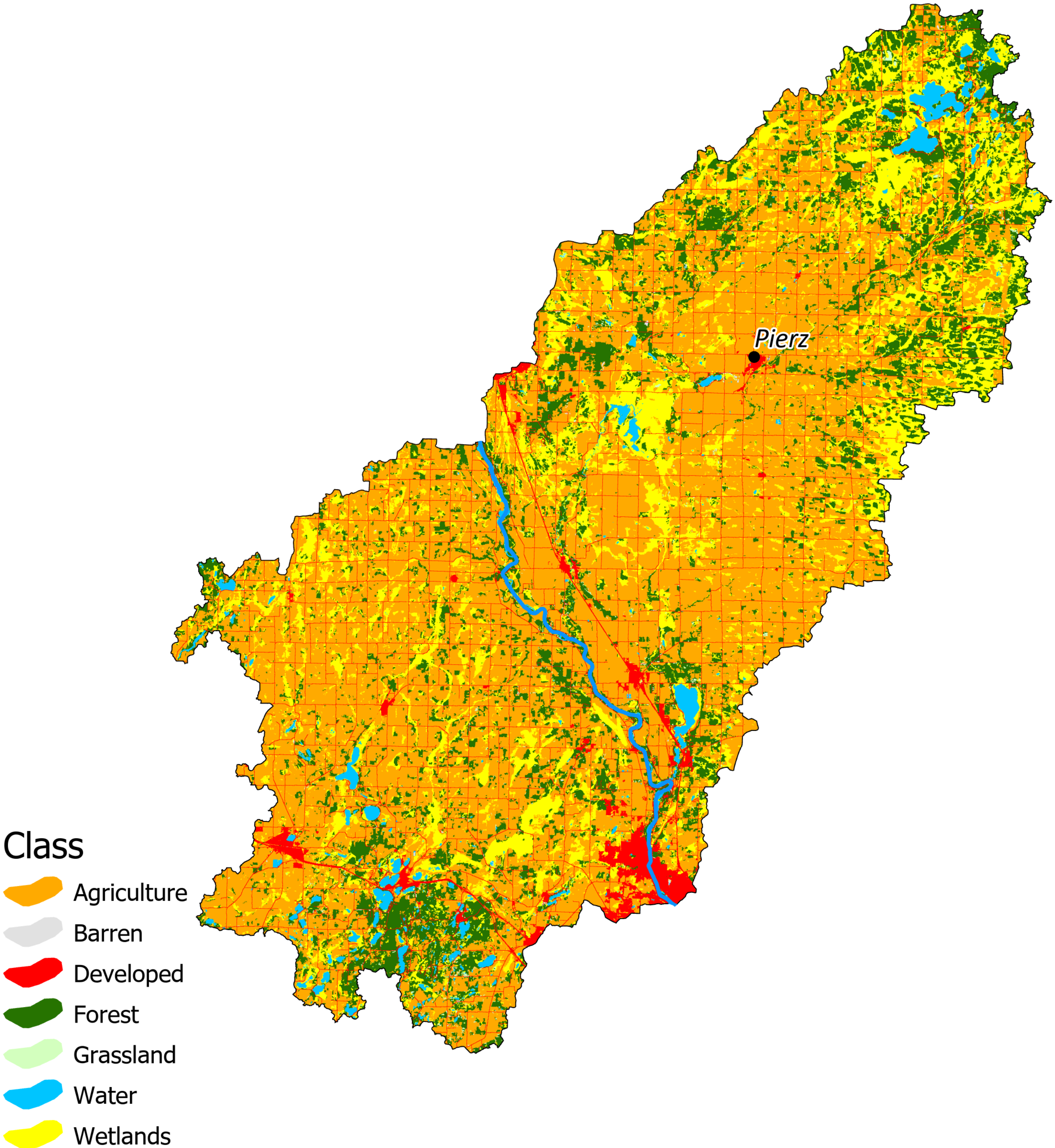
N

Miles
0 2.75 5.5 11

Appendix B

Land Cover Maps

Figure B1: Land Cover (2016)

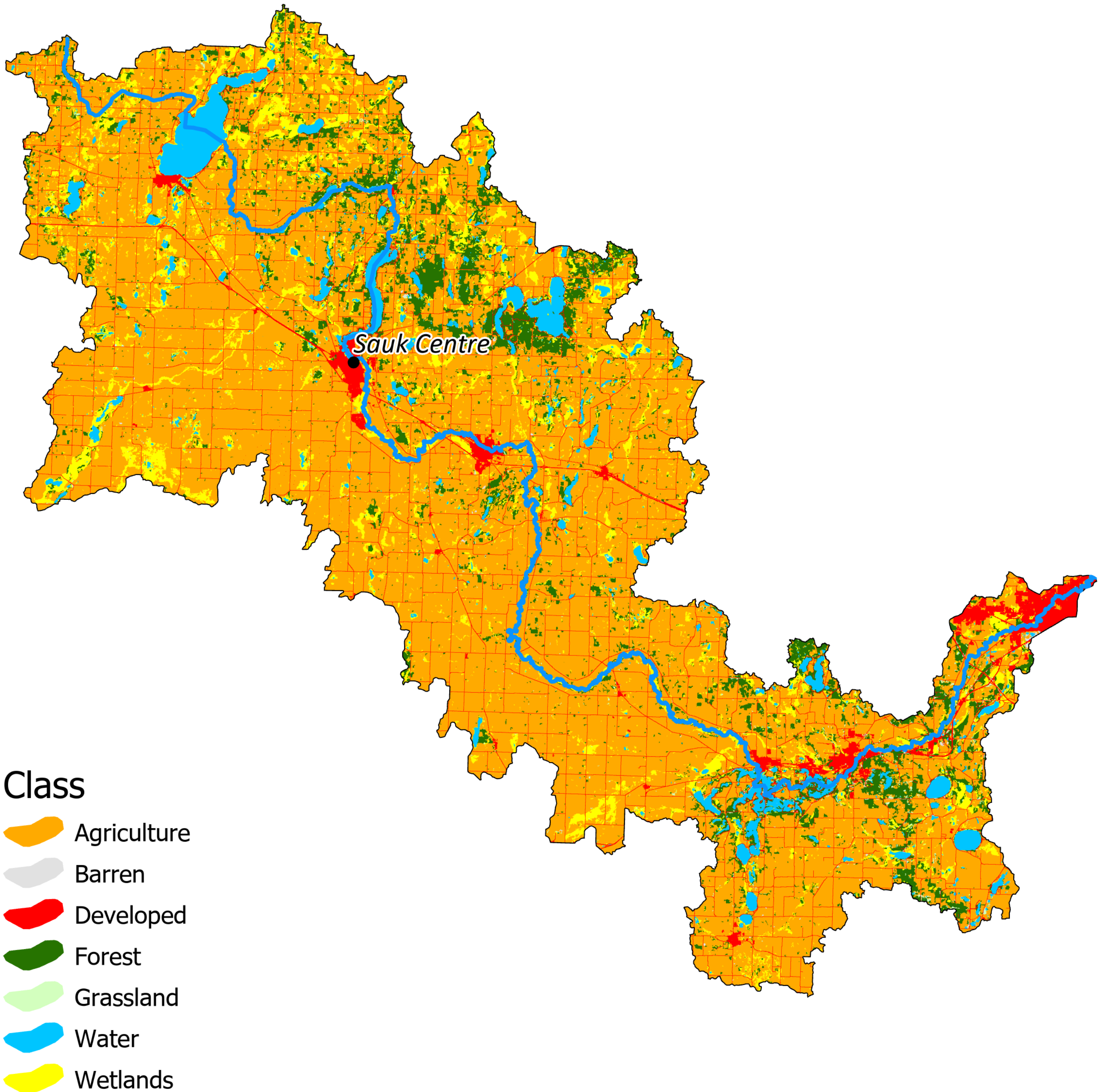


BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Sartell -

Legend: City Watershed River Lake

Figure B2: Land Cover (2016)



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Sauk River -

Legend: City Watershed River Lake

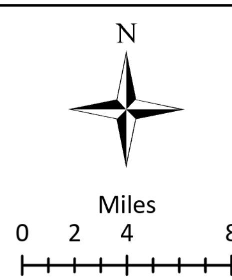
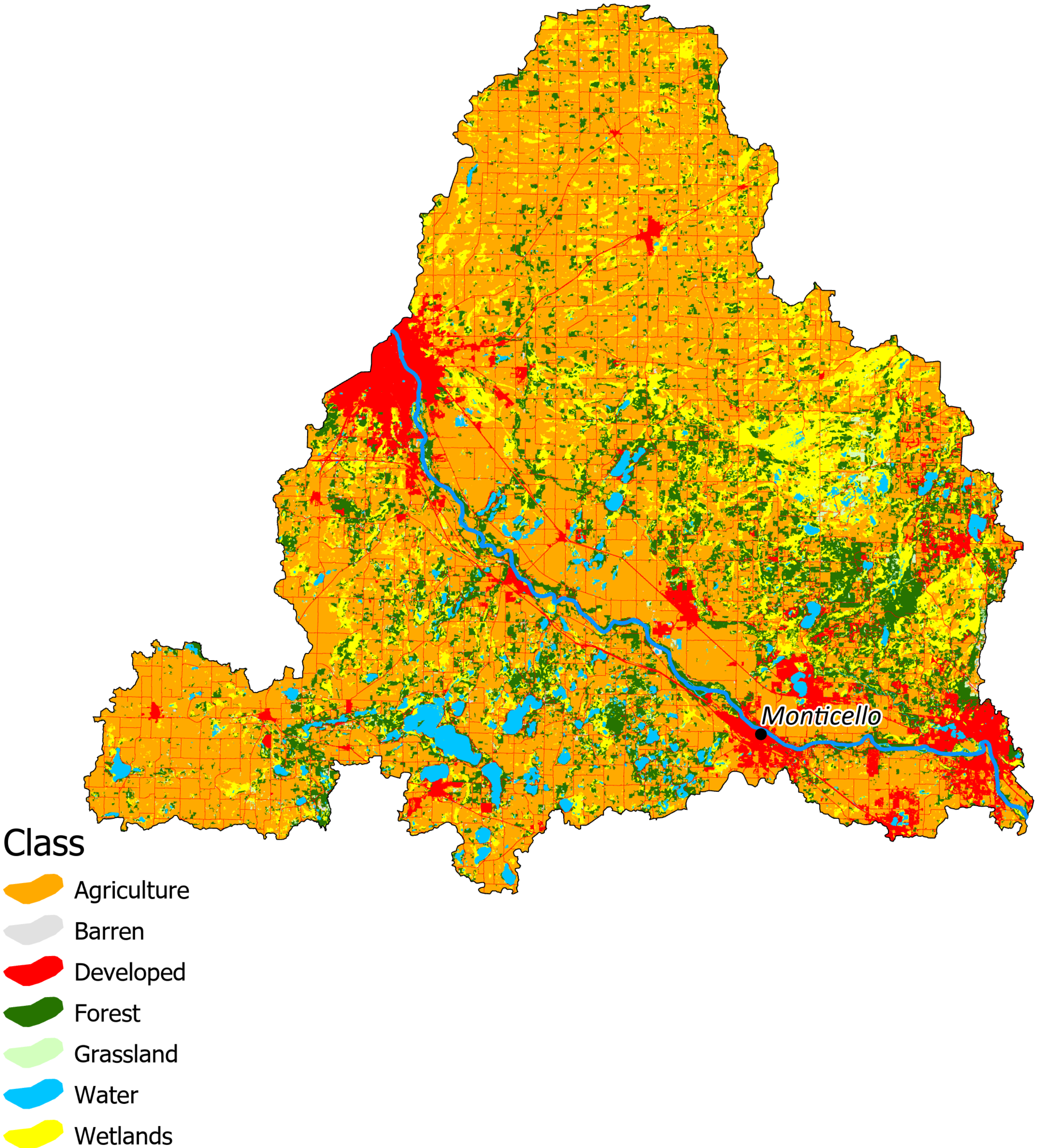


Figure B3: Land Cover (2016)



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Mississippi River-St. Cloud -

Legend: City Watershed River Lake

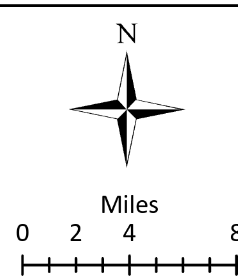
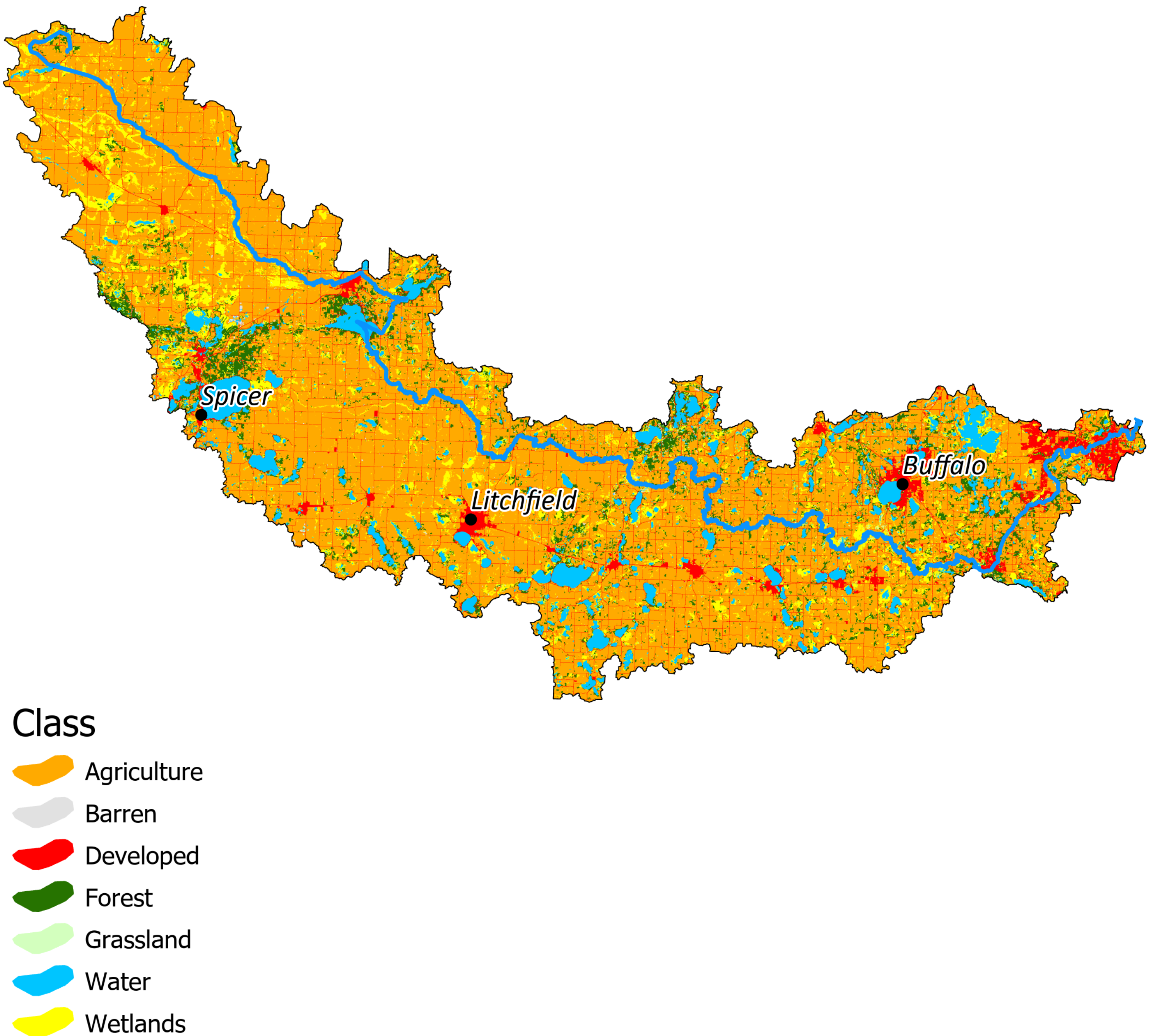


Figure B4: Land Cover (2016)



Middle Mississippi River Watershed Wetland Restoration Planning Study - North Fork Crow River -

Legend: • City, Watershed, River, Lake

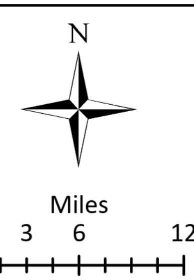
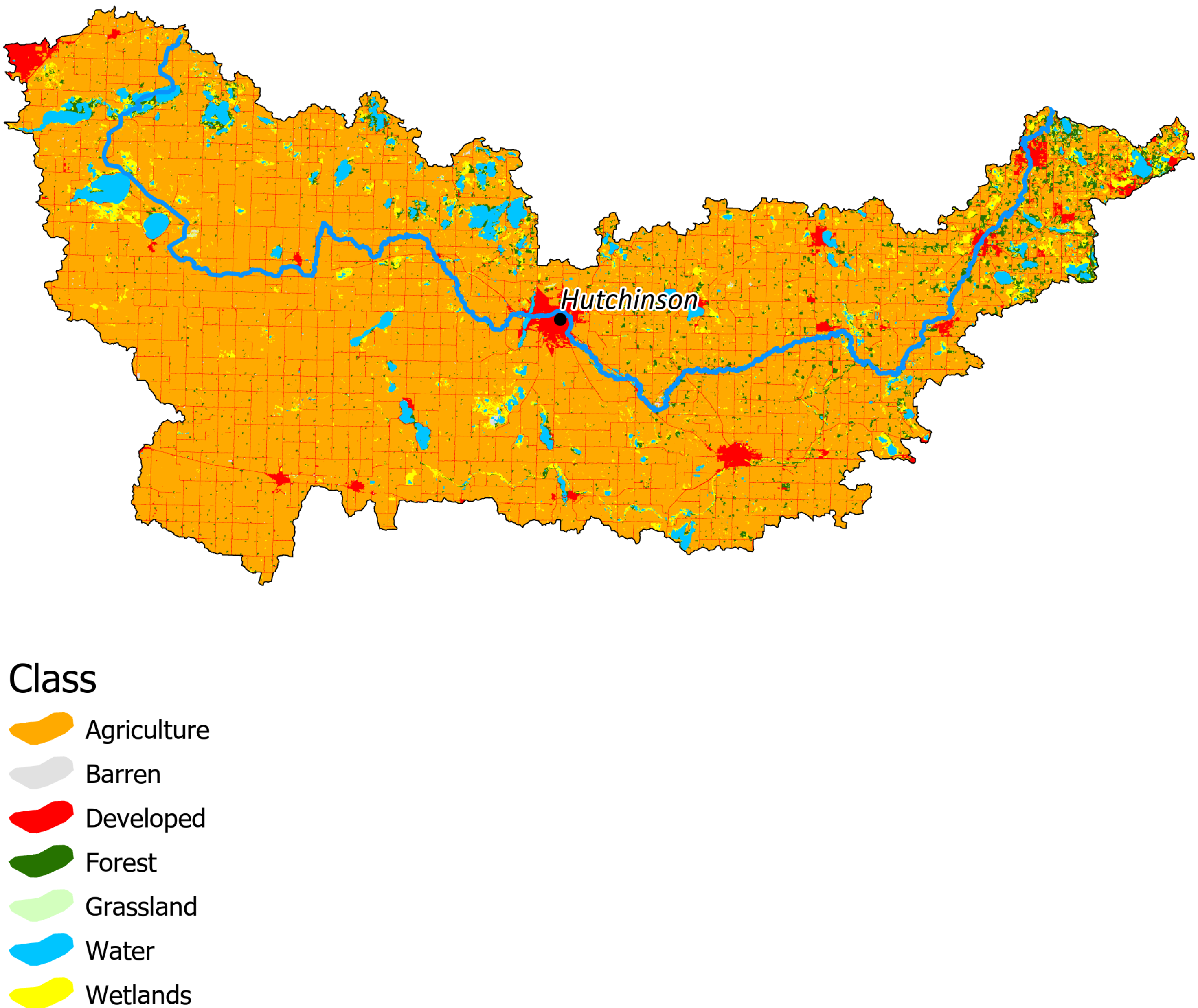


Figure B5: Land Cover (2016)



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study
- South Fork Crow River -

