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The Flint River South Branch Headwaters Watershed Functional Wetland Assessment

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This assessment was developed to serve as a watershed-level analysis of wetland function in the Flint River South Branch Watershed (FRSBW). Previous assessments of wetlands in the FRSBW relied on simple calculation of area gained and lost over time. This assessment seeks a detailed understanding of the functional changes in the wetland communities of the FRSBW from 1800 to 1998. Watershed scale assessments of wetland functions rely on geospatial data and geographic information systems (GIS). The analysis was based on landscape and watershed-level functional wetland assessment methods developed by the United States Fish and Wildlife Service (USFWS) in the Northeastern US. These methods involved enhancing the National Wetland Inventory (NWI) by adding descriptors for landscape position, landform, and waterbody type (LLWW) and then applying correlations between wetland characteristics and functions (Tiner, Assessing cumulative Loss of Wetland Functions in the Nanticoke River Watershed Using Enhanced National Wetlands Inventory Data, 2005). Wetlands of potential significance were identified for five different functions: surface water detention, streamflow maintenance, nutrient transformation, sediment and other particulate reduction, and shoreline stabilization. Wetland data from 1800 and 1998 were compared to quantify the functional changes in the FRSBW wetland community.

Methods

1800 Wetlands

Historic wetland data was reconstructed by integrating two data sources to derive the extent, distribution, and vegetation characteristics of wetlands in the FRSBW. These data sources were: 1) soil survey data from the United States Department of Agriculture Natural Resource Conservation Service (NRCS), and 2) Landcover Circa 1800 developed by the Michigan Natural Features Inventory. Hydric soil map units were obtained from the Michigan Department of Environmental Quality (MDEQ). These hydric soil units were assumed consistent with the extent and distribution of wetlands in the FRSBW, except in the case of natural waterbodies (ponds and lakes). Natural waterbodies were delineated based on 1998 wetland data.

The NWI database contains codes for wetland type, vegetation type, and water regime. The wetland and vegetation type codes were derived by assigning wetland type and vegetation codes to the landcover circa 1800 data and then spatially joining those codes with the hydric soil polygons. The water regime codes were derived from the NRCS soil surveys for Lapeer and Oakland Counties. The end dataset was 95% forested. The wetland types in 1800 were likely more varied than this data suggests; the implications of this simplification is discussed below.

1998 Wetlands

The 1998 wetland data was obtained from the Ducks Unlimited (DU) Great Lakes Regional Office. This dataset was updated based on 1998 color-infrared digital orthoquadrangles from the Michigan Center for Geographic Information (MCGI). The wetlands were coded according to the USFWS official wetland classification system (Cowardin et. al., 1979).

Enhanced Wetland Classification

The NWI data was expanded to include descriptors for landscape position, landform, waterflow path, and waterbody type (LLWW descriptors). This enhanced attribution was performed in ArcGIS 9 using dichotomous keys for LLWW classification (Tiner, 2003) along with consultation of USDA digital-aerial photography and US Geological Survey digital topographic maps (digital raster graphics). The LLWW descriptors are presented in Figure 1.

Assessment of Wetland functions

This study follows Tiner's (2005) methods for "Watershed-Based Preliminary Assessment of Wetland Functions". This method involved adding LLWW descriptors to NWI data and correlating wetland functions with wetland characteristics. Potential significance was assigned to each wetland for five wetland functions: surface water detention, streamflow maintenance, nutrient transformation, sediment and other particulate reduction, and shoreline stabilization. Tiner (2005) evaluated 10 wetland functions. This project focused on only five for two rea-

sons:1) some wetland functions were specific to the northwest 2.) data used to reconstruct 1800 wetlands lacked the detail need to evaluate some wetland functions (i.e. conservation of biodiversity, fish and shellfish habitat.). This process was completed for both the 1800 and 1998 wetland datasets. Wetland polygons were then weighted based on their potential significance. Those with high significance were given a weight of 2, and those with moderate significance were given a weight of 1. The area (in hectares) was then multiplied by the weight to calculate the number of functional units for each wetland polygon. Maps were developed for each of the five functions evaluated for 1800 and 1998. The can be found in appendix 1. (Cowardin, Carter, Golet, & LaRose, 1979)

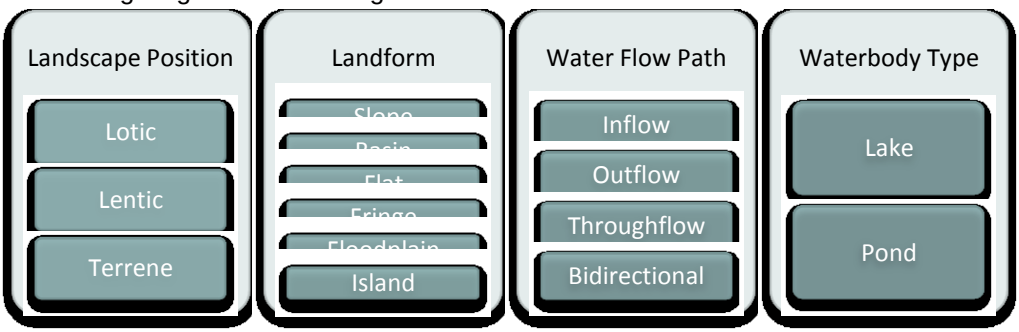

Figure 1. Landscape Position, Landform, Water Flow Path, and Waterbody Type descriptors used in the enhanced wetland classification for the Flint River South Branch Watershed.

Results

LLWW Wetland Comparison

According to the 1800 wetlands data, 1,350 wetlands occupied 20% (5,097 ha) of the FRSBW. Wetland area distributions by landscape position were: approximately 52% lotic, 42% terrene, and seven percent lentic. Wetland area distributions by landforms were: 60% basin type, 28% flat, and seven percent fringe. Less than 6% of the total wetland area were slope, floodplain and island wetlands (floodplain = 4%, slope = 1.0%, and island = <0.1%). With regard to water flow path, 59% of the wetland area was classified as throughflow and 21% as outflow. Approximately 20%, of the total wetland area was geographically isolated and completely surrounded by upland.

By 1998, the total land area occupied by wetlands in the FRSBW had decreased to 16% (4,203 ha). The number of wetlands increased to 2,151. Other than waterbodies, the distribution of wetlands in 1998 was nearly identical to that found in 1800. Approximately 52% percent of the 1998 wetlands were lotic, 42% terrene, and six percent lentic. Over 75% of the total wetland area in 1998 was basin type, 17% was flat, and five percent was fridge. The remaining five percent was composed of slope, floodplain, and island types (slope = <0.1, island = <0.1, and floodplain = 3.5%).

From 1800 to 1998, there was a total wetland area loss of 17% in the FRSBW. This loss was conservative when compared to more urbanized watersheds. Lentic wetlands in the FRSBW experienced the greatest loss since 1800: a decrease of over 29% in area. Lentic fridge wetlands were most critically affected. Lotic and terrene wetlands both exhibited a 23% decrease in total area. The effects of fragmentation were apparent for both lotic and terrene wetlands. The mean size of terrene and lotic wetlands decreased by 50% (from 2 to 1 ha) and 32% (from 14 to 9 ha), respectively. Terrene and lotic wetland types also increased in number by 475 and 23, respectively. The proportion of wetland area classified by landform and water flow type was altered considerably from 1800 to 1998. Basin wetland area increased from 60 to 74%.

Table 1. Historic trends in the Flint River South Branch's wetland area (hectares) by landscape position, landform, and water flow path: 1800 vs. 1998. Codes for water flow path: BI = bidirectional; TH = throughflow; OU = outflow; IS = isolated. Number of wetlands is approximate due to GIS processing

Landscape Position	Landform	Water Flow Path	# 1800	Area 1800	# 1998	Area 1998	% Change in Area
Lentic	Basin	BI			1	6.5	++
		TH	1	1.2	2	24.7	1959.5
		OU			1	0.5	++
		IS			1	2.9	++
	Flat	BI			1	4.2	++
		TH			2	10.9	++
	Fringe	BI	26	34.4	6	19.3	-43.8
		OU			1	0.4	++
		TH	12	288.1	7	158.6	-44.9
	Island	BI	3	.8	3	1.0	22.7
	Total		42	324.6	25	229.1	-29.4
Lotic	Basin	BI			2	1.9	++
		OU			4	39.0	++
		TH	78	1662.8	139	1542.6	-7.2
	Flat	TH	88	676.5	28	221.4	-67.3
	Floodplain	TH	11	179.8	25	120.9	-32.7
		BI			1	9.3	++
	Fringe	TH	1	0.8	5	1.8	125.2
	Slope	TH	3	2.3			-100.0
	Total		181	2522.1	204	1937.0	-23.2
Terrene	Basin	TH	10	43.5	11	170.5	291.9
		IN			1	3.7	++
		OU	147	565.7	60	155.7	-72.5
		IS	385	658.6	1031	803.3	22.0
	Flat	TH			2	53.3	++
		OU	127	422.0	22	132.2	-68.7
		IS	151	262.6	221	223.8	-14.8
		IN			1	1.4	++
	Slope	IS	42	44.2	1	1.0	-97.6
		OU	10	18.9			-100.0
	Fringe	BI	4	5.5	1	1.2	-77.8
	Total		876	2021.0	1351	1546.3	-23.5
	Grand Total		1099	4867.8	1580	3712.4	-23.7