Legend: City Watershed River Lake

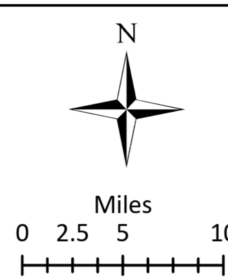
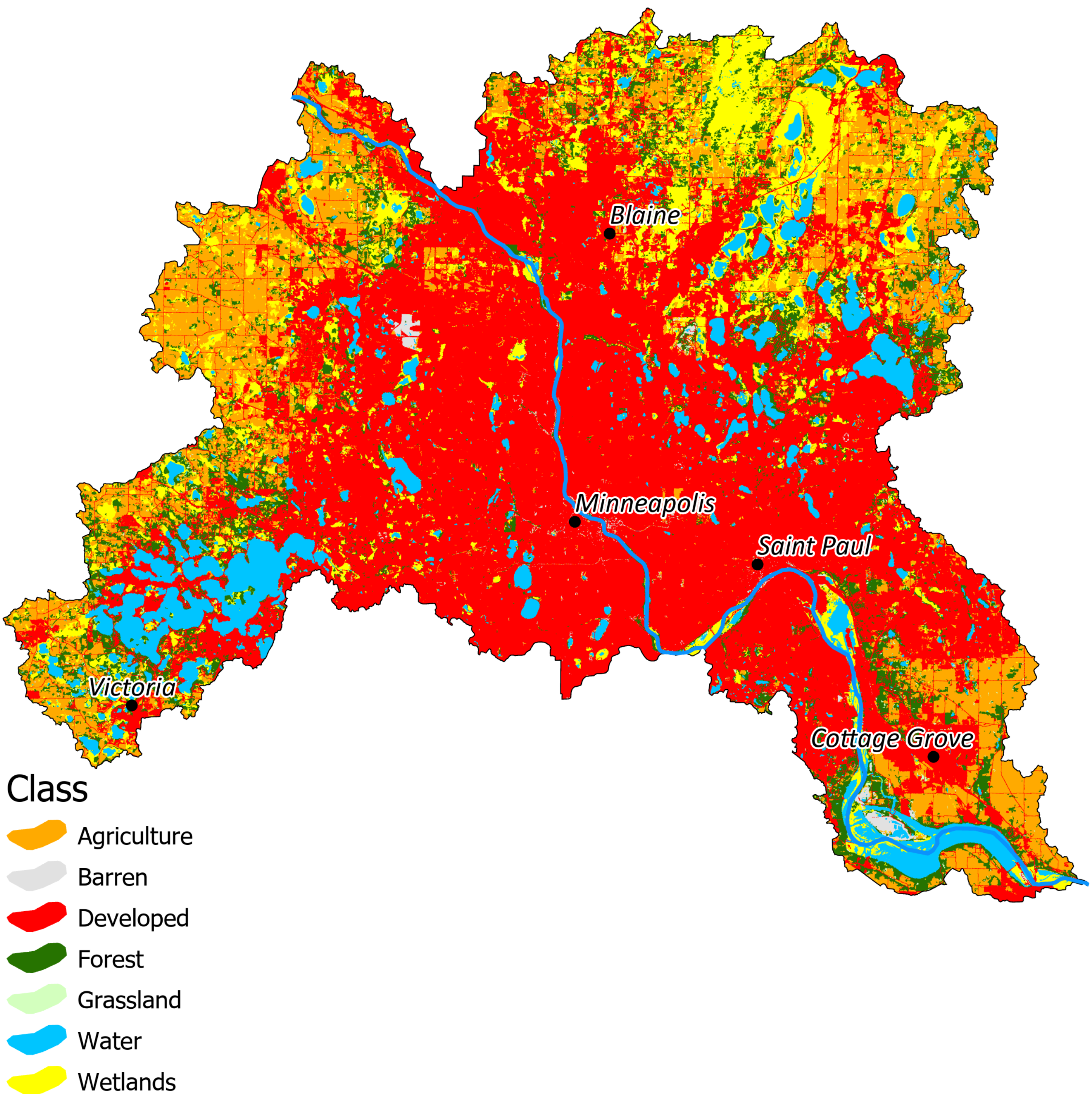


Figure B6: Land Cover (2016)

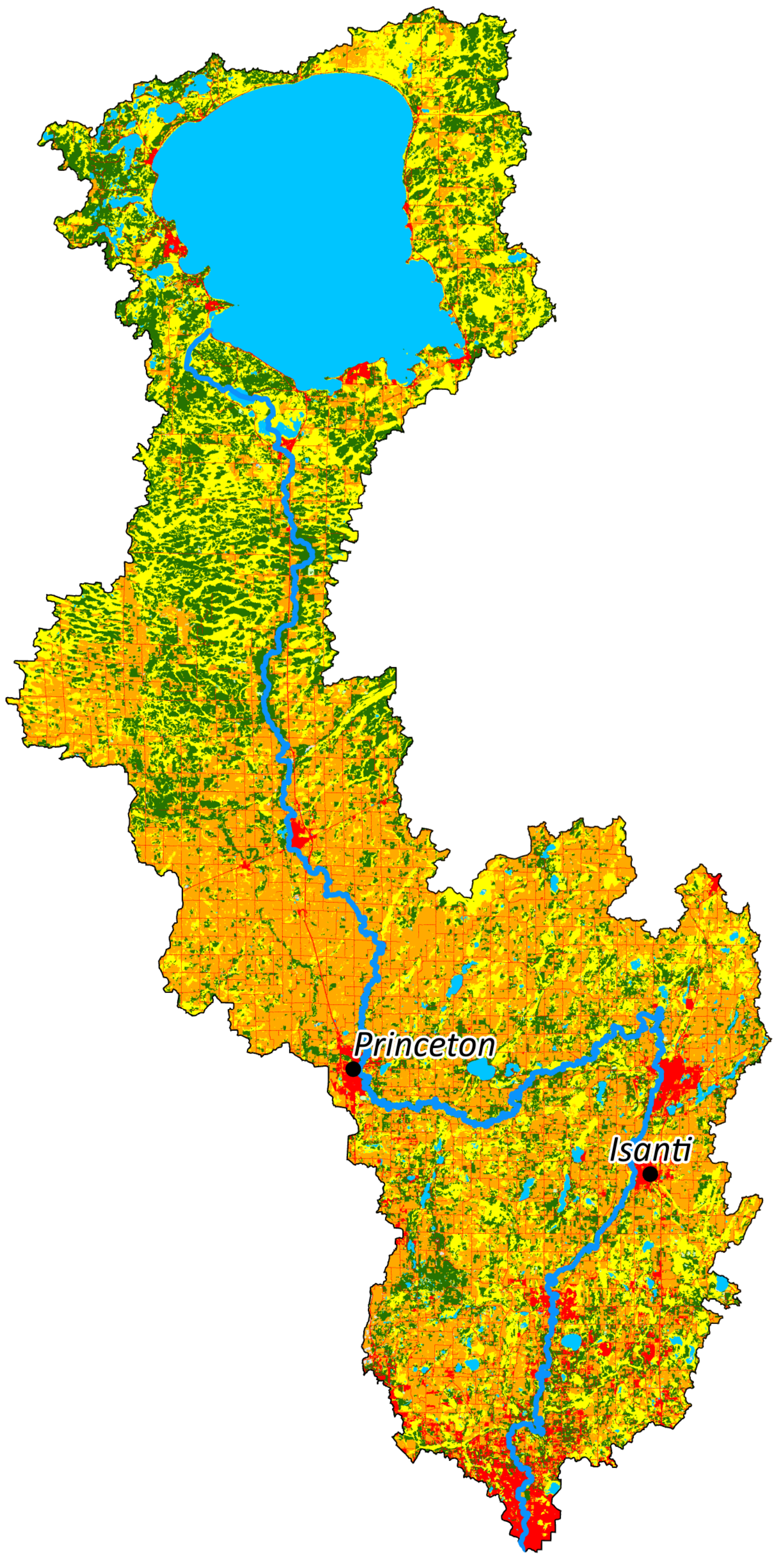


BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study
- Mississippi River-Twin Cities -

Legend: City Watershed River Lake

Figure B7: Land Cover (2016)



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Rum River -

Legend: City Watershed River Lake

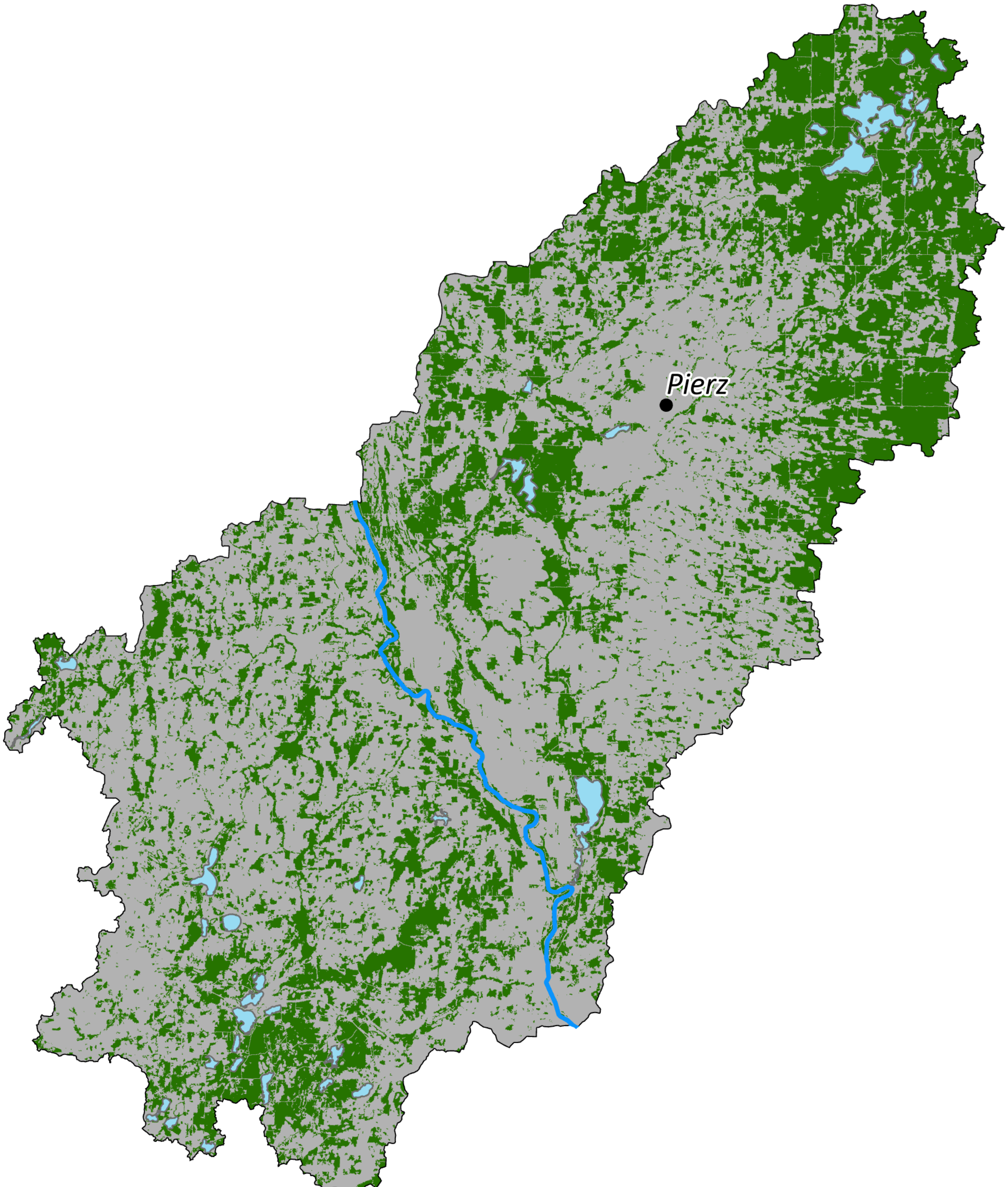
N

Miles
0 2.75 5.5 11

Appendix C

Perennial Cover Maps

Figure C1: Perennial Cover (2016)



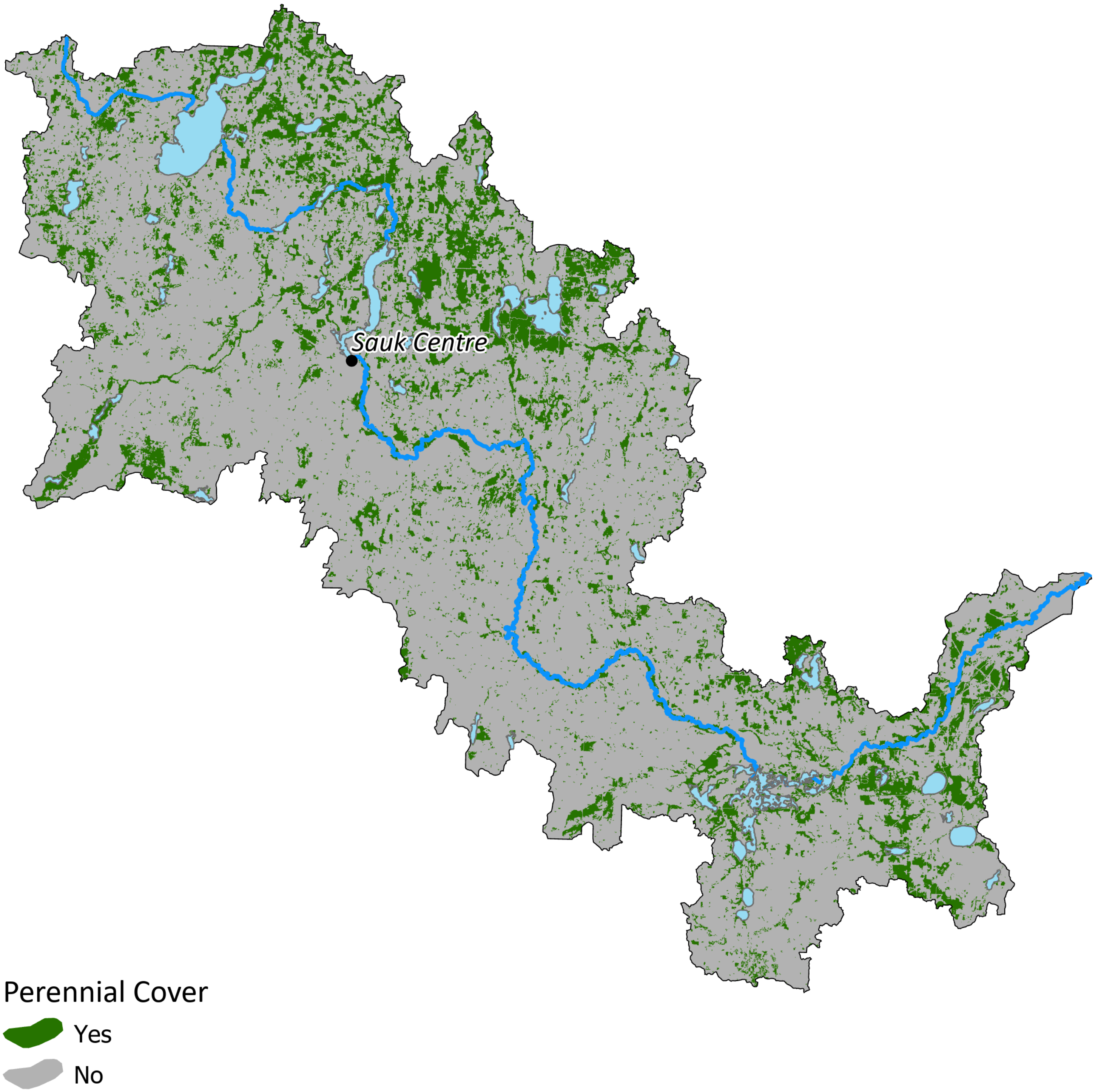
Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Mississippi River-Sartell -

Legend: City, Watershed, River, Lake

BOARD OF WATER AND SOIL RESOURCES

N
Miles
0 2 4 8

Figure C2: Perennial Cover (2016)



Middle Mississippi River Watershed Wetland Restoration Planning Study - Sauk River -

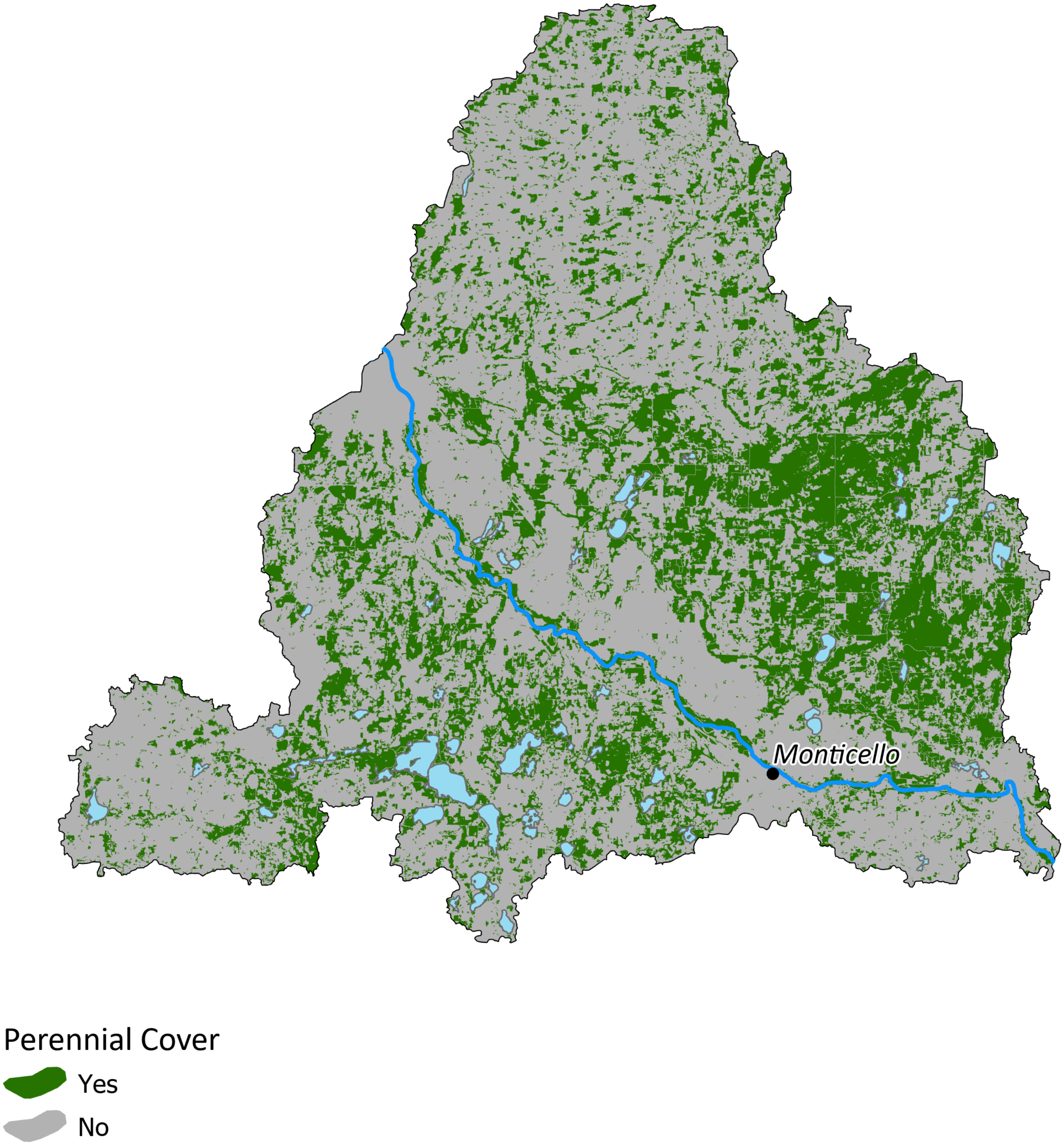
Legend: City, Watershed, River, Lake

BOARD OF WATER AND SOIL RESOURCES

N

Miles
0 2 4 8

Figure C3: Perennial Cover (2016)

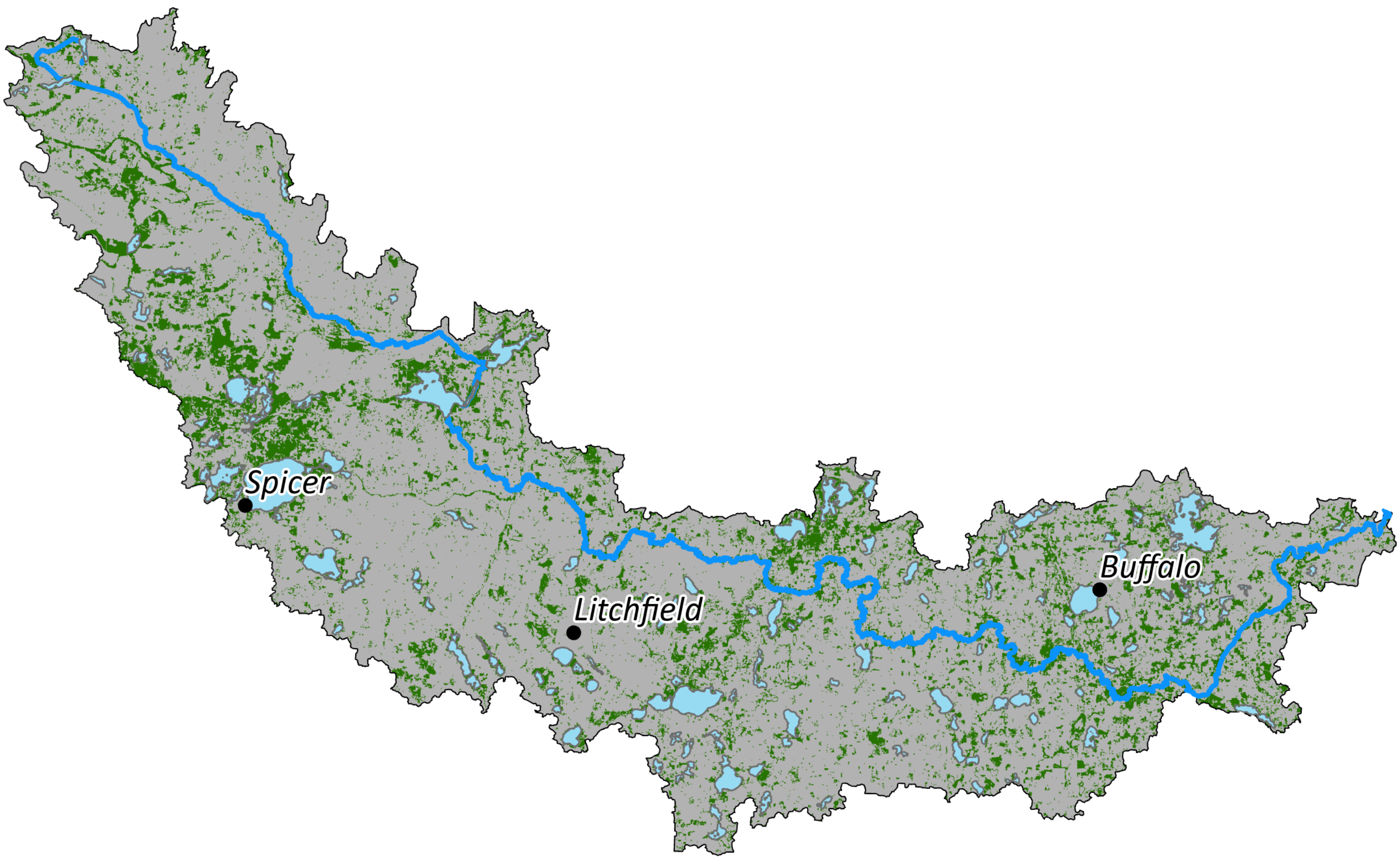


Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Mississippi River-St. Cloud -

Legend: ● City ▢ Watershed ~ River ☁ Lake

BOARD OF WATER AND SOIL RESOURCES

Figure C4: Perennial Cover (2016)



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - North Fork Crow River -

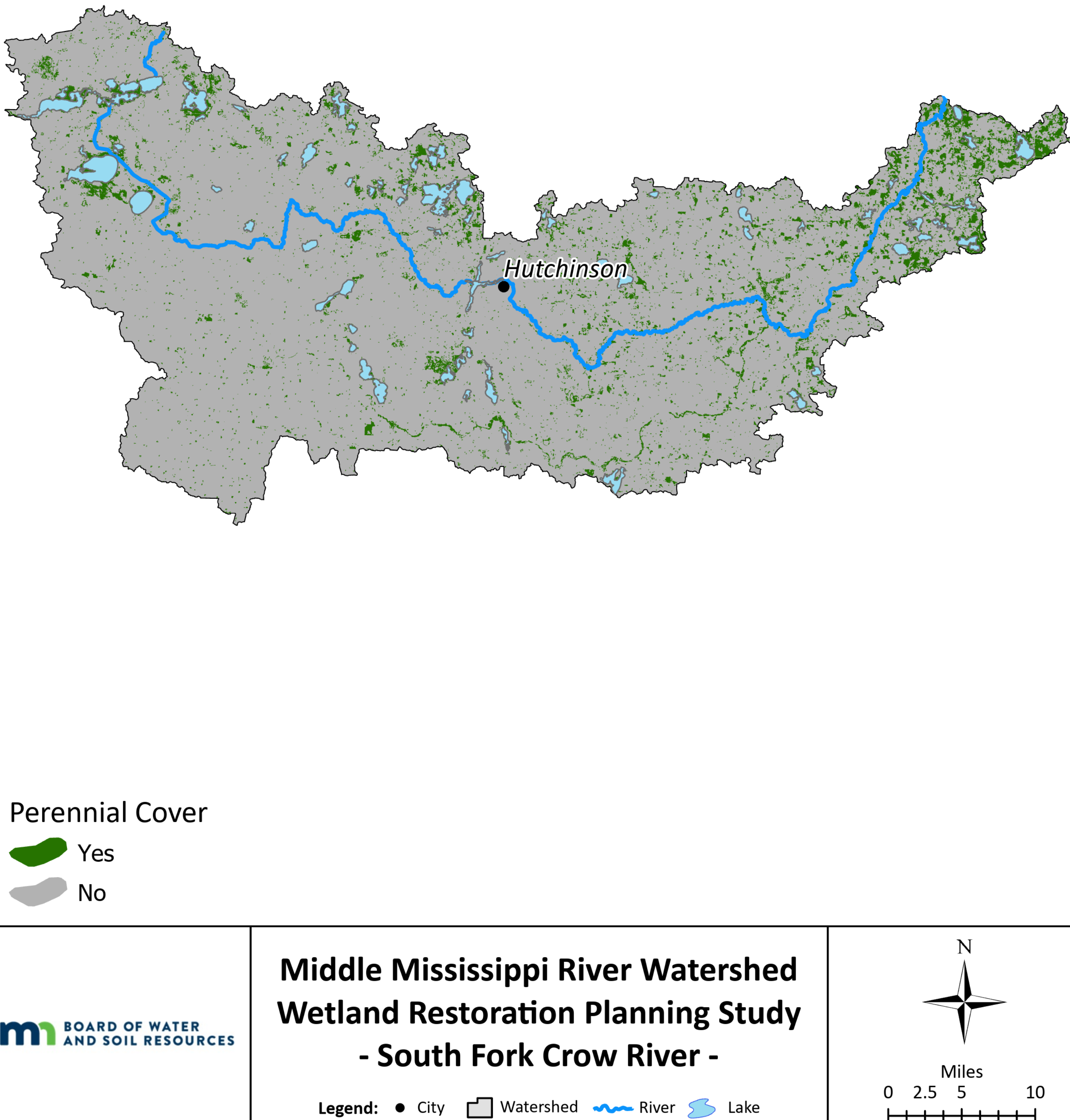
Legend: City Watershed River Lake

N

Miles

0 3 6 12

Figure C5: Perennial Cover (2016)

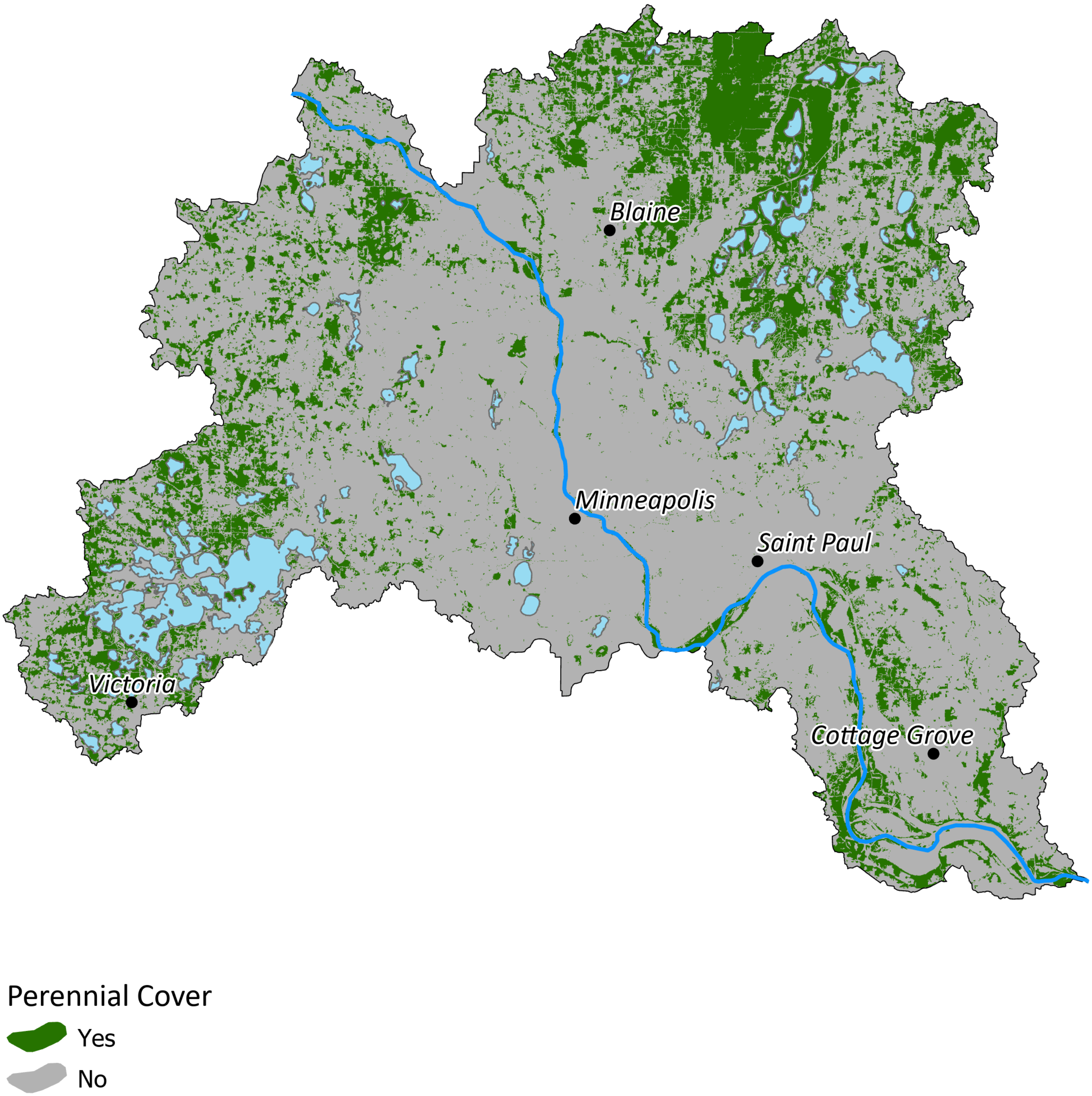


Middle Mississippi River Watershed
Wetland Restoration Planning Study
- South Fork Crow River -

Legend: City Watershed River Lake

BOARD OF WATER AND SOIL RESOURCES

Figure C6: Perennial Cover (2016)



Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Twin Cities -

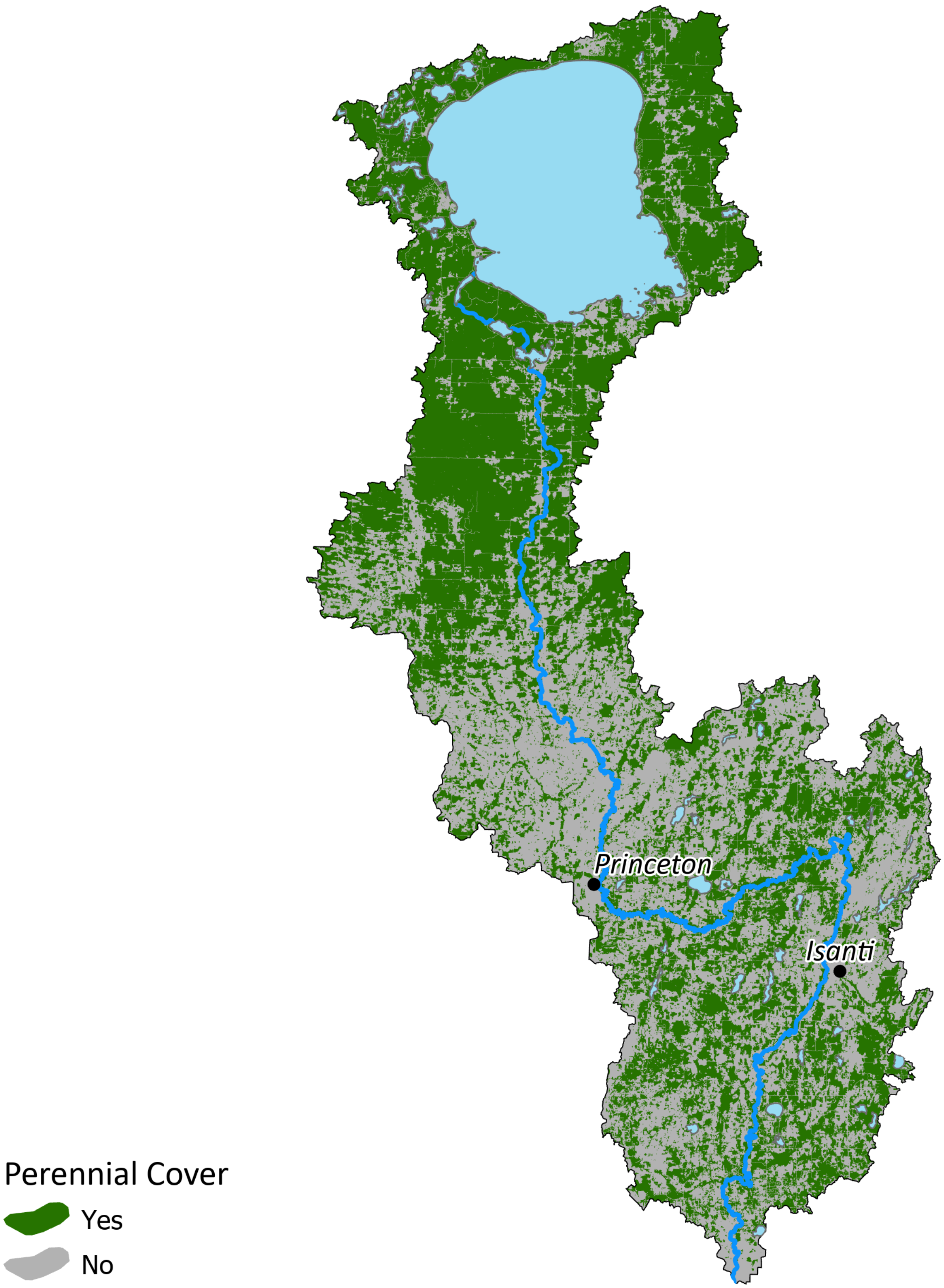
Legend: City, Watershed, River, Lake

BOARD OF WATER AND SOIL RESOURCES

N

Miles
0 1.75 3.5 7

Figure C7: Perennial Cover (2016)



Middle Mississippi River Watershed Wetland Restoration Planning Study
- Rum River -

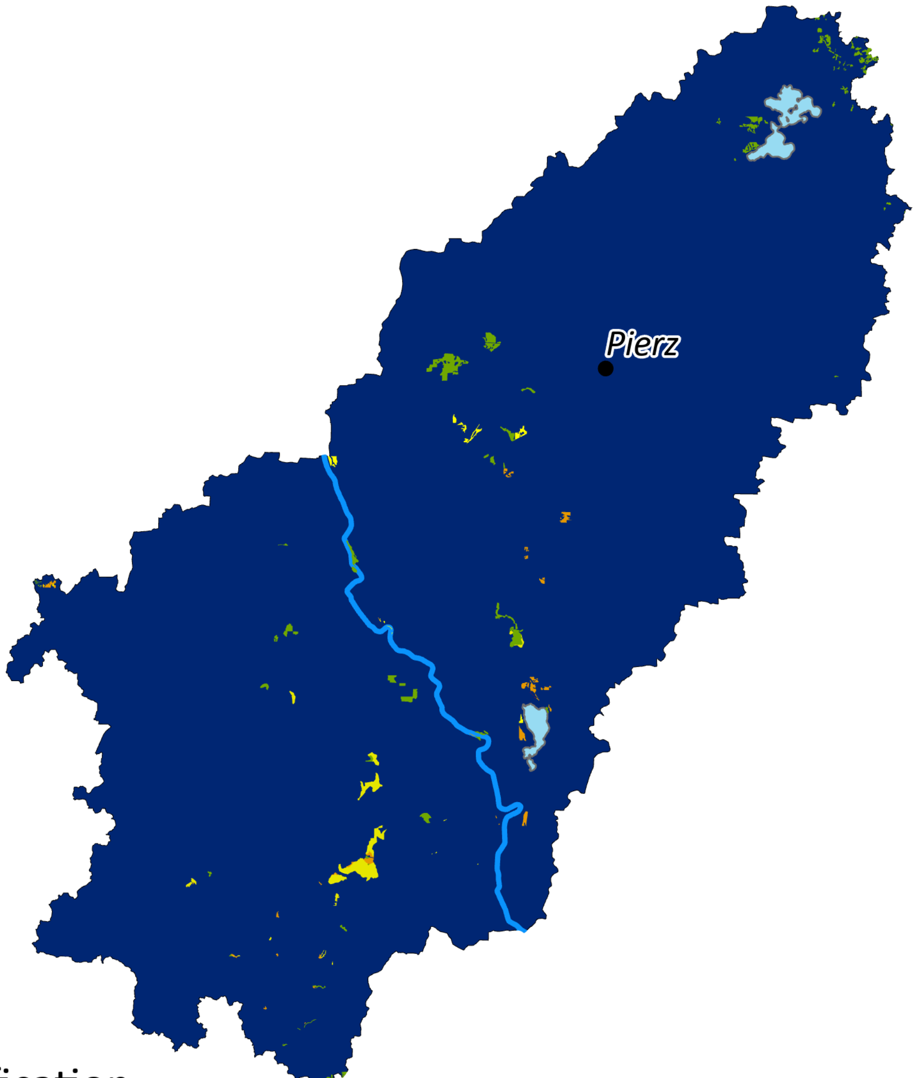
Legend: City Watershed River Lake

BOARD OF WATER AND SOIL RESOURCES

Appendix D

Native Plant Communities

Figure D1: Native Plant Communities (2019)



Threatened Classification

- S1 - Critically Imperiled
- S1 or S2 - Subtype S-Ranks are either S1 or S2
- S1S2 - Between Critically Imperiled and Imperiled
- S2 - Imperiled
- S2S3 - Between Imperiled and Vulnerable to Extirpation
- S3 - Vulnerable to Extirpation
- Mississippi River - Sartell Watershed

BOARD OF WATER AND SOIL RESOURCES

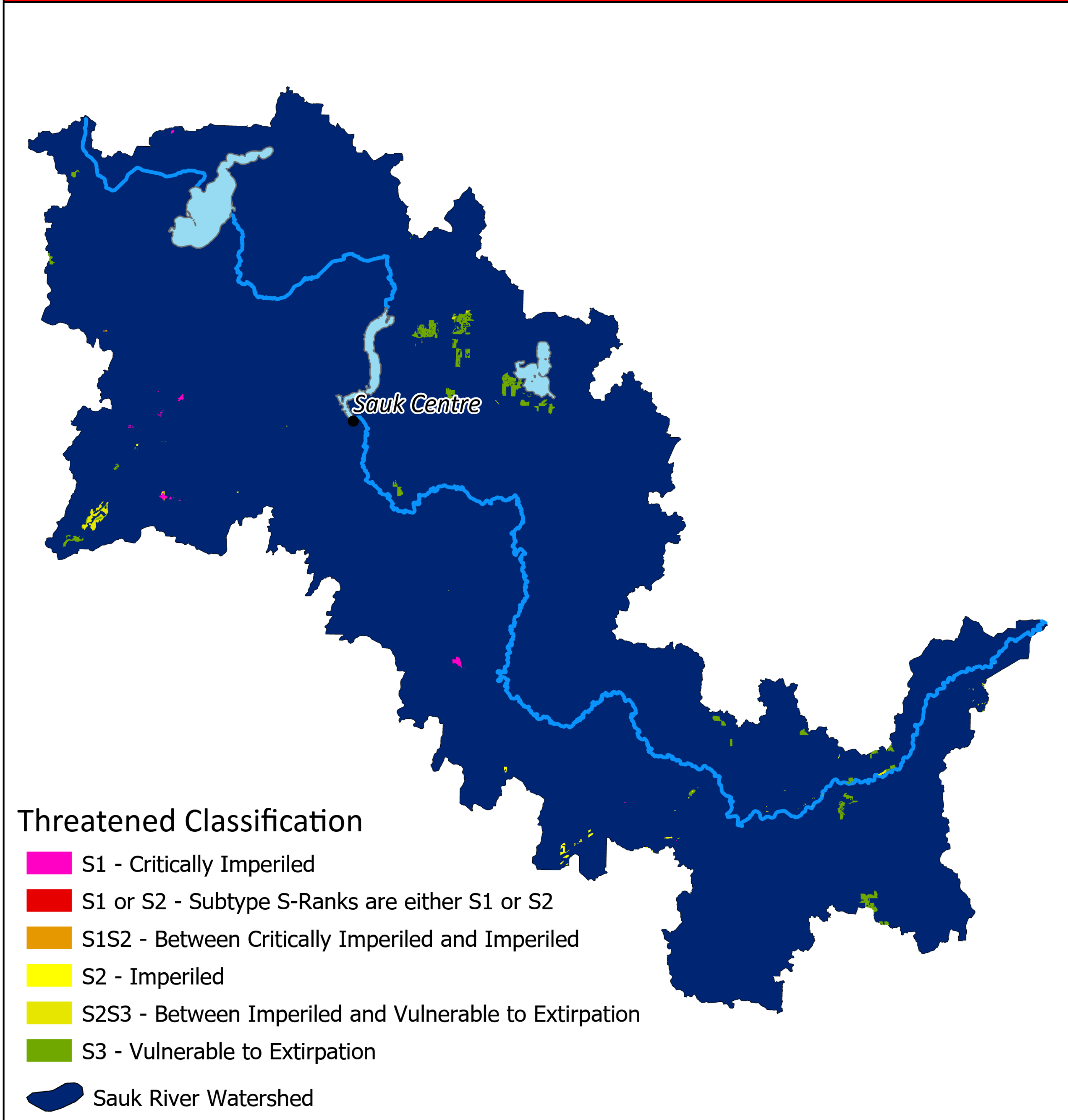
Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Sartell -

Legend: City Watershed River Lake

N

Miles
0 2.5 5 10

Figure D2: Native Plant Communities (2019)