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Flat wetland areas decreased from 28 to 17%. Slope wetlands only accounted for one percent of wetland area in 1800; they were almost totally eliminated by 1998 (< 0.01%). The percentage of outflow wetlands decreased from 21 to 9%. The percentage of isolated and throughflow wetlands increased from 20 to 28% and 59 to 62%, respectively

Causes of Wetland Change

The majority of wetland change in the FRSBW can be attributed to human alteration of the landscape. In areas that have favorable conditions for agriculture, much of the wetland loss was due to draining and clearing associated with agricultural use. Fragmentation has occurred as a result of transportation and suburban development in the FRSBW. An examination of the waterbodies in the FRSBW revealed that human alterations in the watershed do not necessarily result in loss of wetland area.

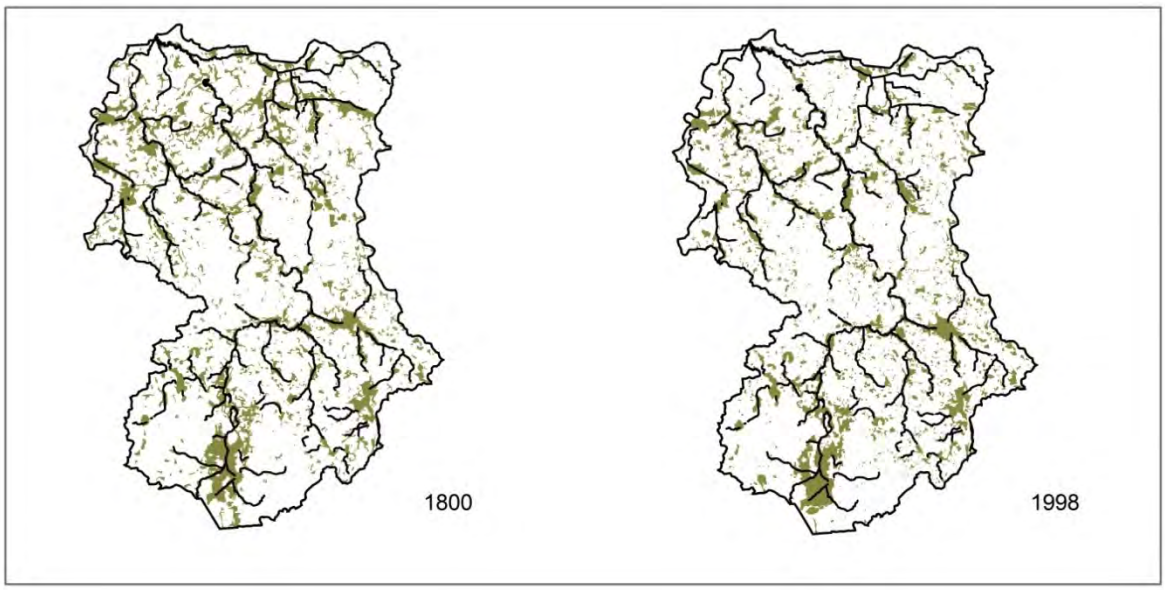

Figure 2. The Flint River South Branch's wetlands and streams at 1800 and 1998. Black areas are streams and green are wetlands

According to the 1800 wetland data there were 20 lakes and 65 ponds in the watershed totaling an area of 55 hectares or one percent of the total wetland area. By 1998 the wetland data indicated there were 11 lakes and 553 ponds in the watershed totaling over 480 hectares or 11% of the total wetland area. While some of the changes can be attributed to altered hydrology in the FRSBW, the fact that 313 of the ponds in the 1998 data were classified as excavated or impounded suggests that the majority of the increase in the number of waterbodies was due to human activities.