BOARD OF WATER AND SOIL RESOURCES

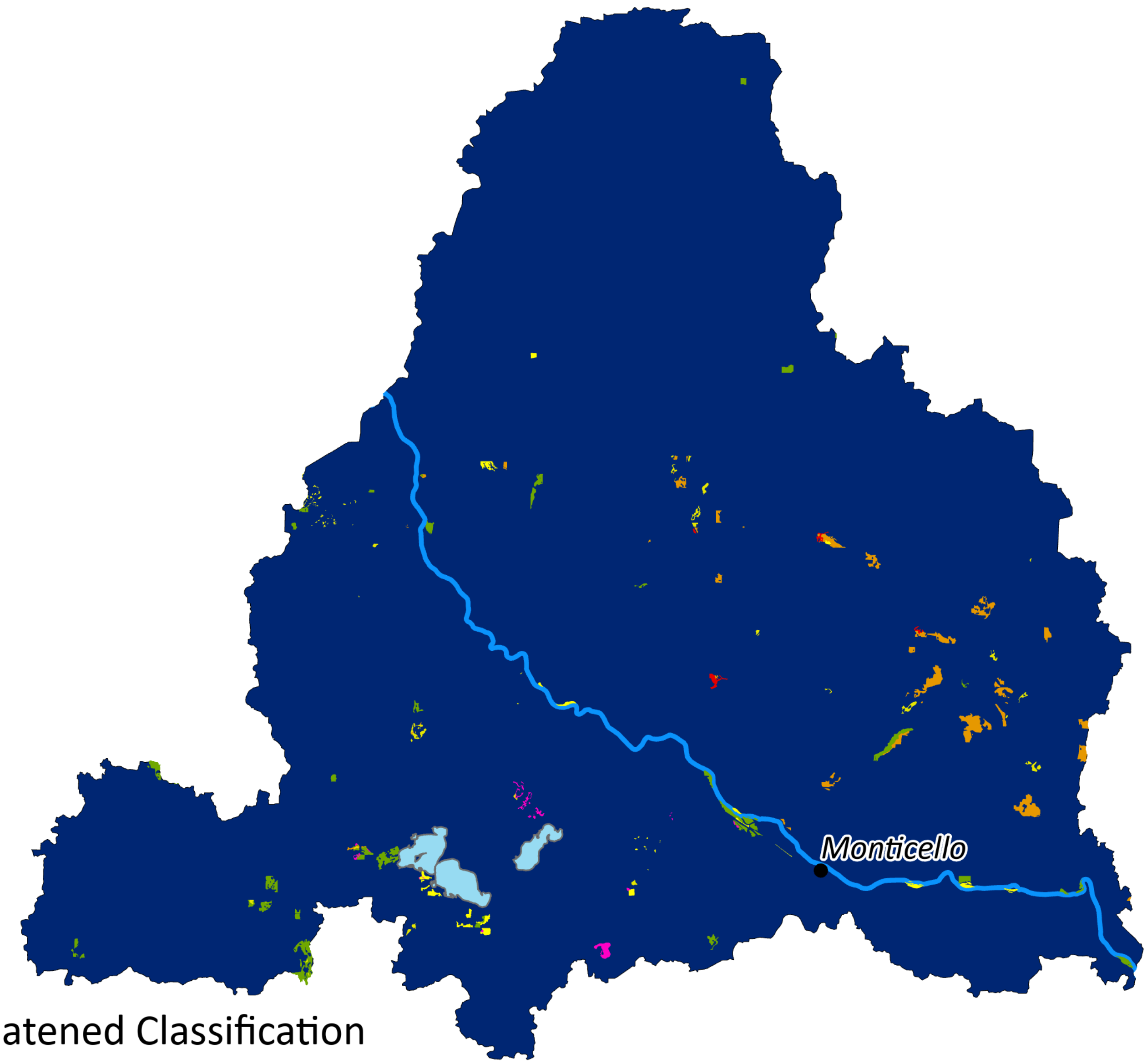
Middle Mississippi River Watershed Wetland Restoration Planning Study
- Sauk River -

Legend: ● City | Watershed | River | Lake

N

Miles
0 2 4 8

Figure D3: Native Plant Communities (2019)



Threatened Classification

- S1 - Critically Imperiled
- S1 or S2 - Subtype S-Ranks are either S1 or S2
- S1S2 - Between Critically Imperiled and Imperiled
- S2 - Imperiled
- S2S3 - Between Imperiled and Vulnerable to Extirpation
- S3 - Vulnerable to Extirpation
- Mississippi River- St. Cloud Watershed

BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-St. Cloud -

Legend: City, Watershed, River, Lake

N

Miles
0 2 4 8

Figure D4: Native Plant Communities (2019)

Threatened Classification

- S1 - Critically Imperiled
- S1 or S2 - Subtype S-Ranks are either S1 or S2
- S1S2 - Between Critically Imperiled and Imperiled
- S2 - Imperiled
- S2S3 - Between Imperiled and Vulnerable to Extirpation
- S3 - Vulnerable to Extirpation
- North Fork Crow River Watershed

BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study
- North Fork Crow River -

Legend: City Watershed River Lake

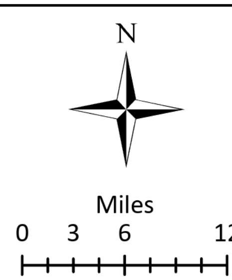


Figure D5: Native Plant Communities (2019)

Threatened Classification

- S1 - Critically Imperiled
- S1 or S2 - Subtype S-Ranks are either S1 or S2
- S1S2 - Between Critically Imperiled and Imperiled
- S2 - Imperiled
- S2S3 - Between Imperiled and Vulnerable to Extirpation
- S3 - Vulnerable to Extirpation
- South Fork Crow River Watershed

BOARD OF WATER AND SOIL RESOURCES

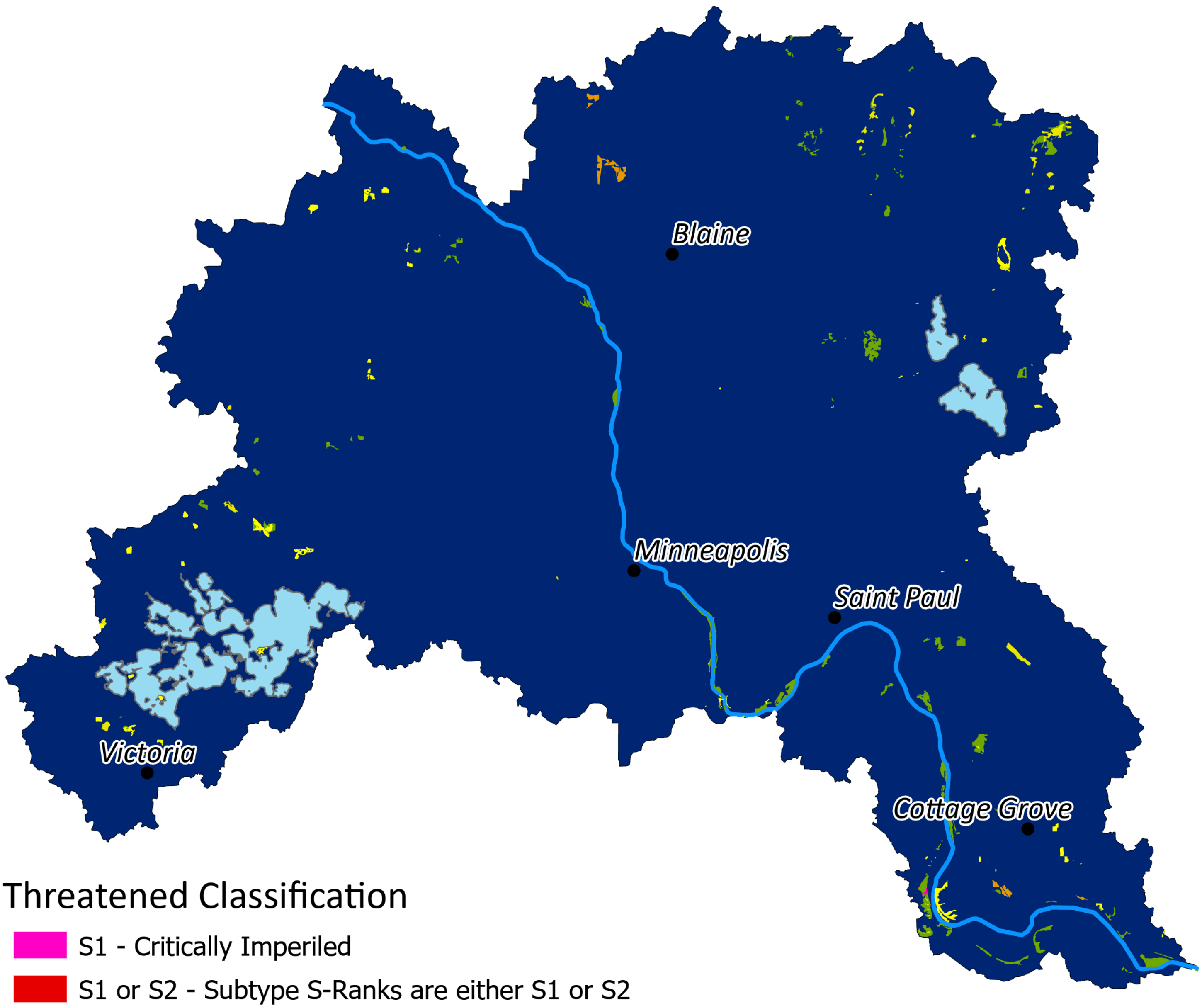
Middle Mississippi River Watershed
Wetland Restoration Planning Study
- South Fork Crow River -

Legend: City Watershed River Lake

N

Miles
0 2.5 5 10

Figure D6: Native Plant Communities (2019)



Threatened Classification

- S1 - Critically Imperiled
- S1 or S2 - Subtype S-Ranks are either S1 or S2
- S1S2 - Between Critically Imperiled and Imperiled
- S2 - Imperiled
- S2S3 - Between Imperiled and Vulnerable to Extirpation
- S3 - Vulnerable to Extirpation
- Mississippi River - Twin Cities Watershed

BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Twin Cities -

Legend: City Watershed River Lake

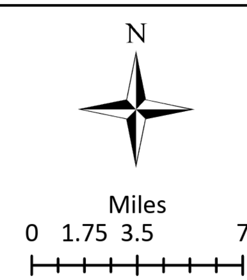
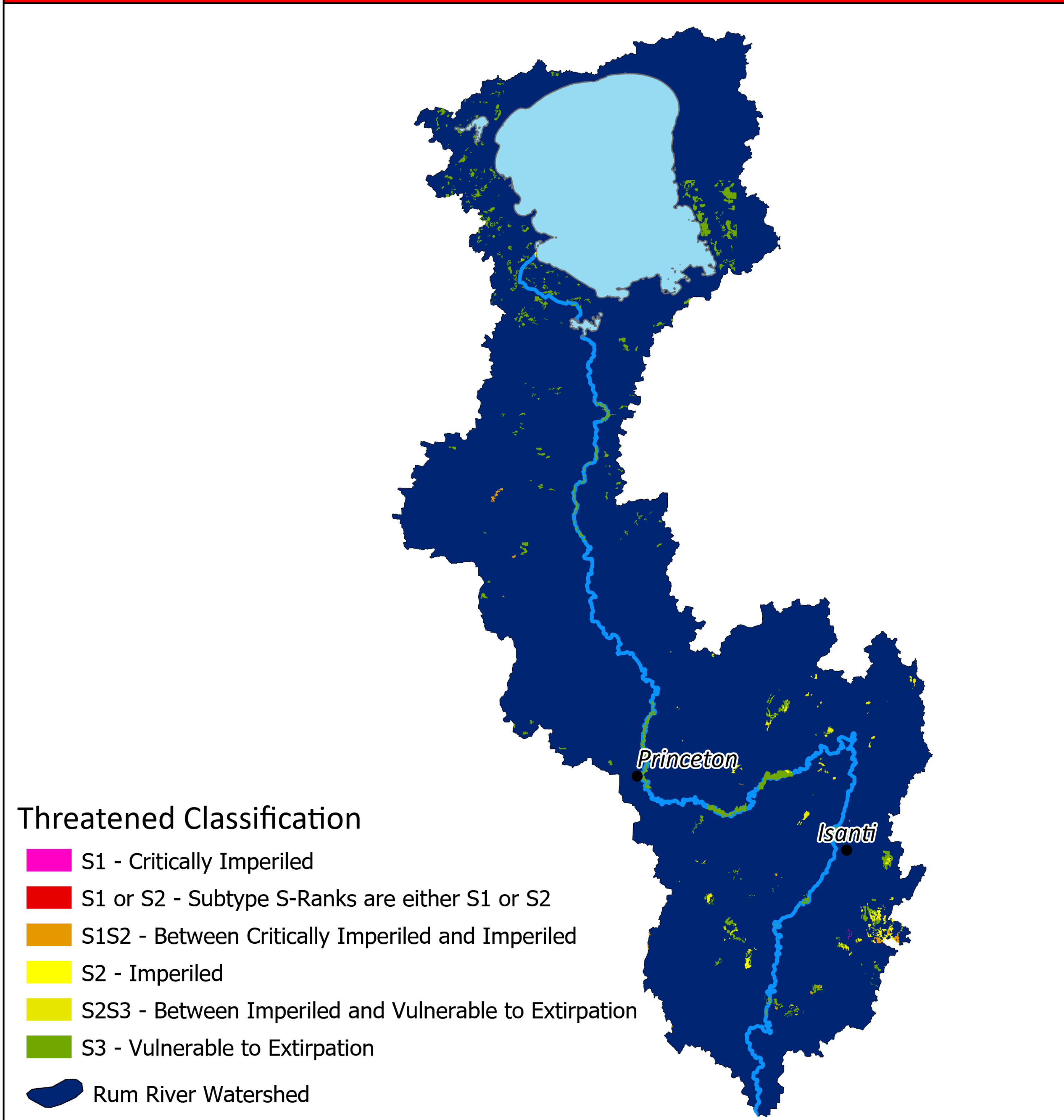


Figure D7: Native Plant Communities (2019)



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Rum River -

Legend: City Watershed River Lake

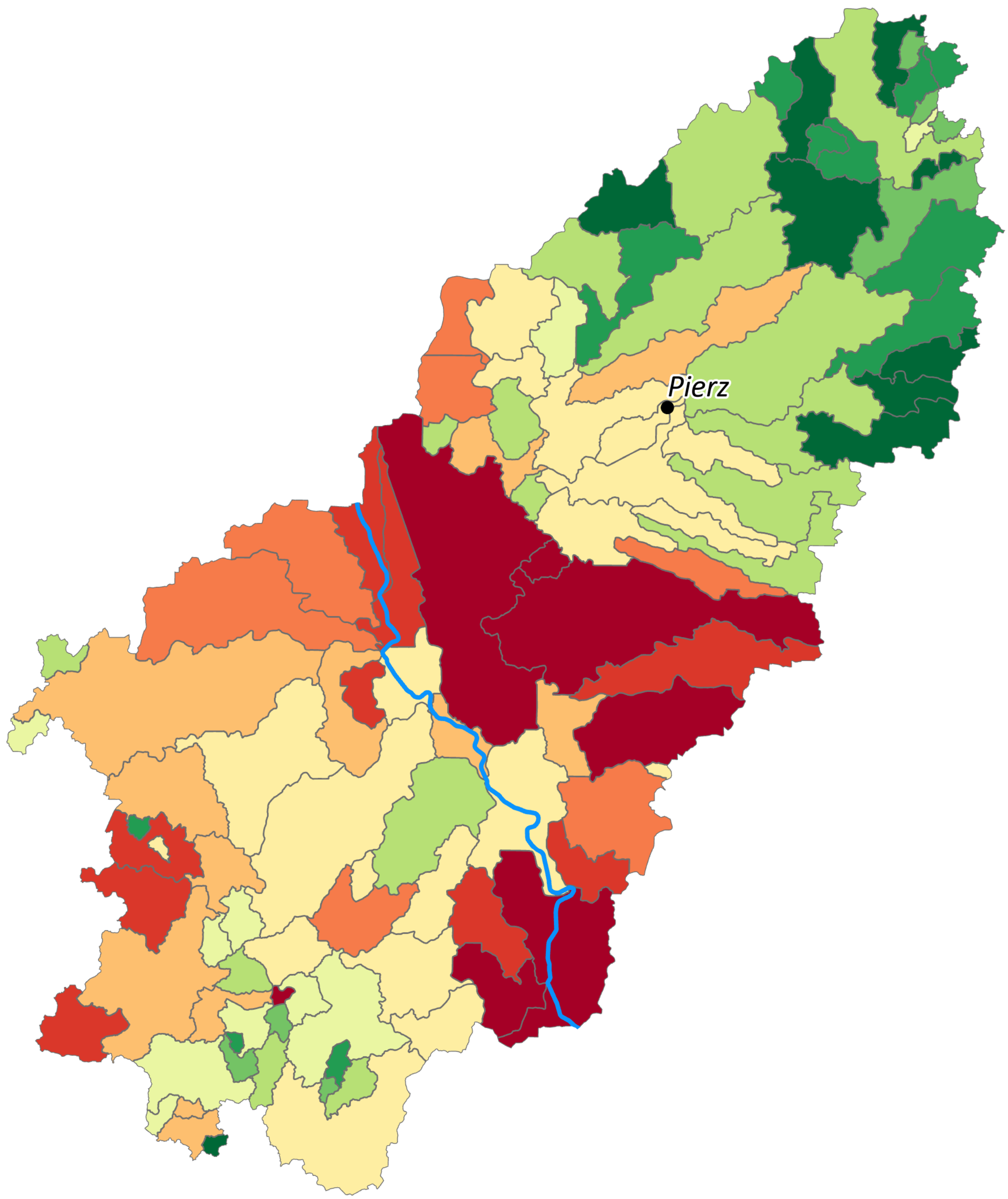
N

Miles
0 2.75 5.5 11

Appendix E

Unweighted Catchment Prioritization

Figure E1: Unweighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

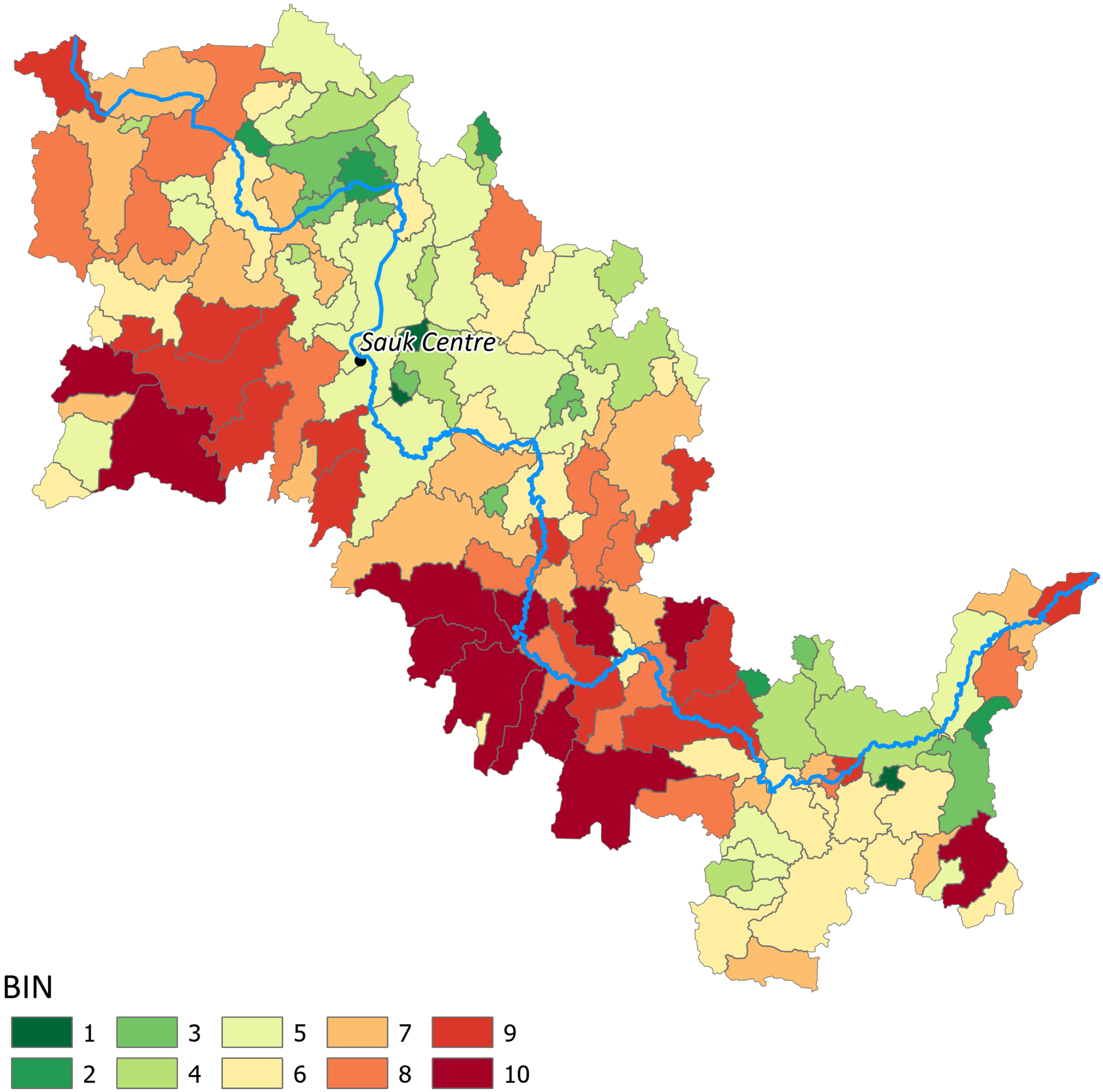
Middle Mississippi River Watershed Wetland Restoration Planning Study
- Mississippi River-Sartell -

Legend: City Watershed River Lake

N

Miles
0 2 4 8

Figure E2: Unweighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

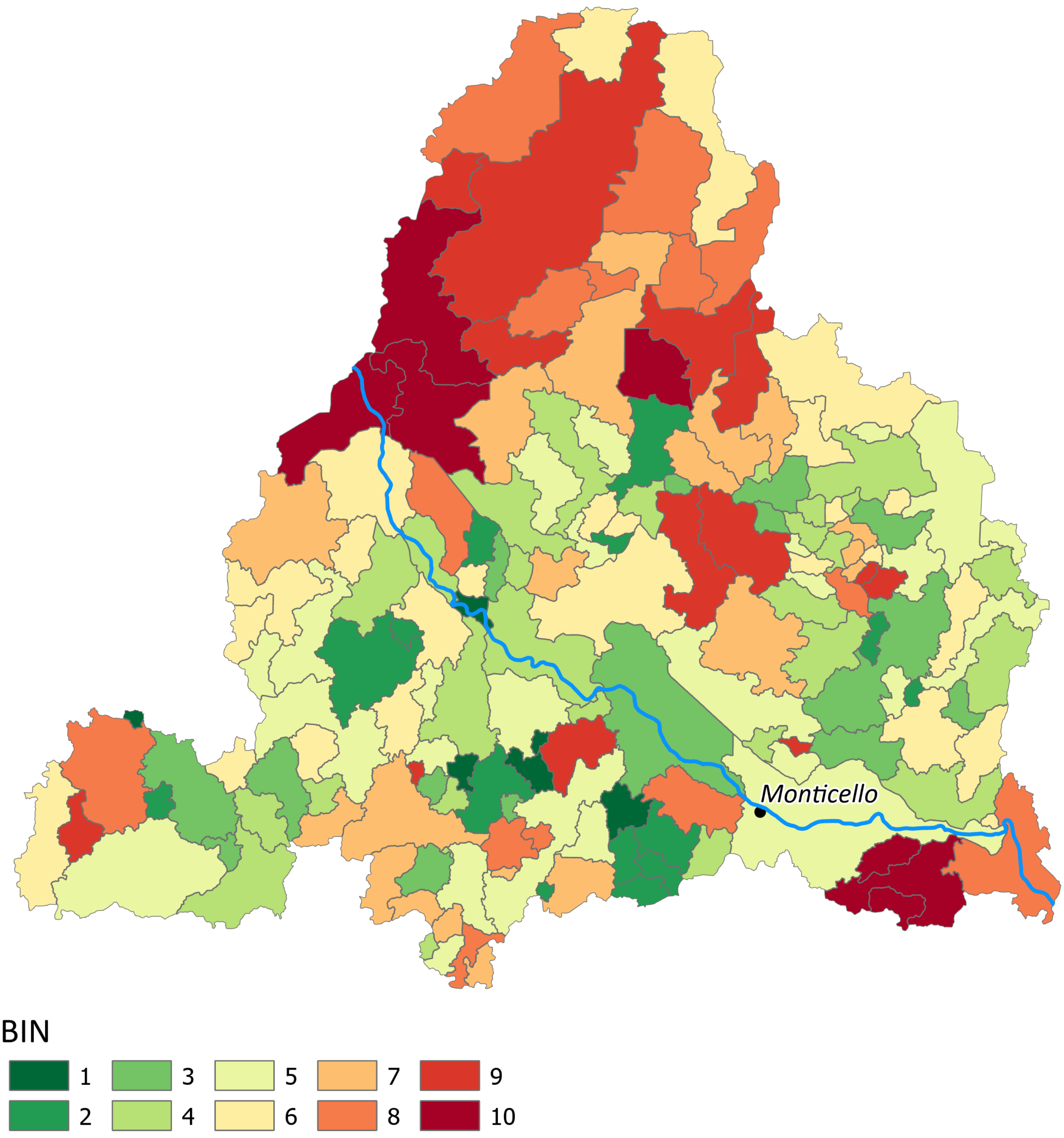
Middle Mississippi River Watershed Wetland Restoration Planning Study - Sauk River -

Legend: City Watershed River Lake

N

Miles
0 2 4 8

Figure E3: Unweighted Catchment Prioritization

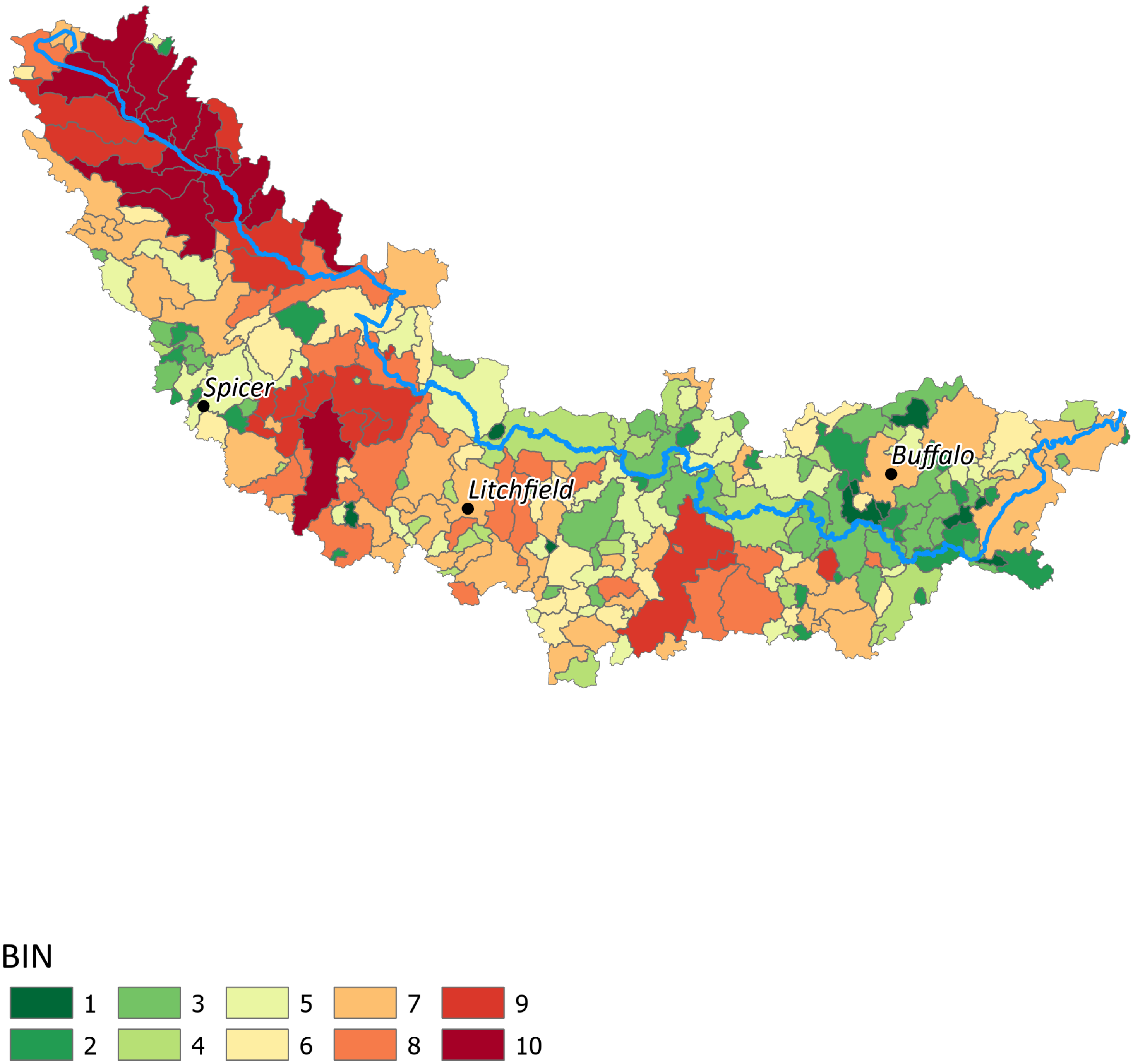


BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Mississippi River-St. Cloud -

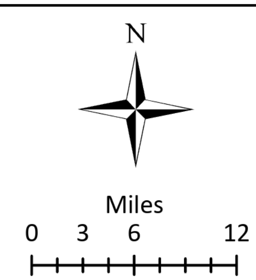
Legend: • City ▢ Watershed River Lake

Figure E4: Unweighted Catchment Prioritization



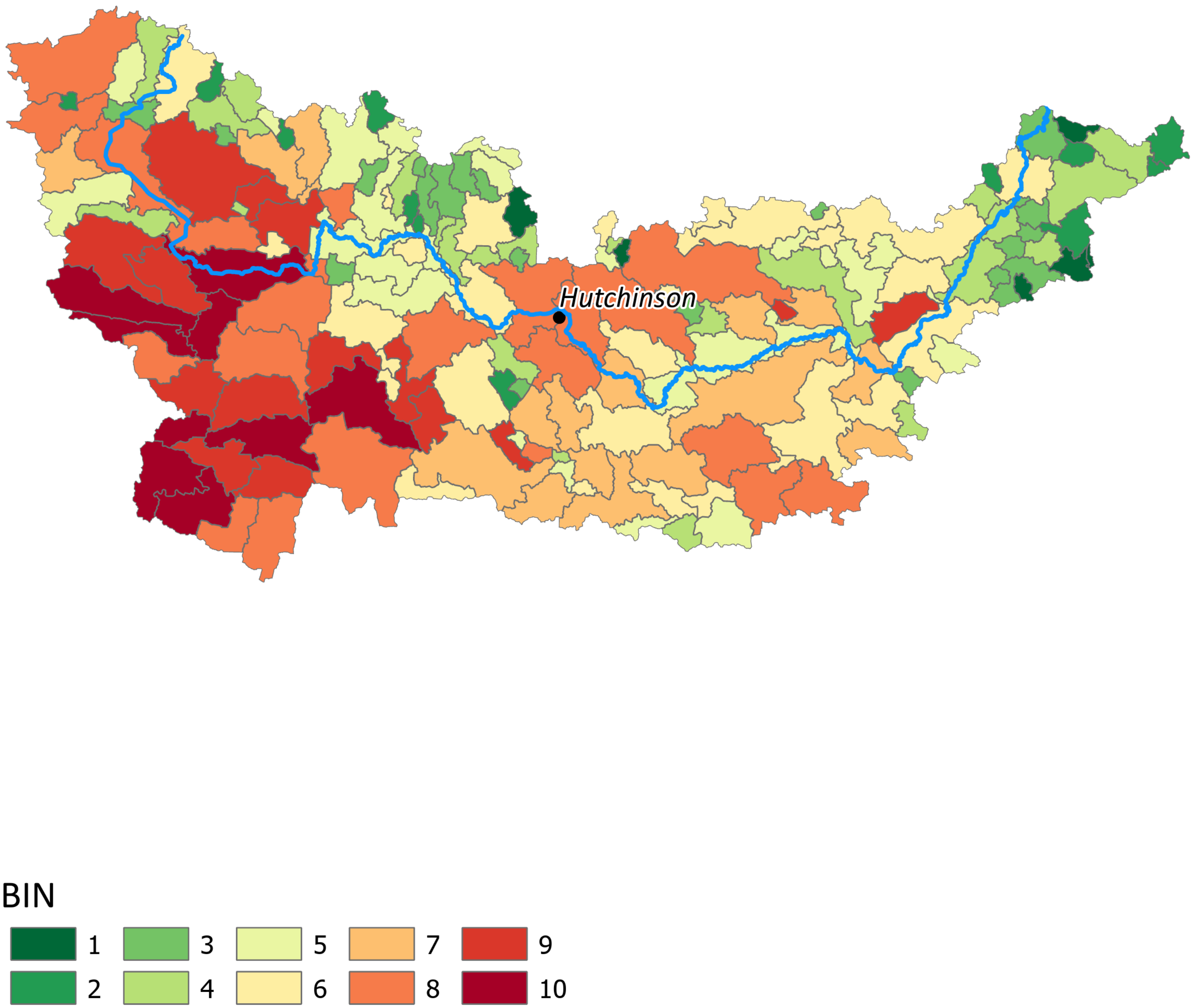
Middle Mississippi River Watershed Wetland Restoration Planning Study
- North Fork Crow River -

Legend: City Watershed River Lake



BOARD OF WATER AND SOIL RESOURCES

Figure E5: Unweighted Catchment Prioritization

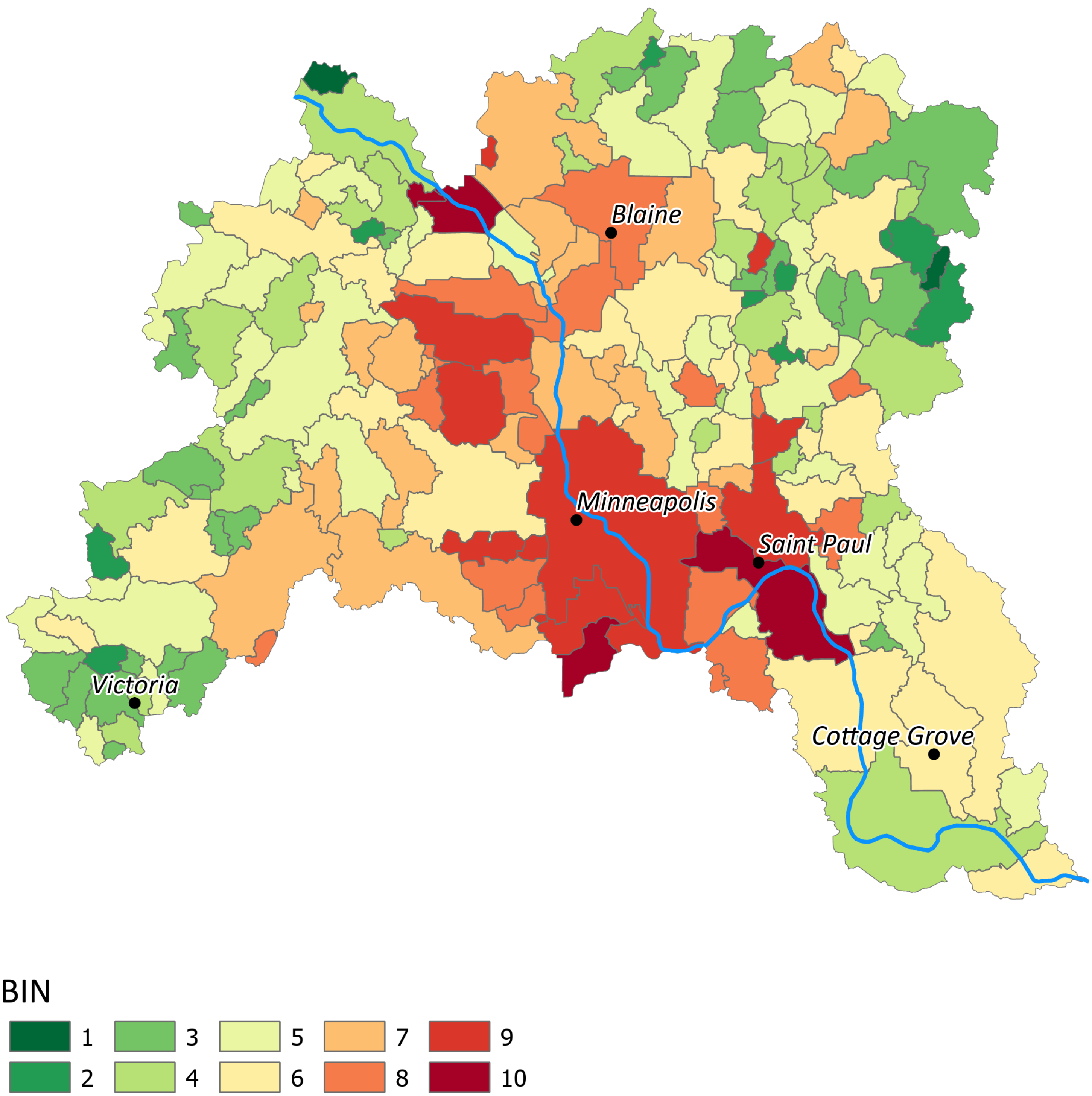


Middle Mississippi River Watershed Wetland Restoration Planning Study - South Fork Crow River -

Legend: City Watershed River Lake

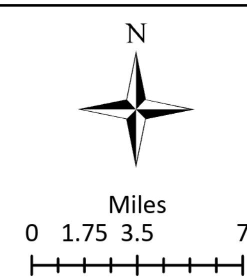
BOARD OF WATER AND SOIL RESOURCES

Figure E6: Unweighted Catchment Prioritization



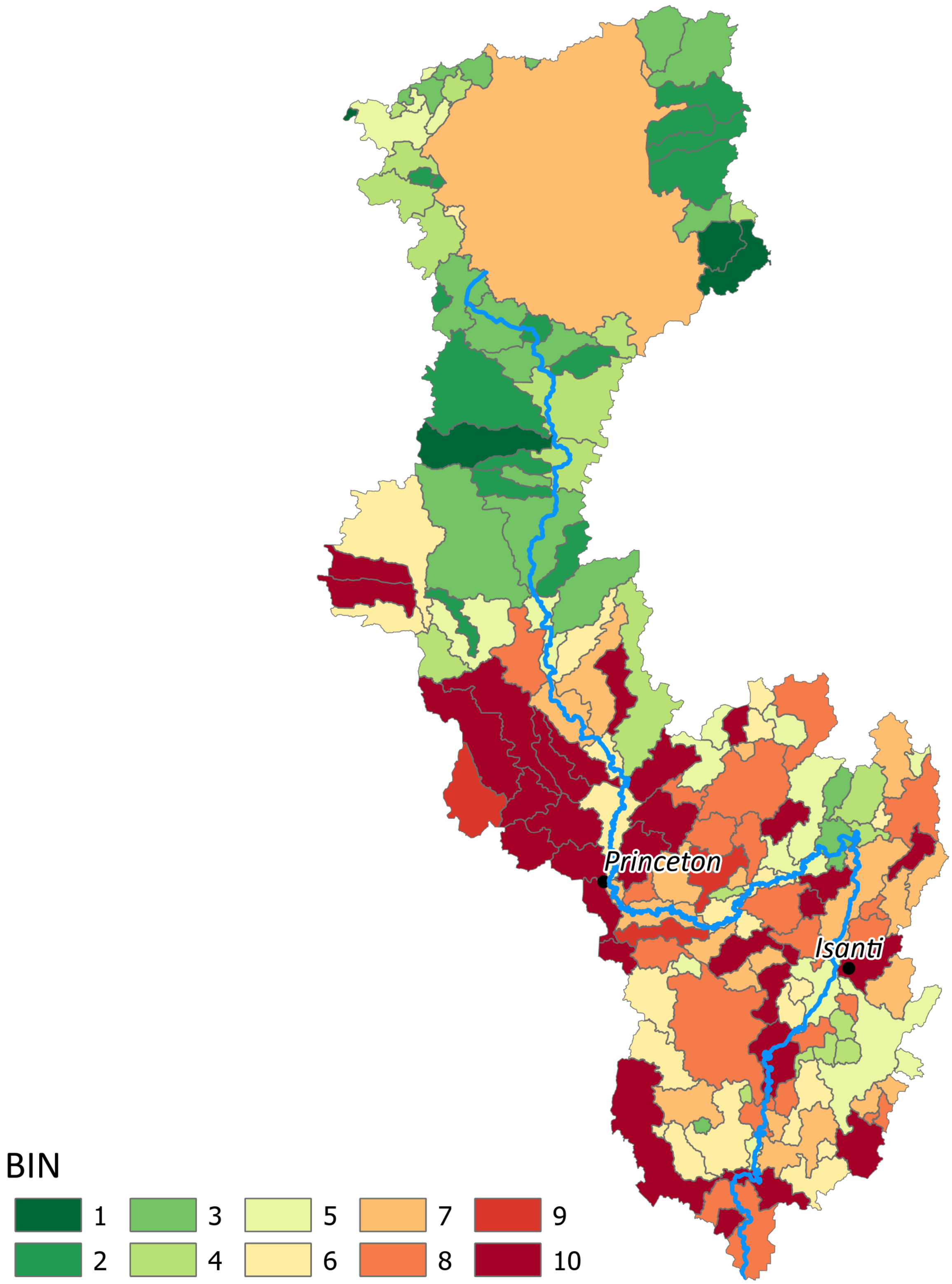
Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Twin Cities -