Trends by Wetland Function

Two comparisons of functional changes in the wetland communities of the FRSBW were made, one showing changes in wetland area providing significant level of functions (table 2) and the other estimating changes in functional units (table 3). From an area standpoint, losses in the total area of wetlands performing all five functions ranged from 22 to 36% decreases. Wetlands performing sediment and other particulate reduction exhibited the greatest decrease at 36% while the other four functions ranged between 22 and 24% losses in total area.

Table 2. Comparison of preliminary functional assessment results for the Flint River South Branch's wetlands at 1800 versus 1998. Area (in hectares) and percentage of the wetland area total are given for each function.

Function	Significance	1800 Area (ha)	1800 Percent	1998 Area (ha)	1998 Percent	Percent Change
Surface Water Detention	High	2082.2	40.9	2105.4	50.1	1.1
	Moderate	2093.1	41.1	1069.1	25.4	-48.9
	Total	4175.3	82.0	3174.5	75.5	-24.0
Streamflow Maintenance	High	1328.9	26.1	1968.5	46.8	48.1
	Moderate	2131.5	41.8	721.8	17.2	-66.1
	Total	3460.5	67.9	2690.3	64.0	-22.3
Nutrient Transformation	High	3259.5	64.0	3715.1	88.4	14.0
	Moderate	1601.4	31.4	0.2	0.0	-100.0
	Total	4860.8	95.4	3715.2	88.4	-23.6
Sediment and Other Particulate Reduction	High	2312.5	45.4	2256.9	53.7	-2.4
	Moderate	1992.3	39.1	494.0	11.8	-75.2
	Total	4304.8	84.5	2750.9	65.5	-36.1
Shoreline Stabilization	High	2845.9	55.9	2165.1	51.5	-23.9
	Moderate	226.5	4.4	155.7	3.7	-31.2
	Total	3072.4	60.3	2320.9	55.2	-24.5

Table 3. Predicted change in the Flint River South Branch's capacity to perform five wetland functions from 1800 to 1998. Functional units were derived from predictive values for each time period by applying a weighting scheme (2 for high; 1 for moderate).

Wetland Function	Functional Units 1800	Functional Units 1998	Percent Change
Surface Water Detention	6257.4	6083.3	-2.8
Streamflow maintenance	4789.4	3412.1	-28.8
Nutrient Transformation	8134.3	7430.3	-8.7
Sediment and Other Particulate Reduction	6635.0	5735.0	-13.6
Shoreline Stabilization	5918.43	4486.0	-24.2

The evaluation of functional units showed that potential functional capacity of the FRSBW had been reduced for all five wetland functions. The capacity for stream flow maintenance and shoreline stabilization had been impacted the most with reductions of 29 and 24% respectively. The watershed capacity to reduce sediment and other particulates had been reduced by 14%. Less substantial reductions in the wetland community's capacity to transform nutrients and detain surface water were seen at 9 and 3% respectively. There were no increases in functional capacity.

Uses of this study

Of all sub-watersheds in the Flint River Basin, the FRSBW is potentially the healthiest. This is due, in part, to successful retention of wetlands. In 1800, there were approximately 5,100 hectares of wetlands. In 1998, 4,200 hectares of wetlands remained—a loss of 900 hectares.

While this loss is significant, the rate of wetland retention is more important. Approximately 80% of wetland area was retained from 1800 to 1998.

The need for watershed management in the FRSBW was not compelled water quality problems; rather, it was based on the perceived threat of urban development and the potential for successful conservation. This study provides direction for preservation efforts by identifying areas where wetland losses have occurred and wetland areas with high functional capacity. This information may contribute to land management decision-making within the watershed. Wetlands with high functional capacity may be targeted for efficient conservation and preservation efforts.

Analyses of this type can provide deeper insight into the physical characteristics than are observed during typical inventory and management planning processes. Functional capacity analysis elucidates wetland function at a watershed scale to provide direction in management. For instance, sediment is a priority pollutant in the FRSBW. From 1800 to 1998, there was a 14% decrease in sediment reduction capacity, 24% decrease in shoreline stabilization, and a 29% decrease in stream flow maintenance capacity. Future wetland restoration and conservation efforts may target wetlands with high capacity to reduce sediment, stabilize shorelines and stream flow. Appendix 1, contains maps that highlight wetland function.

In 1998, these three wetland functions were potentially operating at 71 to 86% capacity. This suggests that factors other than wetland loss were significant contributors to sedimentation in the watershed. Wetland restoration efforts can be an effective component of a larger management strategy mitigating sediment pollution within the FRSBW.