Legend: City Watershed River Lake



BOARD OF WATER AND SOIL RESOURCES

Figure E7: Unweighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

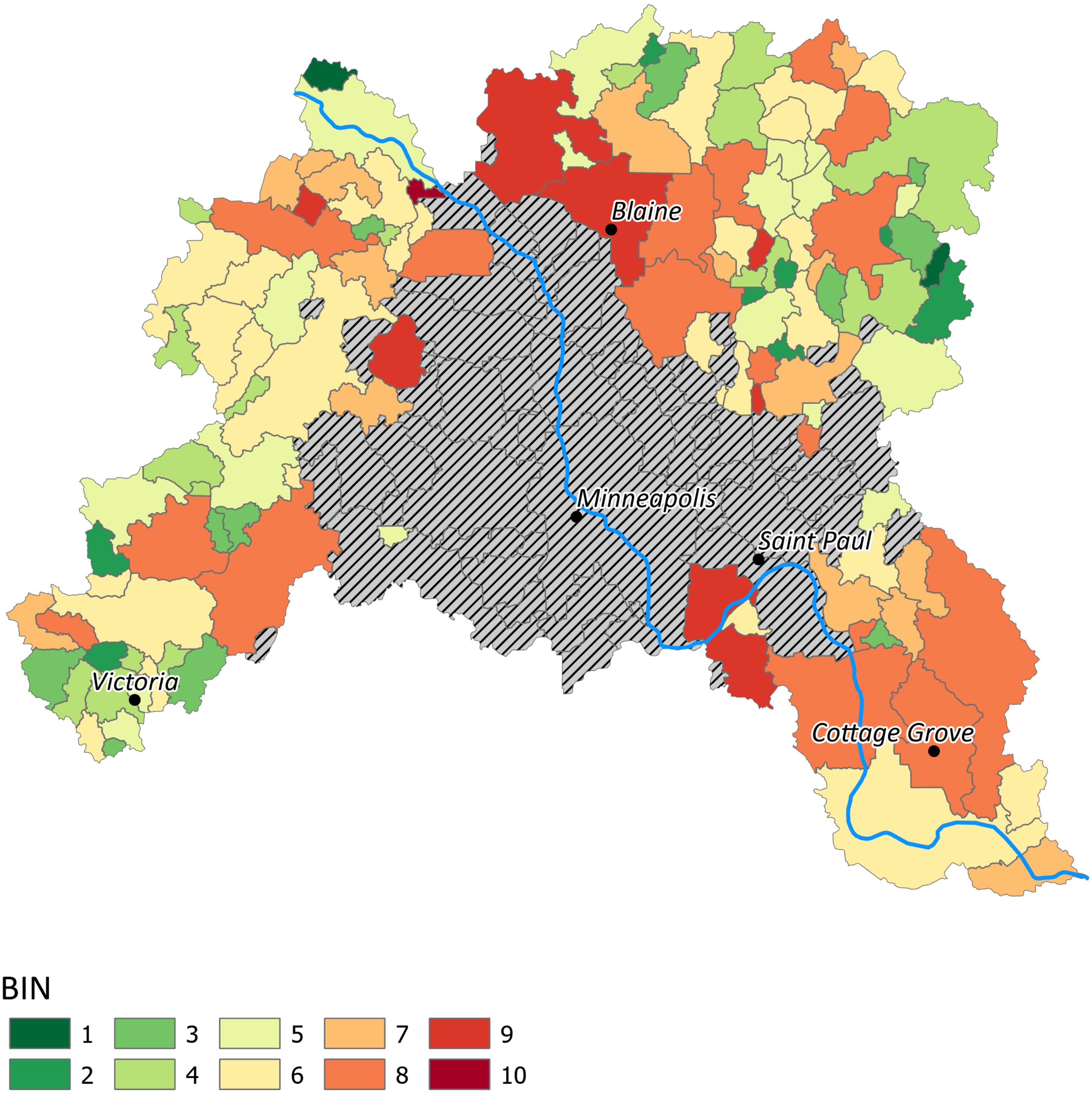
Middle Mississippi River Watershed Wetland Restoration Planning Study
- Rum River -

Legend: City | Watershed | River | Lake

N

Miles
0 2.75 5.5 11

Figure E8: Updated Unweighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Twin Cities -

Legend: City Watershed River Removed Catchment

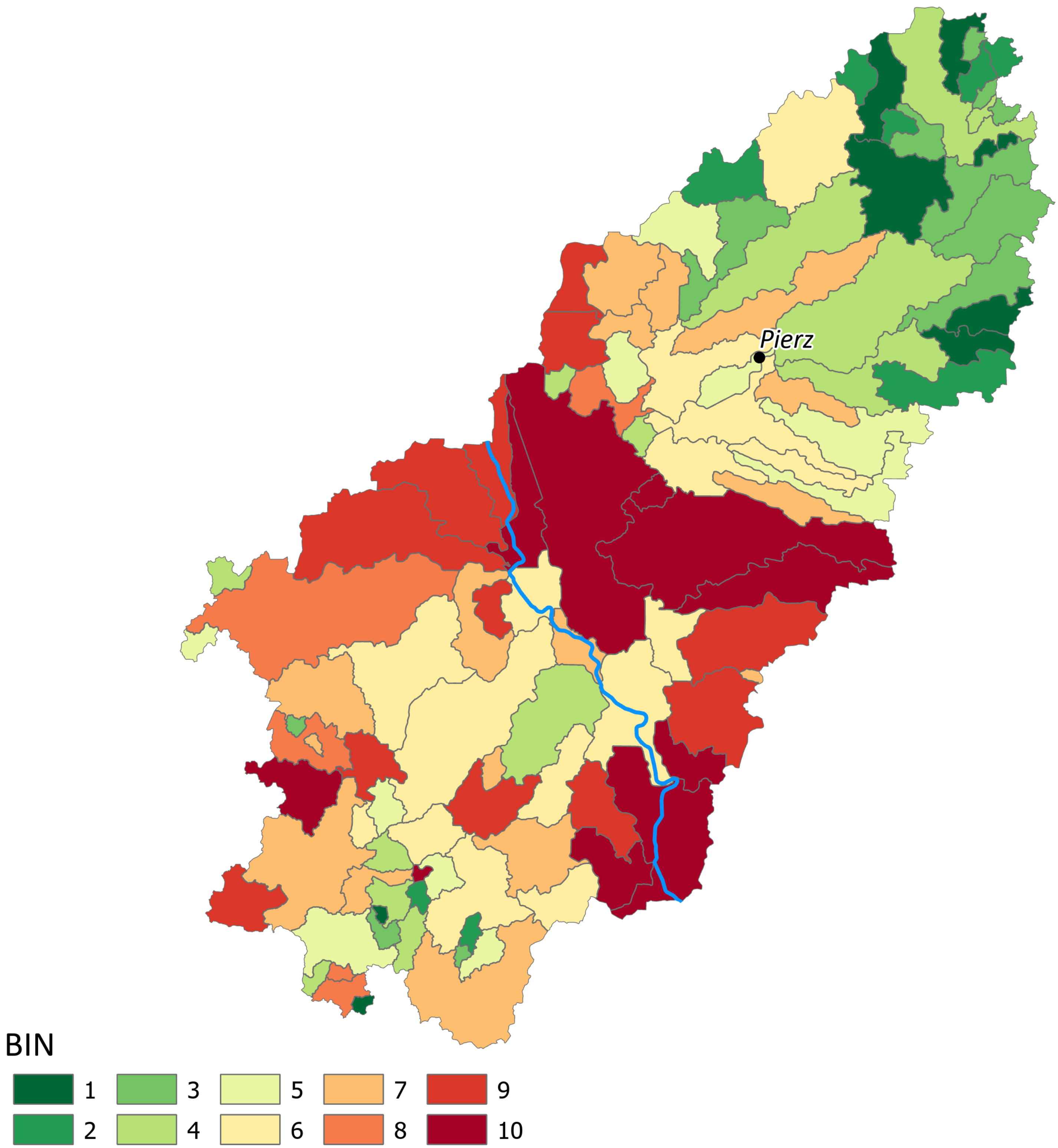
N

Miles
0 1.75 3.5 7

Appendix F

Weighted Catchment Prioritization

Figure F1: Weighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

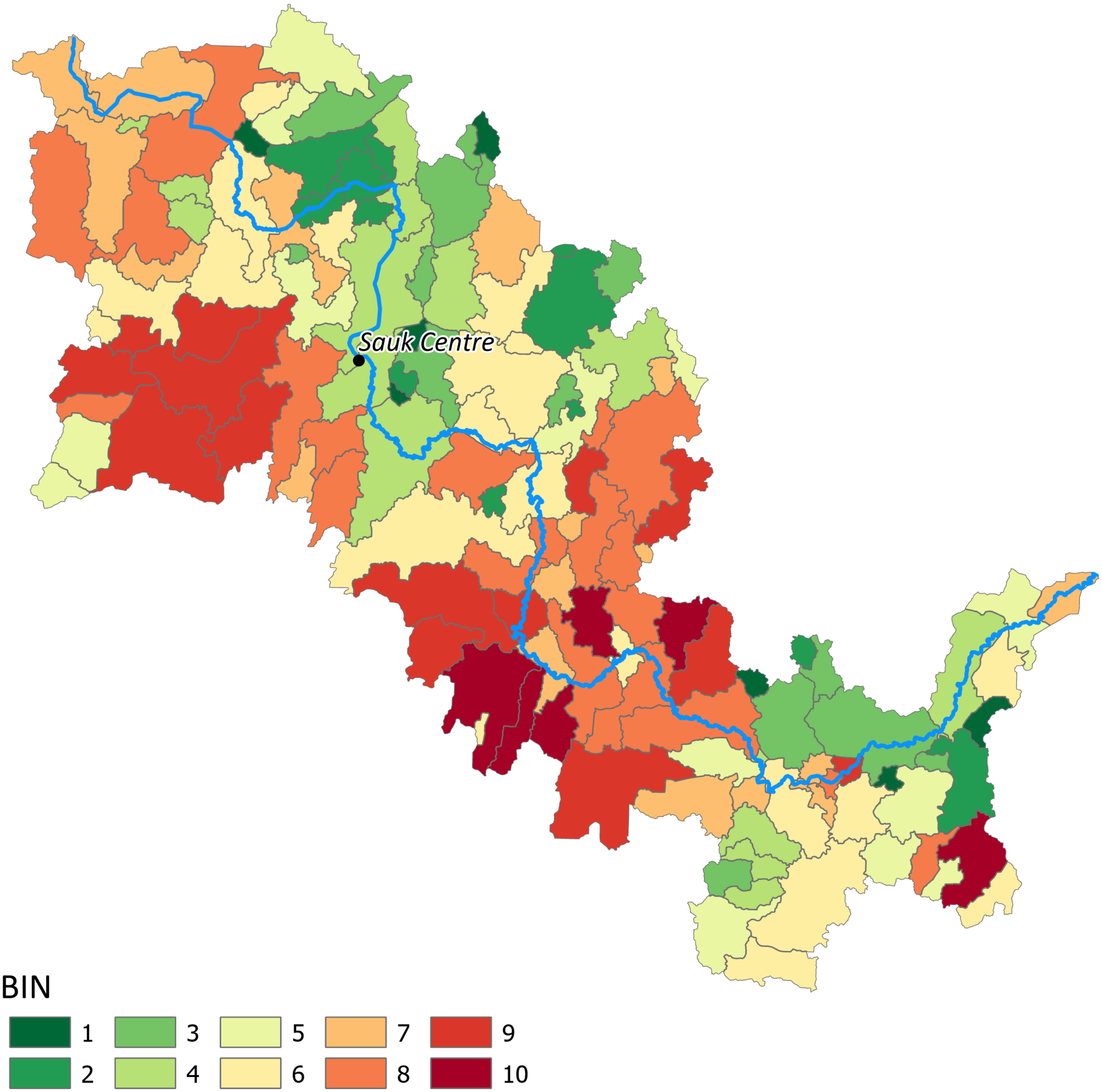
Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Sartell -

Legend: City Watershed River Lake

N

Miles
0 2 4 8

Figure F2: Weighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

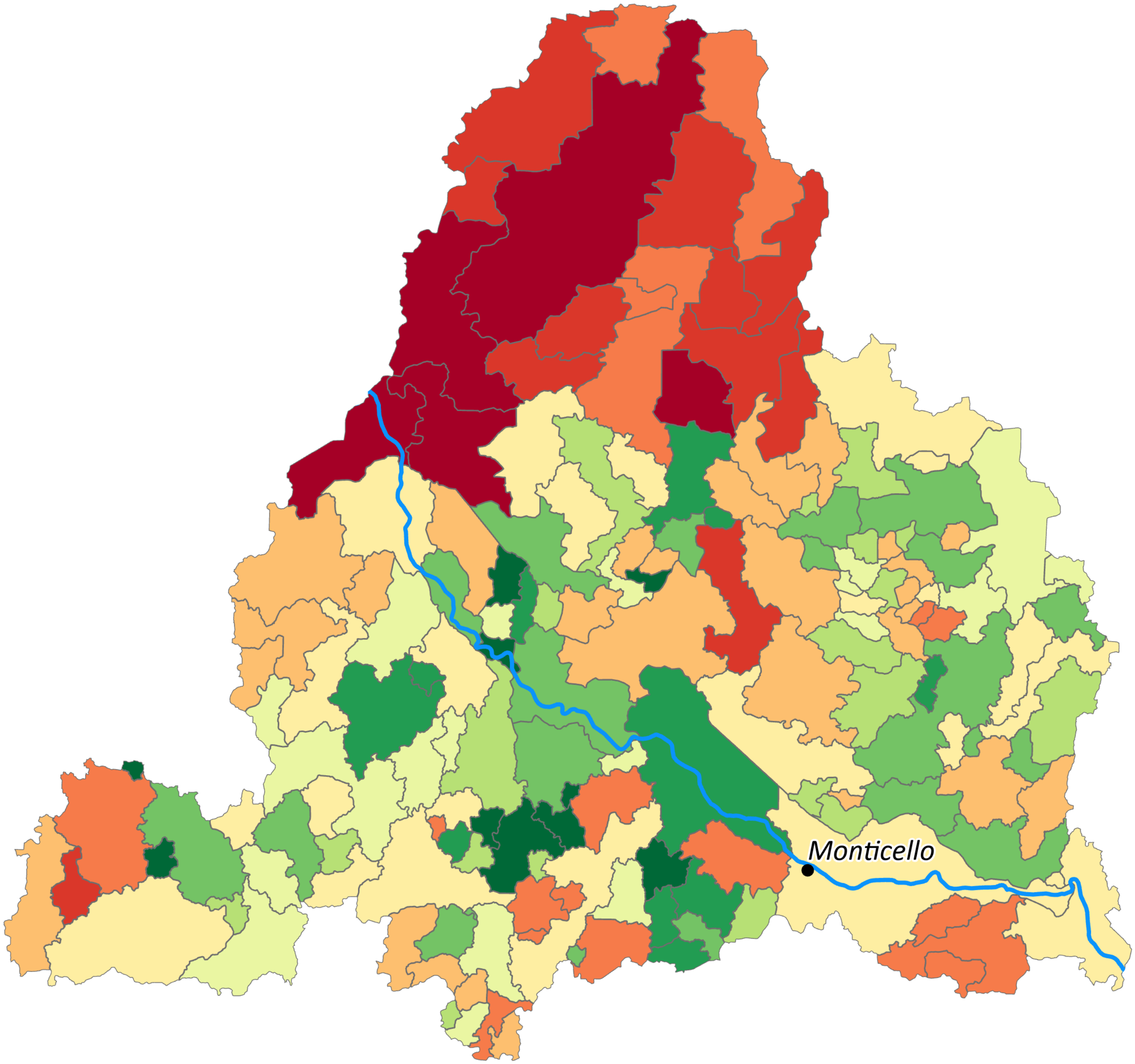
Middle Mississippi River Watershed Wetland Restoration Planning Study - Sauk River -

Legend: City Watershed River Lake

N

Miles
0 2 4 8

Figure F3: Weighted Catchment Prioritization



BIN

1	3	5	7	9
2	4	6	8	10

BOARD OF WATER AND SOIL RESOURCES

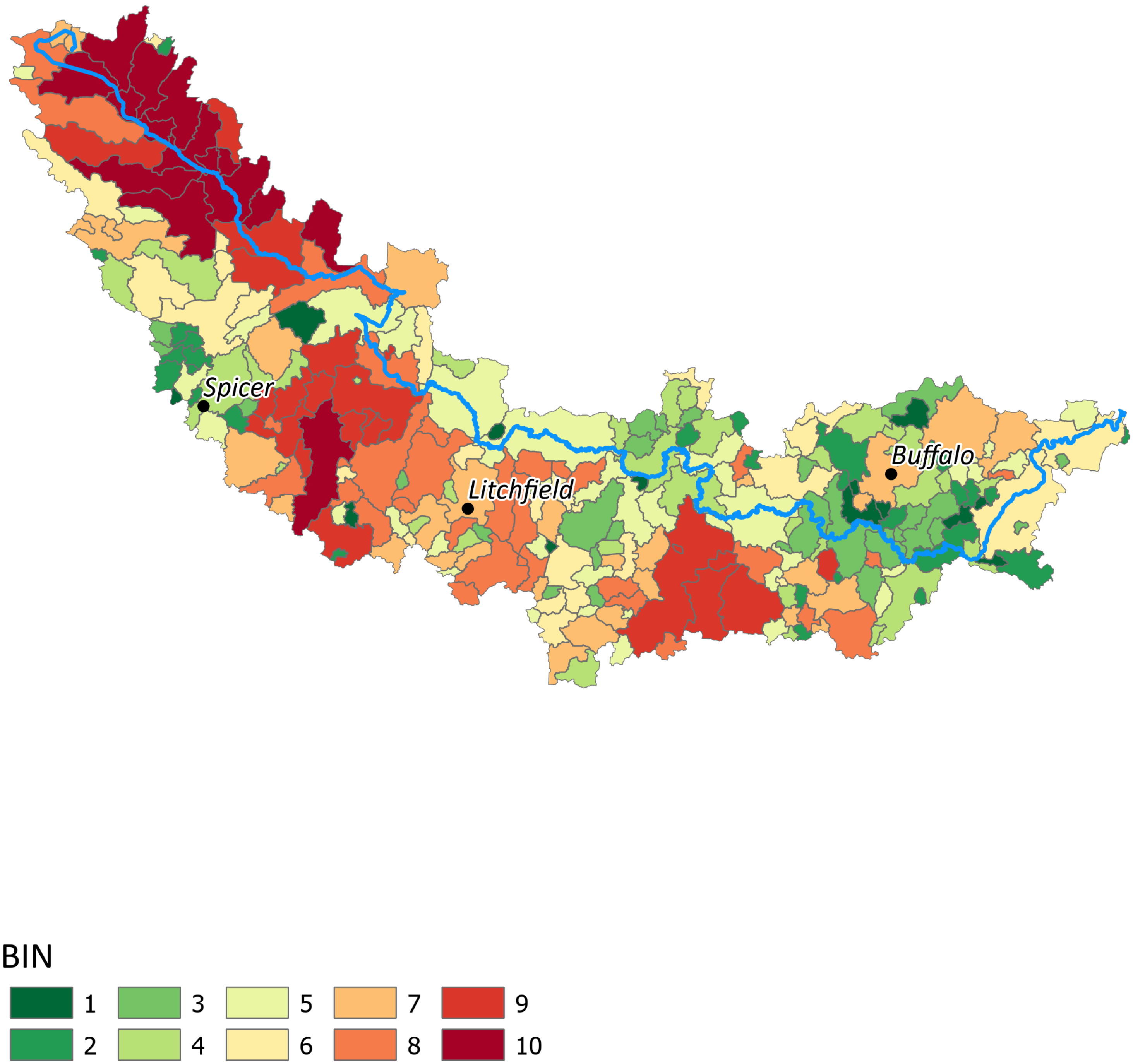
Middle Mississippi River Watershed Wetland Restoration Planning Study
- Mississippi River-St. Cloud -

Legend: City, Watershed, River, Lake

N

Miles
0 1.75 3.5 7

Figure F4: Weighted Catchment Prioritization



BOARD OF WATER
AND SOIL RESOURCES

Middle Mississippi River Watershed
Wetland Restoration Planning Study
- North Fork Crow River -