This study also identified situations where water quality improvement should be focused in areas other than wetland management. For example, the FRSBW has over 96% of its nutrient transforming capacity. This would suggest that a situation where nutrient loadings are an issue could not be mitigated by restoring wetland function. By coupling a deeper understanding of wetland functions with knowledge of land use change in the watershed this helps land managers identify situations where wetland management can be used to improve water quality.

This study can be used as tool for management and education by land managers in the FRSBW. It provides watershed scale information about the function of wetlands in the FRSBW. By doing so, this study takes a step toward the use wetlands analysis as an important component of watershed assessment and management.

Acknowledgements

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Works Cited

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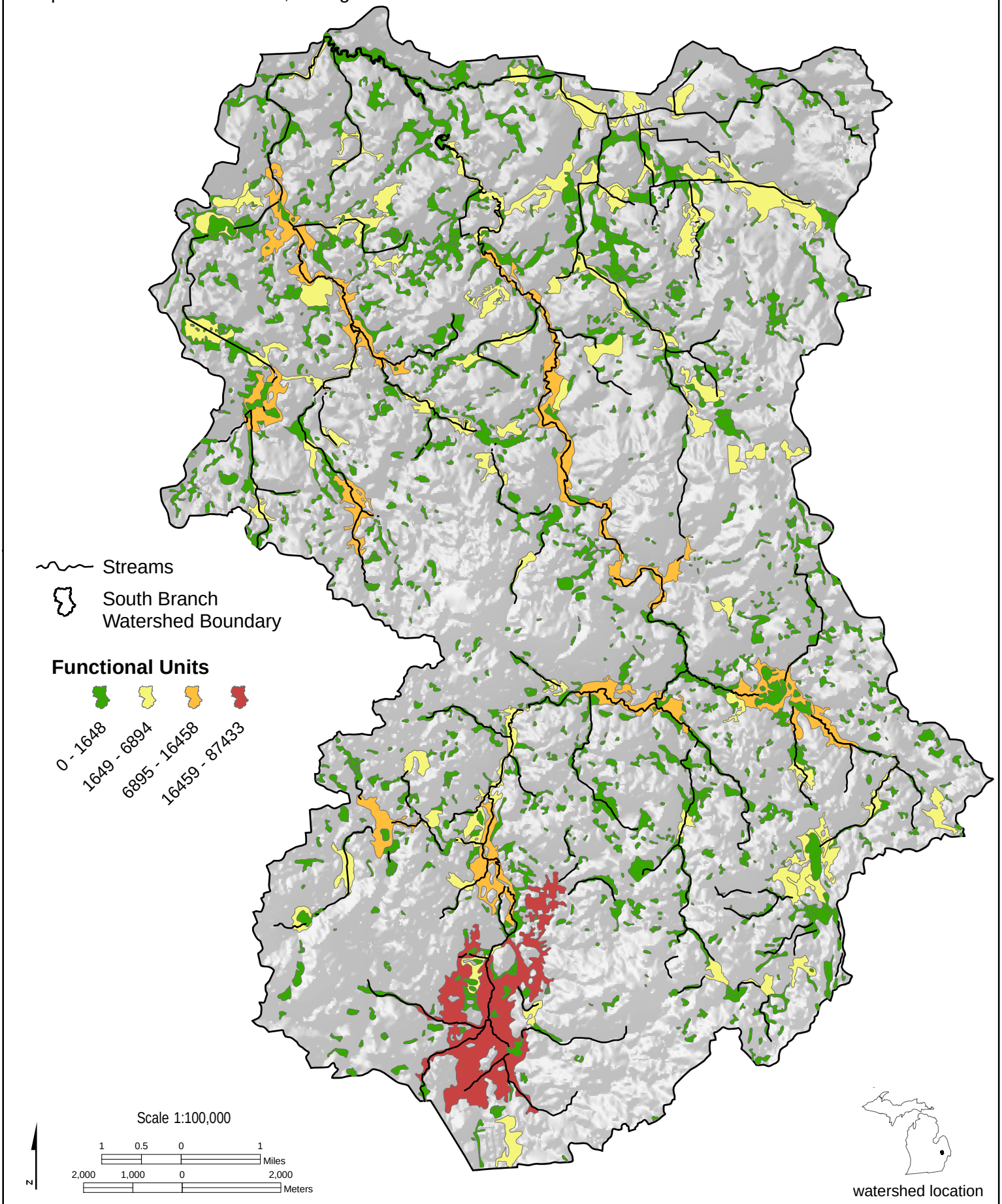
Appendix 1

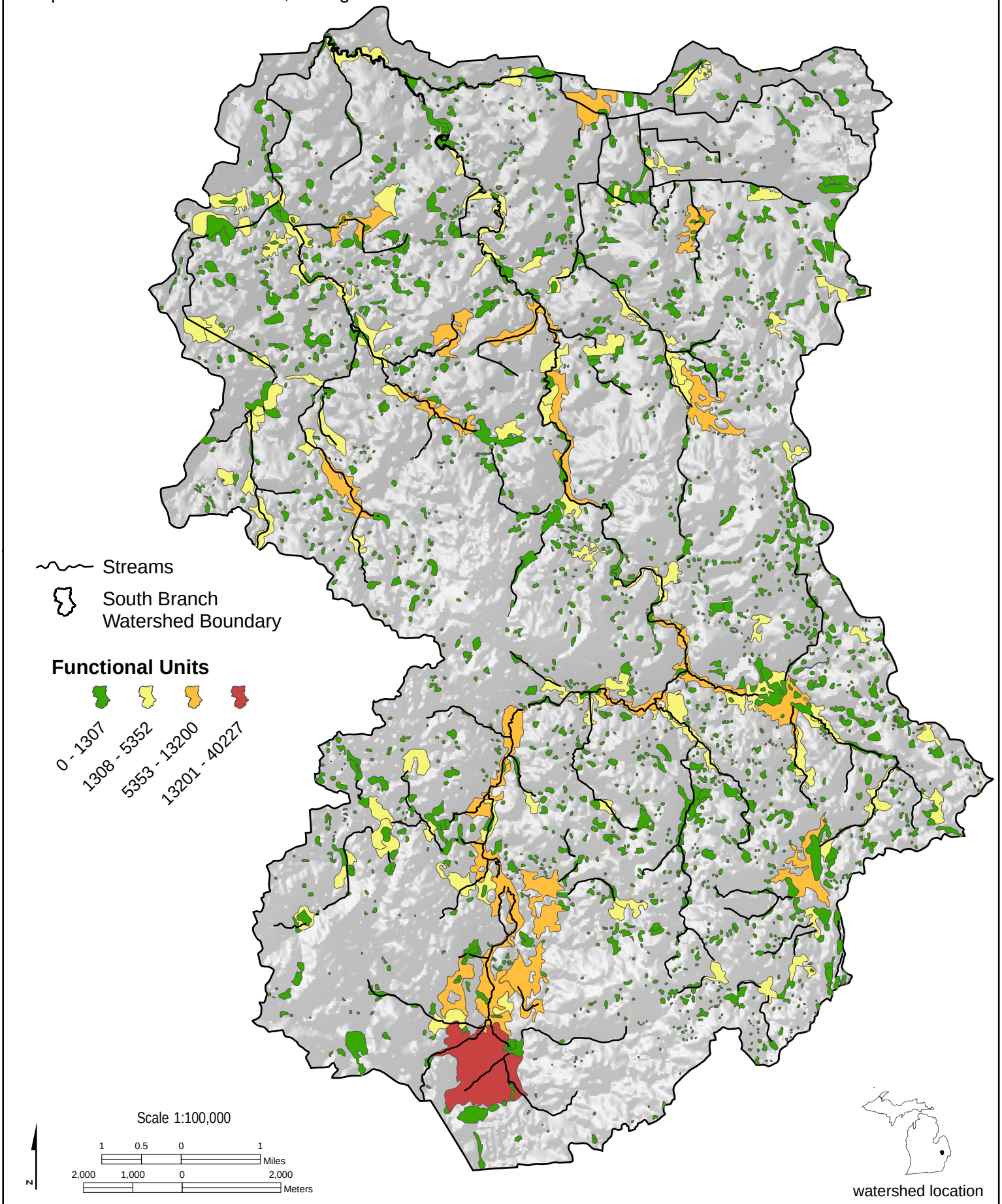
1800 Wetlands

Estimated Functional Units for Nutrient Transformation

Flint River South Branch Watershed,
Lapeer and Oakland Counties, Michigan



1998 Wetlands

Estimated Functional Units for Nutrient Transformation

Flint River South Branch Watershed,
Lapeer and Oakland Counties, Michigan