Legend: City Watershed River Lake

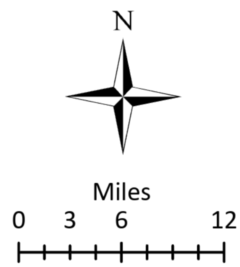
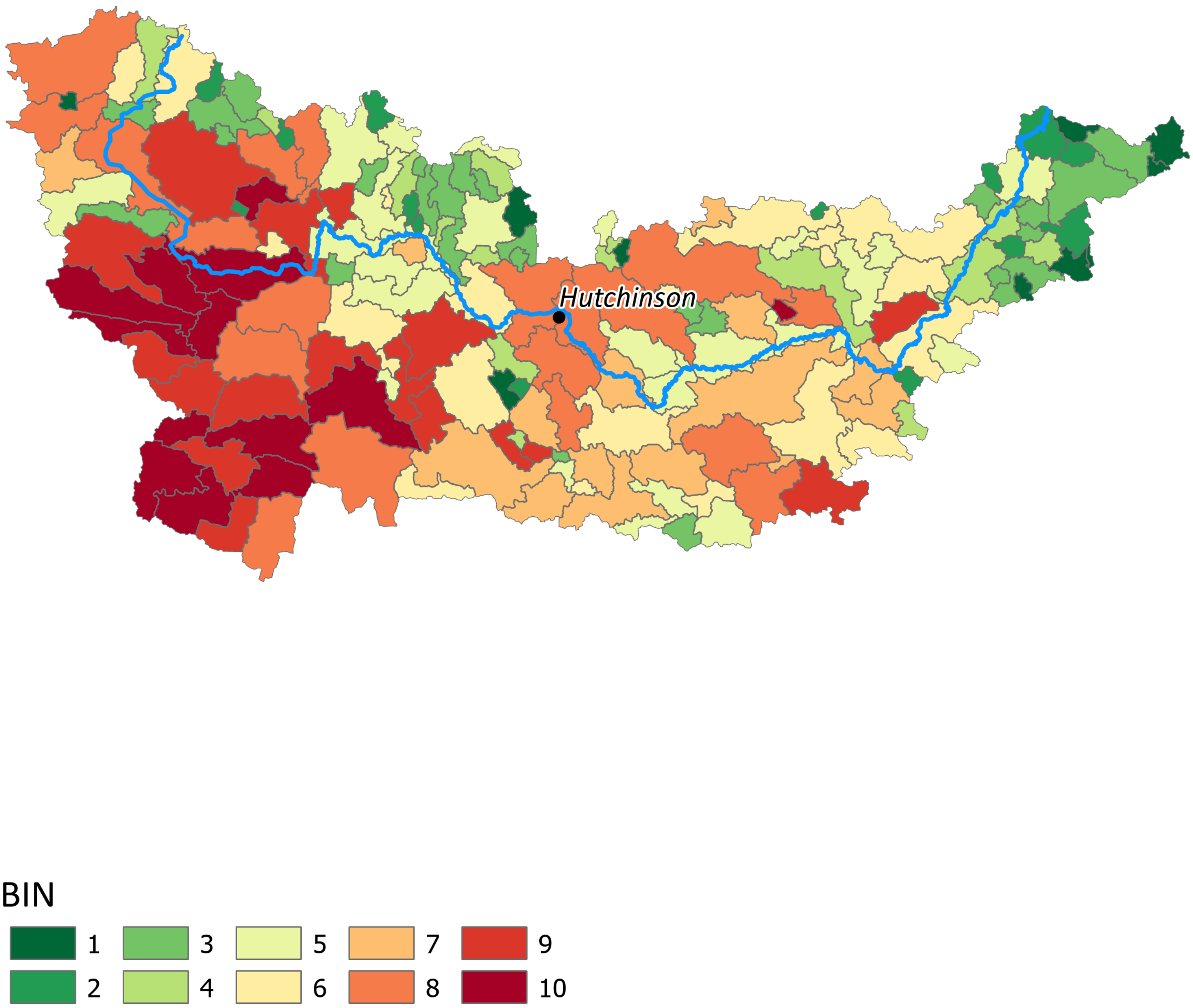


Figure F5: Weighted Catchment Prioritization

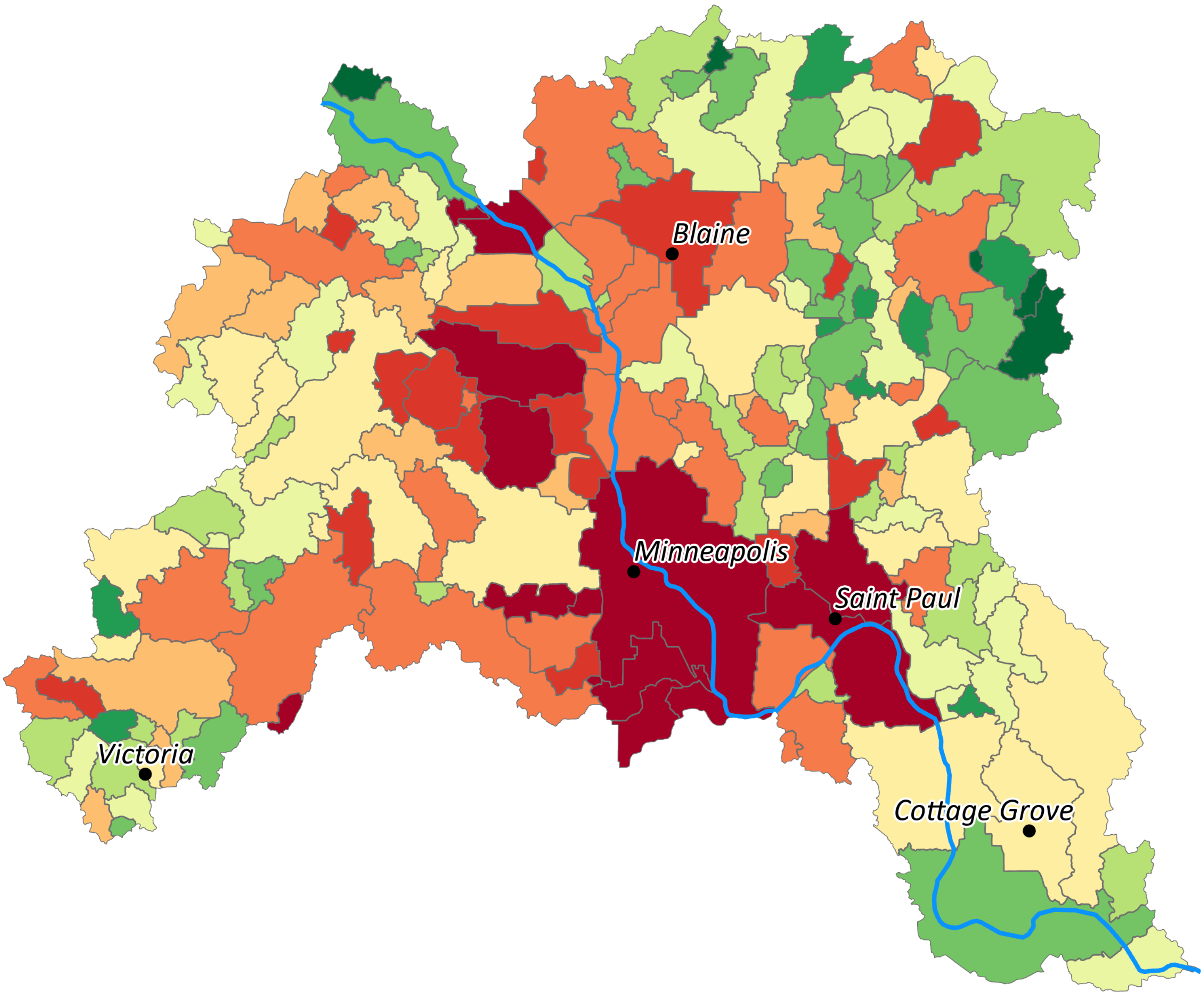


Middle Mississippi River Watershed
Wetland Restoration Planning Study
- South Fork Crow River -

Legend: City Watershed River Lake

BOARD OF WATER AND SOIL RESOURCES

Figure F6: Weighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

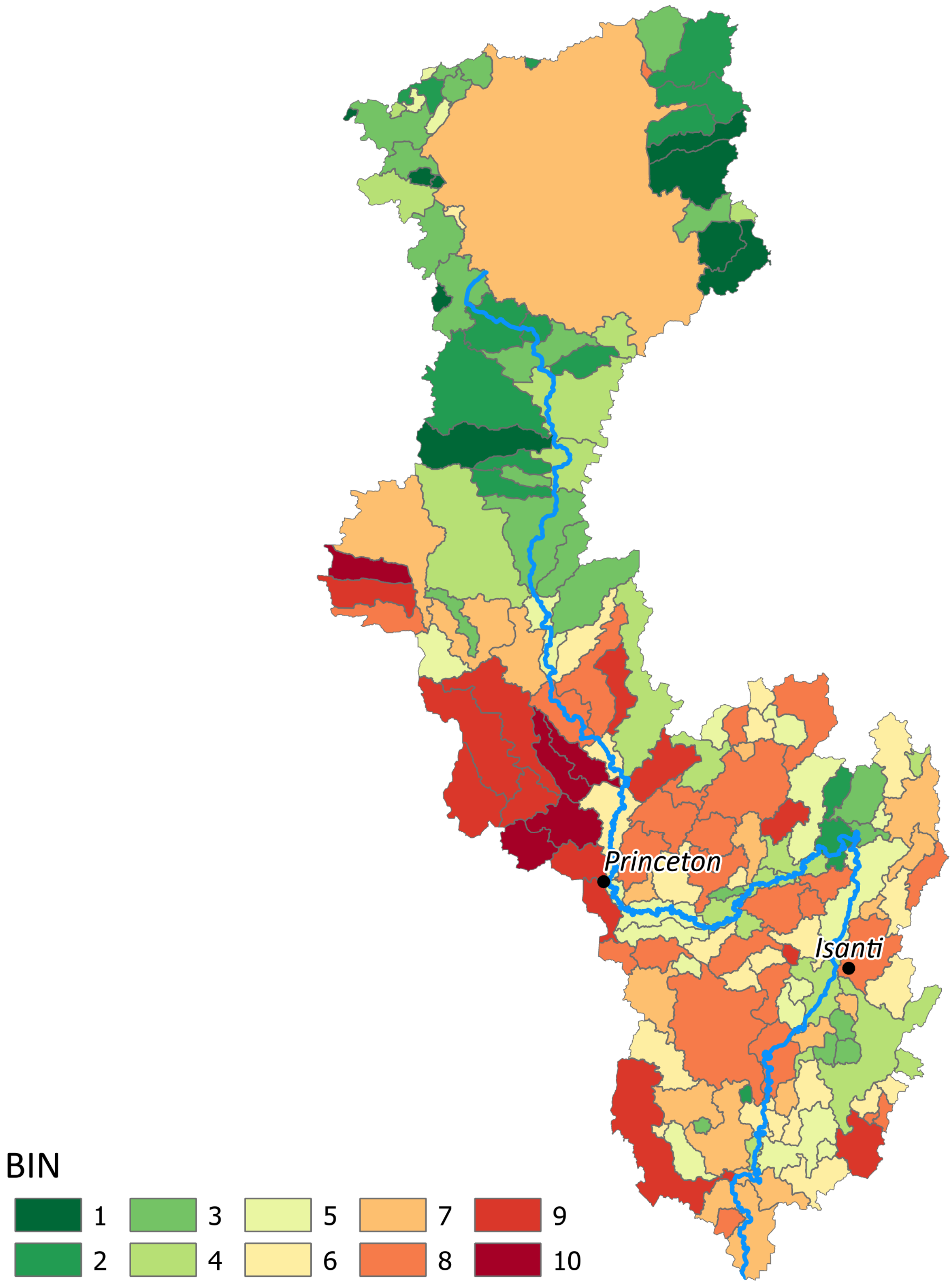
Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Twin Cities -

Legend: City Watershed River Lake

N

Miles
0 1.75 3.5 7

Figure F7: Weighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study - Rum River -

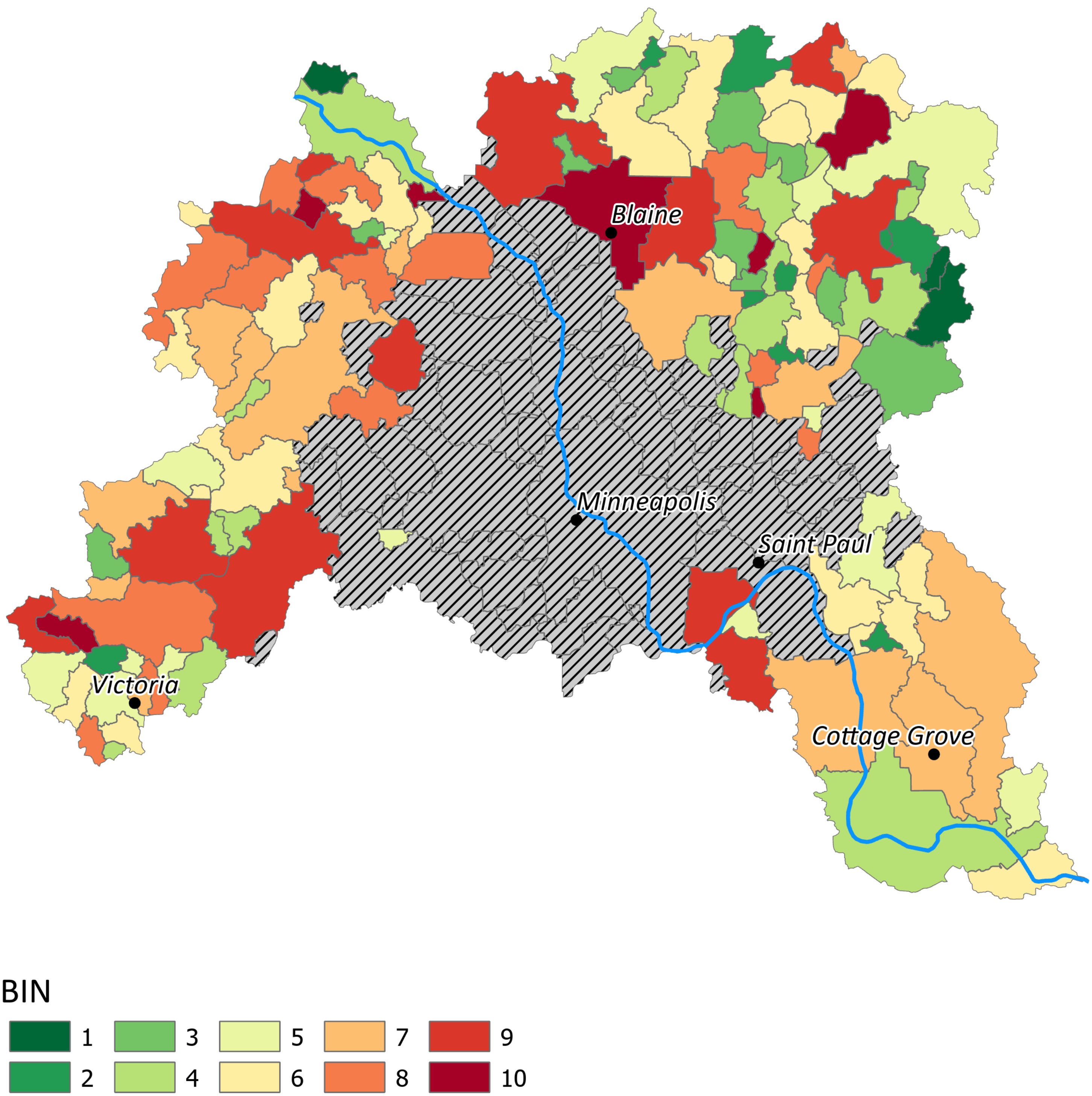
Legend: ● City · Watershed · River · Lake

N

Miles

0 2.75 5.5 11

Figure F8: Updated Weighted Catchment Prioritization



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Mississippi River-Twin Cities -

Legend: City | Watershed | River | Removed Catchment

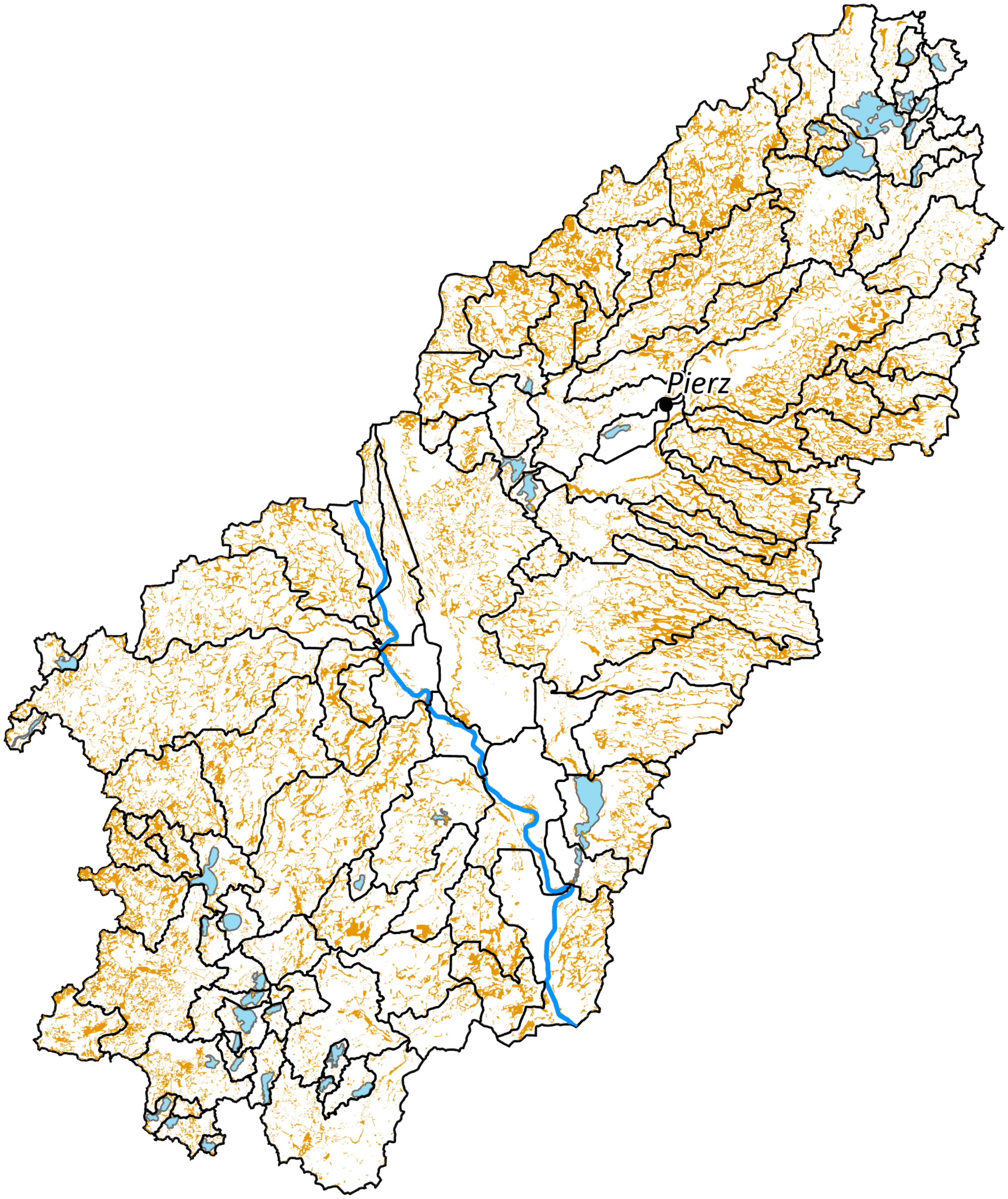
N

Miles
0 1.75 3.5 7

Appendix G

Historic Wetland Loss

Figure G1: Historic Wetland Loss



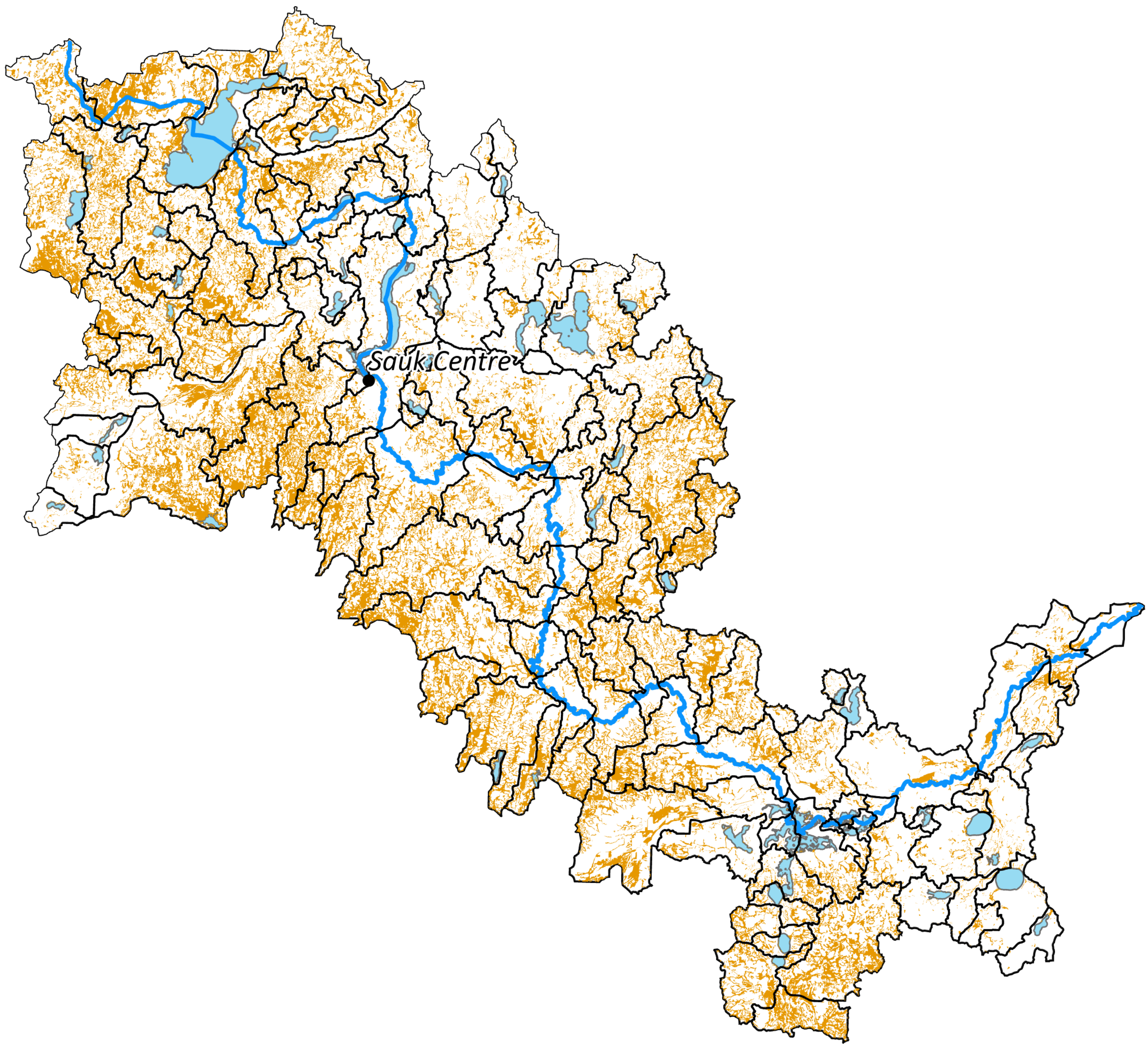
Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Sartell -

Legend: • City, Watershed, River, Lake

N

Miles 0 2 4 8

Figure G2: Historic Wetland Loss



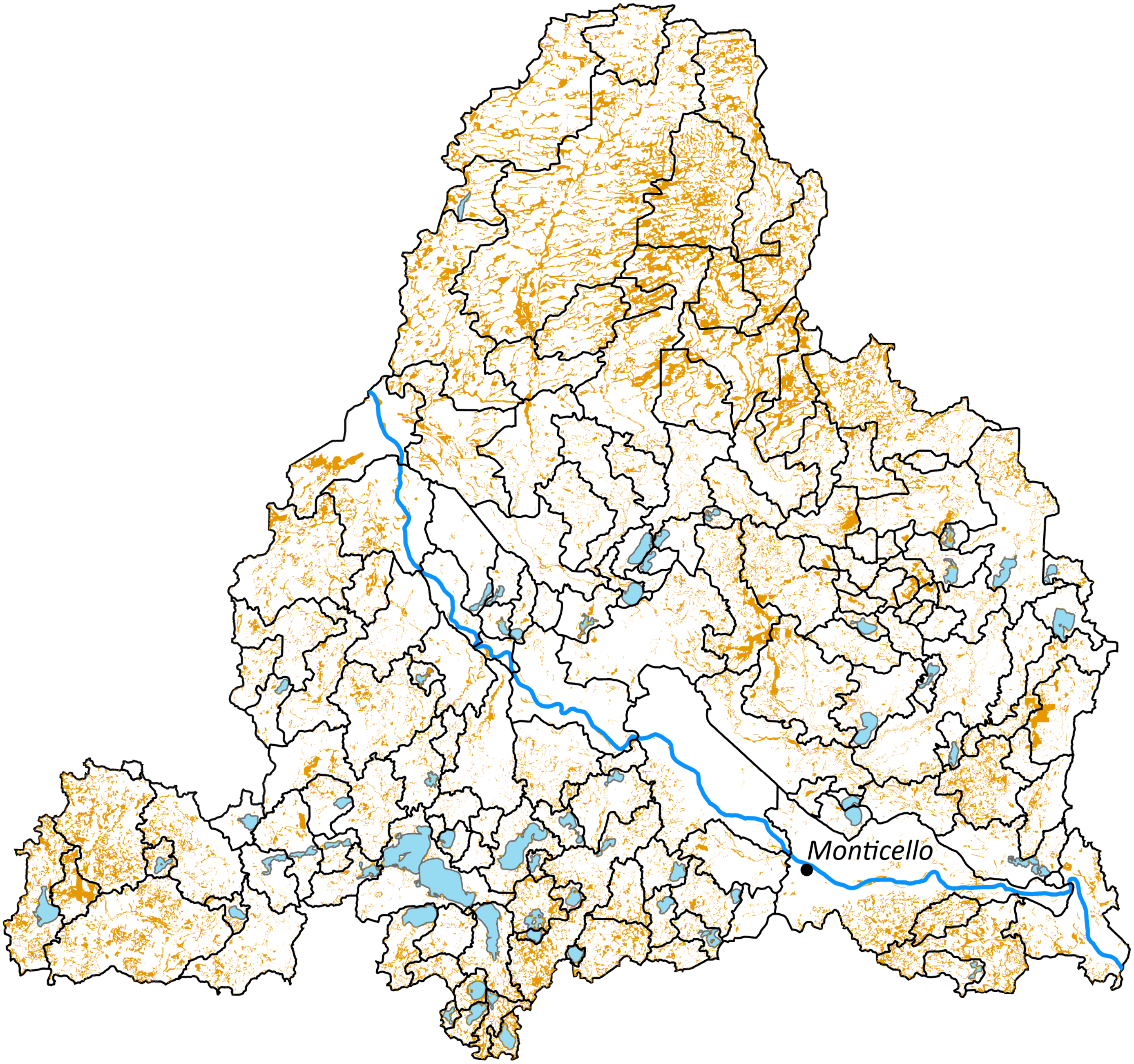
BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Sauk River -

Legend: City, Watershed, River, Lake

N
Miles
0 2 4 8

Figure G3: Historic Wetland Loss



Historic Wetlands

Middle Mississippi River Watershed
Wetland Restoration Planning Study
- Mississippi River-St. Cloud -

Legend: City | Catchment | River | Lake

BOARD OF WATER AND SOIL RESOURCES

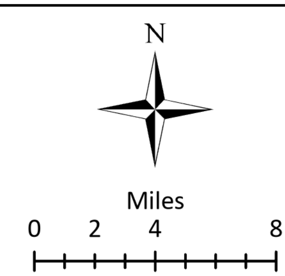
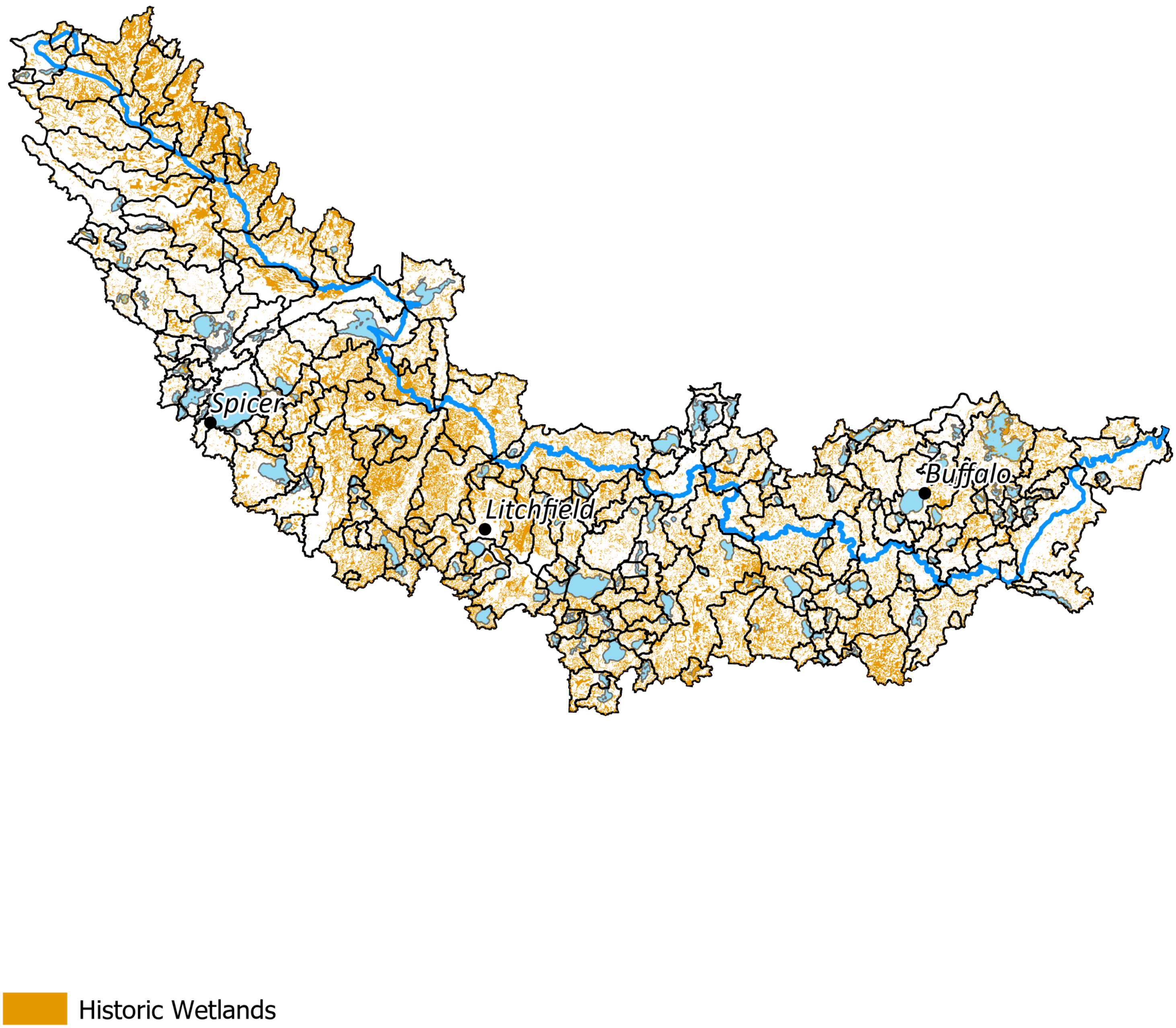


Figure G4: Historic Wetland Loss



BOARD OF WATER AND SOIL RESOURCES

Middle Mississippi River Watershed Wetland Restoration Planning Study

- North Fork Crow River -

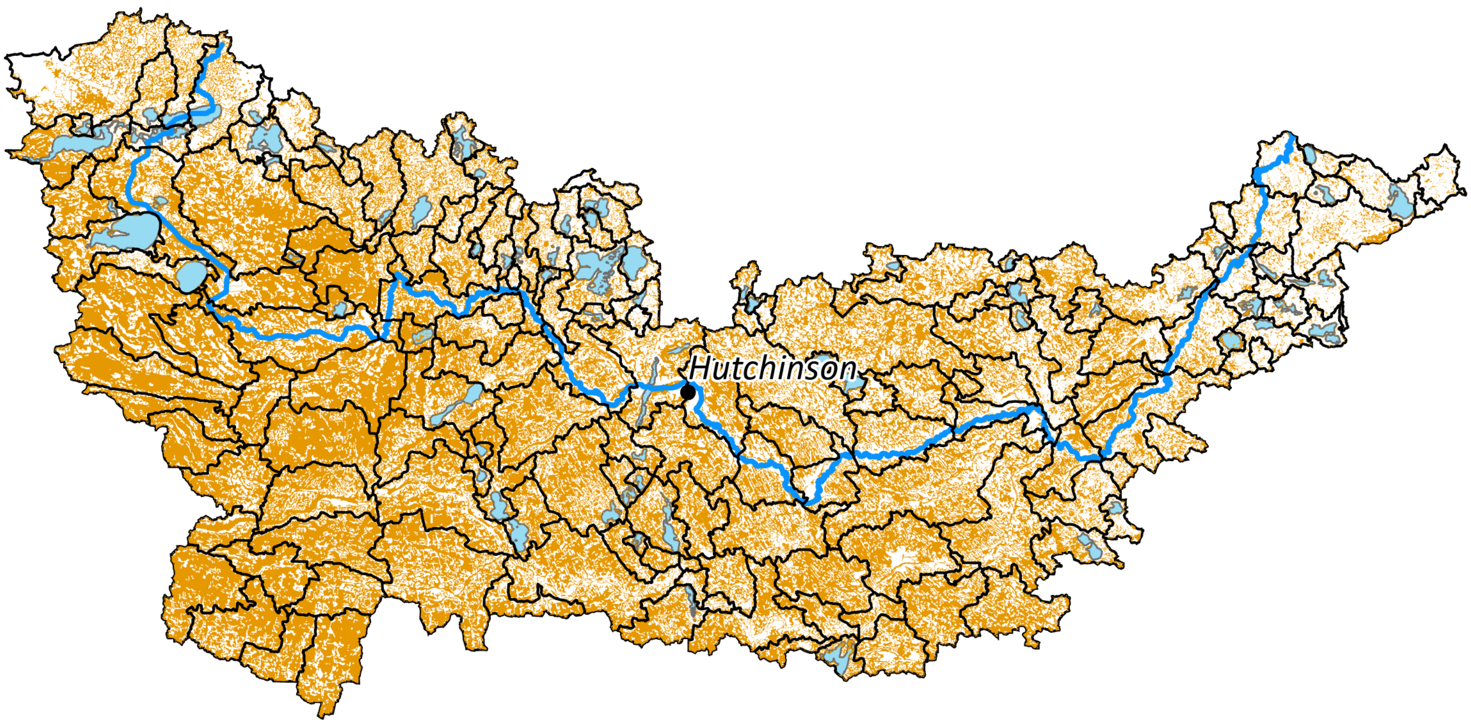
Legend: • City, Catchment, River, Lake

N

Miles

0 3.25 6.5 13

Figure G5: Historic Wetland Loss



BOARD OF WATER AND SOIL RESOURCES

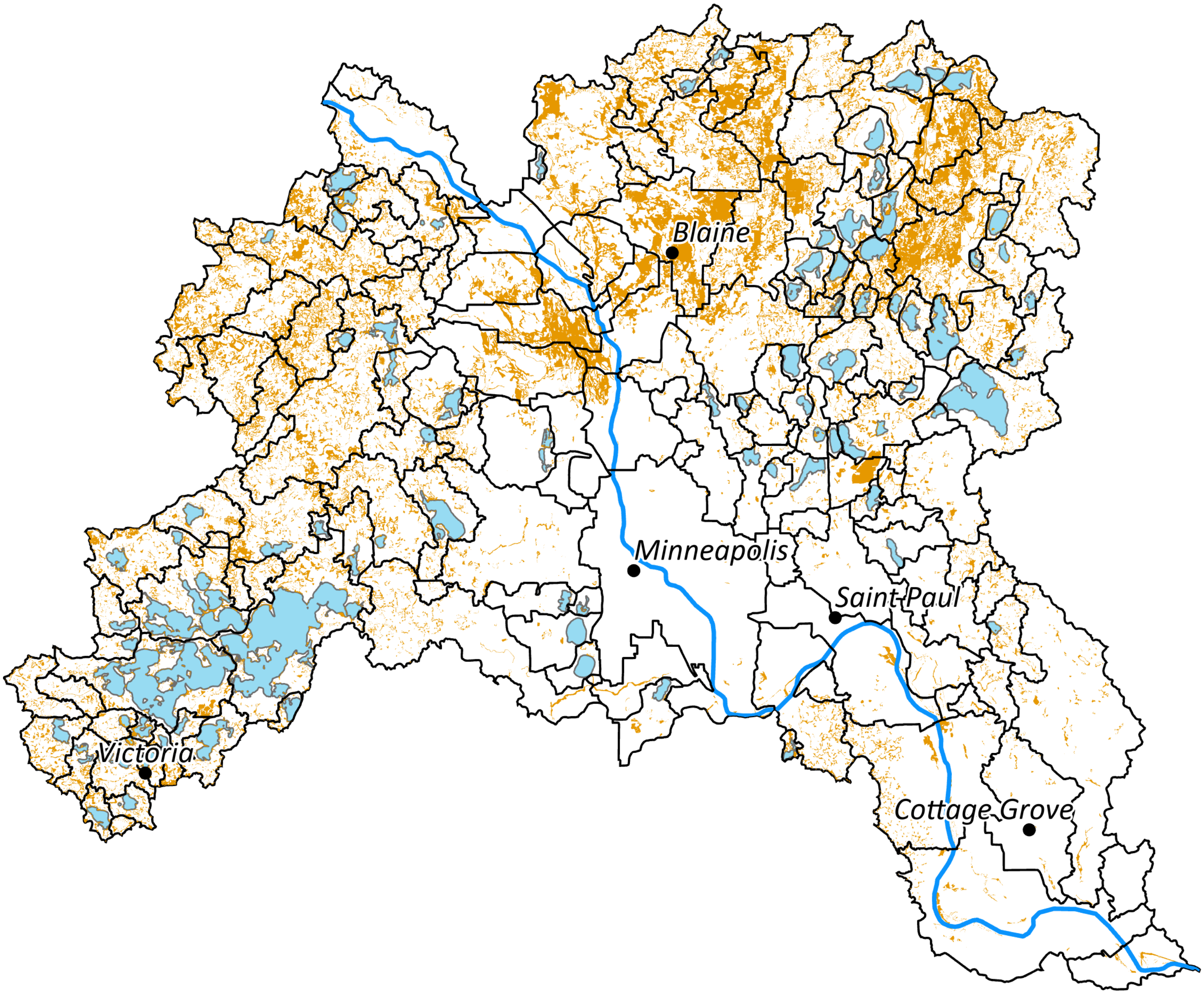
Middle Mississippi River Watershed
Wetland Restoration Planning Study
- South Fork Crow River -

Legend: City Watershed River Lake

N

Miles
0 2.5 5 10

Figure G6: Historic Wetland Loss



Middle Mississippi River Watershed Wetland Restoration Planning Study - Mississippi River-Twin Cities -

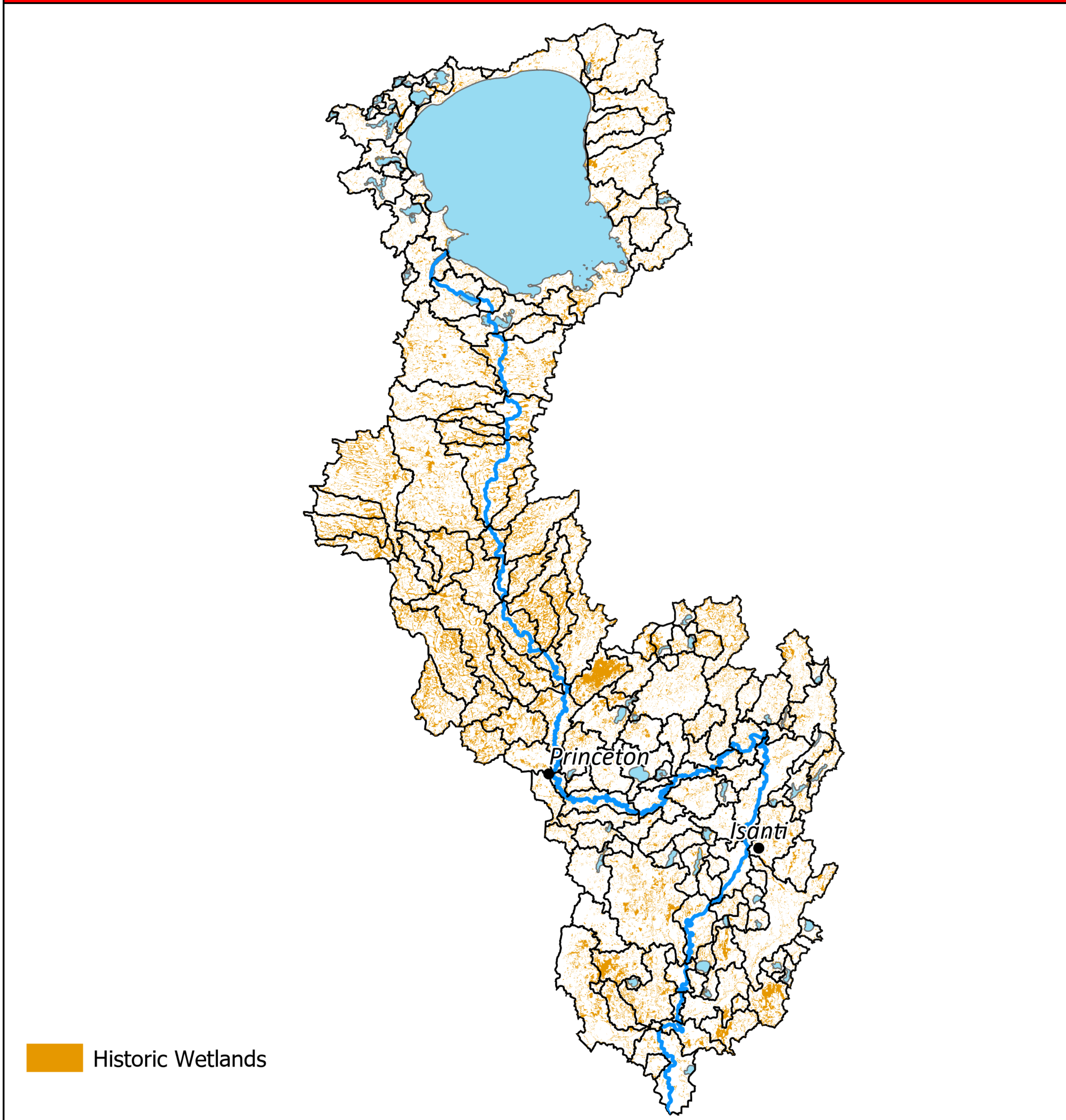
Legend: City, Catchment, River, Lake

Miles
0 1.75 3.5 7

N

BOARD OF WATER AND SOIL RESOURCES

Figure G7: Historic Wetland Loss



Middle Mississippi River Watershed Wetland Restoration Planning Study
- Rum River -

Legend: City | Catchment | River | Lake

N

Miles
0 3.25 6.5 13

BOARD OF WATER AND SOIL RESOURCES